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Agroforestry Potentials of Under-Exploited Multipurpose Trees and Shrubs (MPTS) in Lare Woreda of Gambella Region, Ethiopia

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Abstract:
A study was conducted in Lare woreda of Gambella region with the aim of assessing the type and role of under-exploited multipurpose trees and shrubs. The study was specifically to identify under-exploited multipurpose tree and shrub species in different land use systems in the study area, determine the production and services role of the species and assess the local trees management practices. Key informants, formal survey with structured questionnaires and vegetation inventory were used to collect data on household's resources, local uses of multipurpose trees and shrubs , management practices and biomass of trees and shrubs. SPSS version 13 was employed to analyze the results and mean values were used to compare vegetation biomass between the two ethnic groups (Anuak and Nuer).The species richness or diversity was higher in the woodland(Nuer survey households) than the river bank (Anuak survey Kebeles) but the standing volume was higher in the river bank. A total of 19 and 7 trees and shrubs were locally used for food and medicine in the study area, respectively. It was also found that multipurpose trees and shrubs play various traditional roles to local community. They are used for fuel, construction, food, local medicine, folder, tools, religious function, shade, windbreak, soil conservation and fertility improvement, bee forage, local boat and other uses.

Keywords: *Under-exploited multipurpose tree and shrub, Species diversity, Woodland, River bank, Anuak, Nuer, Gambella*

1. Introduction

Throughout the world, there are many useful tree species that are commercially unknown or are sold only in local markets, but that produce potential marketable outputs. Many of such species are so called undomesticated or under exploited species, if subjected to genetic improvement and exploitation, can find a wide market and/or even if only locally used can help improve the quality of life for farm families. Within a region, there can be a wide choice of such species. For instance, studies on indigenous systems by Padoch and Jong *(*1987) indicate species that are commercially unknown but with improvement, they could find a wide market. Classical example of tree outputs that upon improvement found wide markets include kiwi fruit (*Actinidia arguta*) and macadamia nuts (*Macadamia* spp) (Cooper et al, 1996). With exploitation and improvement come greater opportunities for the use of trees in the farm landscape.

As the role and use of trees in the farm landscape and in close association with crops is better understood, there are expanded opportunities to use more tree species in the farm landscape. These expanded opportunities include identifying useful properties or characteristics of unused, underutilized or undomesticated trees and determining how these fit or can be best used in the overall farm landscape including outside the native habitat. This can include productive species as well as those that can play some facilitative role or can fill some growth and/or use niche that is missing. It may include tree species found in natural forests, unknown tree species without role in the farm landscape that can also be included to advantage in an agriculture or agroforestry environment. It also involves the introduction of non-native tree species into a region where no indigenous species exist that have desired growth and/or use characteristics (Wojtkowski, 1998)

The concept of multipurpose tree (MPT) mean having multiple uses for individual trees within the farm landscape. To qualify, besides the primary designed use, a tree can also have a number of secondary uses. For example, living fence posts, as secondary output, be pruned to provide leaf fodder and/or the pruned branches can also be used for fire wood. In addition to increasing land-use efficiency of a system through multiple use, multi-purpose trees, used as selection criteria for woody perennial and can provide some degree of flexibility in an otherwise rigid design.

Broad-use MPTs produce a range of general outputs where the productive outputs from one tree species can be easily replaced or substituted by outputs from another. List of broad-use multipurpose trees have been compiled by Von Carlowitz et al (1991), and are

based around the broad output or use categories such as fodder, fuel wood and fruit tree etc. In providing a range of usable products from one tree, MPTs use space in farm landscape more efficiently than single-purpose trees. In most cases where trees are incorporated in farming system, local people favor multipurpose trees that provide multiple uses (Wiersum, 1985). Legumes are particularly used, as they offer a range of productive and protective services and they combine rapid growth with good ecological adaptability. The humid lowland area of Gambella region is very rich in plant species diversity with more underexploited multi-purpose trees and shrubs that are specialized only locally and yet no research has been done so far in respect to these species.

1.1. Significance of the Study

The present study aimed to assess Agroforestry potentials of under exploited multipurpose trees and shrubs in Lare woreda of Gambella region, because there was no previous particular assessment conducted on Agroforestry potentials of such species. The study contributes to understanding of the different MPTs in the woreda and their potential roles in land use systems. The information obtained will also serve as base for future improvement and domestication of underexploited multi-purpose trees and shrubs and also will fill the gap of information required for those who are interested to conduct further multi-dimensional studies on underexploited species in the woreda as well as in the region.

1.2. Objectives

1.2.1. General Objective

The major objective of this study is to assess the type and roles of underexploited multipurpose trees and shrubs in Lare woreda of Gambella region.

1.2.2. Specific Objective

1 To identify underexploited multipurpose tree species in the different land use systems of the study area.
2 To determine the production and services role of the species.
3 To assess the local management practices of these tree and shrub species.
4 To compare tree management and utilization practices between the two dominant ethnic groups, Nuer and Anuak.
5 To develop recommendation for better management and utilization.

2. Materials and Methods

2.1. Study Area

The study was conducted in Lare woreda of Gambella region. The Gambella people's National Regional state is located in the extreme western part of Ethiopia covering an area about 34,063 km^2. The region is bordered in the north by Benishangul Gumuz and Oromiya states, in the south by South Nation's Nationalities and people's Region and in the east by Oromiya and South Nation's Nationalities and people's Region and in the west by the Republic of South Sudan. From the point of grid reference, the region is located between 7^{o}N to 8^{o}N latitude and 33^{o}E to 35^{o}E longitude. Lare Woreda is located in the north western part of the Gambella region and it is located 85km away from the Gambella city, which in itself is 862km far away from Addis Ababa. (CSA, 1995). See figure 1.

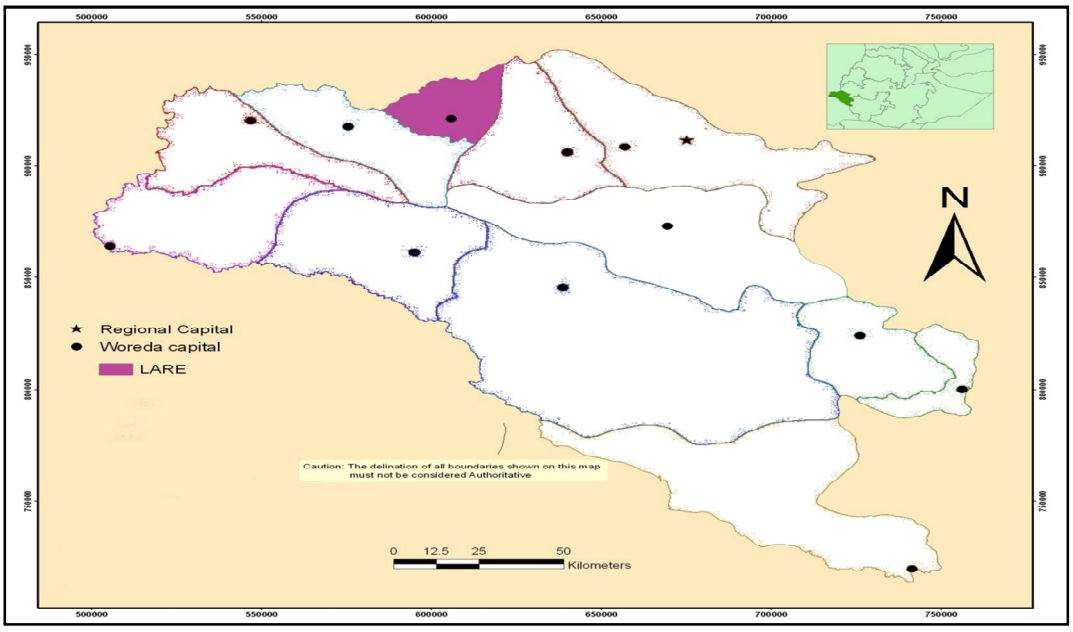

Figure 1: Location of Lare woreda within Gambella Regional State

2.2. Climate

As part of Gambella region, Lare woreda is characterized by unimodal rainfall brought by tropical monsoon blowing from South Atlantic and Indian oceans. It is also characterized by heavy rainfall during the wet season (May to October) and very little precipitation during the dry season (Nov. to Apr.). The mean annual rainfall of this area is 1400mm. The mean annual temperature is 27^oC but the mean monthly temperature varies significantly. The absolute maximum temperature of 45^oC is recorded in mid March while the absolute minimum temperature 10.3^oC is recorded in December (CSG, 2000),

2.3. Topography

The region comprises contrasting topographic features with altitude varying from 394m a.s.l.in western lowland areas to 2300m a.s.l. in eastern highlands. The land mass of the region is extensive flat plain that is surrounded by chains of mountains, which form drainage system in the north and South eastern part of the region. (Selkhozpomexport, 1989). Lare Woreda falls at altitude of 394m to 500m above sea level in the western lowland and has flat surface.

2.4. Vegetation

The natural vegetation varies with altitude. However, it can be broadly classified into riverbank forest, woodland or wooded grassland and bush land. The forests are rich in species diversity and are closely related to tropical rainforest. It is also estimated that forest and woodland (open and closed woodland cover 26% and 57% of the region's land area, respectively (Menassie et al, 2003). The dominant type of vegetation in Lare Woreda is woodland, common tree species being *Acacia seyal, Acacia senegal, Acacia nilotica, Tamarindus indica* and *Balanites aegyptiaca.*

2.5. Method of Data Collection

2.5.1. Sampling Procedure and Data Collection

There are 25 kebeles in the study woreda, inhabited by the two ethnic groups, Nuer (22) and Anuak (3). Accordingly, 4 representatives Kebeles from Nuer and 2 from Anuak were systematically selected for the study thus making up a total 6 kebeles. Again a sample of 10 households from each selected kebele was taken that make up total of 60 households. Five key informants were also systematically selected from each kebele which make up total of 30 key informants. Besides the ethnic composition, the households' selection was based on economic status (rich, medium and poor).

Based on the information obtained from the Key informants and woreda administrators, Lare woreda was divided into four areas namely: Mading, Mongok, Teluth and Kurthony areas. The kebeles were systematically selected from these areas. See Table 1 for characteristics of the selected kebeles.

Kebele	Area	Ethnic group	Total No Households	Population
Metduerkong	Mongok	Nuer	240	1320
Teluth	Teluth	Nuer	208	1042
Duakuarmach	Kurthony	Nuer	166	866
Tongdol	Mading	Nuer	165	825
Cham	Kurthony	Anuak	143	715
Adene	Kurthony	Anuak	163	813

Table 1: Selected Study kebeles
Source: Lare Woreda Rural and Agricultural Office

2.5.2. Wealth Ranking

Farmers distinguish among themselves as poor, middle and rich. The distinction is usually based on the number of livestock, number of wives, type of crop, and number of children and size of farmland one owns (Table 2 and 3). This categorization, therefore, indicates the relative abundance of productive resources among farmers within an area. The Nuers are largely dependent on livestock than Anuak. Therefore, the two ethnic groups do have different criteria in classifying their wealth.

Indicator	Poor	Medium	Rich	Remark
Farm size	≤0.5	0.5-1.5	≥1.5	
number of cattle	≤5	5-30	≥30	
number of Goats	≤5	5-20	≥20	
number of Sheep	≤2	2-20	≥20	
Chicken	≤2	2-12	≥12	
Children	≤2	2-5	≥5	Combination of boys &girls
Wives	≤2	2-3	≥3	

Table 2: Criteria for wealth ranking of Nuer
Source: Key informants

Indicator	Poor	Medium	Rich	Remark
Farm size	<0.75	0.75-1.5	≥1.5	
number of fruit tree	≤3	3-4	≥4	
number of cattle	≤1	1-2	≥2	
number of Goats	≤1	1-2	≥3	
number of Sheep	≤1	1-2	≥3	
number of Chicken	≤4	4-10	≥10	
Children	≤2	2-5	≥5	Combination of boys &girls
Wives	≤2	2-3	≥3	

Table 3: Criteria for wealth ranking of Anuak
Source: Key informants

2.6. Sources of Data
Data for the study were collected from both primary and secondary sources. Secondary sources are mainly published and unpublished sources, such as annual reports of the agricultural and rural development office of the study woreda. Literature review of other documents was also made to complement and refine the information that has been collected. The primary sources involved both socio-economic survey and vegetation inventory. Details of the methods used for primary data collection are described below.

2.7. Socio Economic Survey
The socio economic survey involved various data collection techniques, such as semi-structured questionnaire survey, informal discussion, group discussions and observations. Before the survey began, selected household members and key informants were contacted to explain the purpose of the survey and to develop trust.
Semi-structured questionnaires were developed and pre-tested and interviews were finally undertaken with the selected households. Information regarding production and service role of multipurpose trees and shrubs, attitude of people toward different trees, traditional trees management and utilization practices were collected through the interview. In addition to interviews informal discussions and group discussions were held with individuals, institutions and key informants.

2.8. Identification of Multipurpose Trees (MPTS) and Vegetation Inventory
Key informants and selected households members in Lare woreda representing Anuak and Nuer tribes were involved and asked the local names and uses of MPTs encountered in the survey. The botanic names of the MPTs were identified using tree identification guidance such as Azene Bekele (2007), Tesfaye Awas (1997) and the publications of Ethiopian flora project. Inventory of the forest was conducted to obtain information on the population structure, density of stems/ha and to estimate some of the outputs that can be harvested and collected from the woodlands and riverbank.
The inventory was conducted by means of systematic transect sampling in the woodland and riverbank. A total of 30 sample plots 40x40m (1600m^2) 500m apart and 5 plots from each selected kebeles were measured. On each plot, the name of the species and total number of individuals' species were counted and recorded. The Dbh and height of each trees and shrubs were measured, using diameter tape and clinometers, respectively.

2.9. Data Analysis
The collected data were summarized and analyzed using SPSS version 13, taking each species and households as a unit of analysis. Descriptive statistics such as means, minimum, maximum, percentage, table, figure, and standard error were calculated to present the results. Analysis of variance was calculated whenever possible. The Volume was calculated using FORMIX model Bossel and Krieger (1991) for Malaysian lowland Dipterocarp forest use five –six classes, normally defined as canopy layer.
Volume =$fgh=\prod/4fd^2h$
Where f is a form factor (0.38-0.5) depending on the tree biomass, g is basal area, h is tree height and d is diameter depending on the tree biomass

3. Result and Discussion

3.1. Under Exploited MPTS in the Different Land Use of Lare Woreda Species Richness
The woodland, riverbanks and farmlands in Lare woreda were surveyed and about 68 MPTs species; shrubs (27 species), Trees (38 species) indigenous palm (1 species) and climbers (2 species) were recorded. They belong to 61 genera and 32 families. The diverse genera were *Acacia,* followed by *Ficus* and *Ziziphus*, which were represented by five and four species, respectively. They are followed by *Grewia* (three species), *Albizia, Celtis, Combretum, Lannea* and *Tamarindus* (two species each). The remaining genera were represented by single species. The diverse families' include Fabaceae, which is represented by 13 species and Moraceae by 5 species followed by Anacardiaceae, Combreceae and Rhamnaceae which are represented by 4 species each. The diversity of MPTs was higher in the woodland (Nuer surveyed household) than river bank area of the Anuak households (Table 4).This is because of the presence of flooding and extensive farms on the river banks.
The list of identified MPTS is presented in local name and scientific names for easy identification. However, it is advisable not to rely on the local names for species identification because some local names were given to more than one species. The present study

revealed that ethno-botanical knowledge of indigenous people is public and all member of the society are equally knowledgeable about the trees and shrubs in their locality. This is in agreement with result of previous studies made in Gambella region (Mengistu Woube, 1995; Tesfaye Awas, 1999).

Vegetation type	N	Mean ±SE	% of Total N
Woodland	47	3.09±0.15	69
River bank	13	1.85 ±0.10	21.2
Share species	8	1.31±0.21	9.7
Total	68	2.08±0.15	100

Table 4: Species richness of MPTS in woodland and river banks of Lare woreda
SE =Standard Error of the mean N=Total number of MPTS

3.2. Density and Abundance of MPTS

The range of underexploited MPTs in woodland and riverbank of Lare woreda has not been covered by this inventory. However, a total of 199 individual MPTS per plot (1244/ha) that belong to 27 MPTs were recorded by the inventory. The density of trees varied between the woodlands and riverbank. Woodlands had an average density of 950 trees and shrubs/ha while the riverbank had average density of 294 trees/ha. Therefore, it can be concluded that, the density is higher in the woodland than riverbank.

The highest abundance of the species was recorded for *Acacia senegal* with 32 individuals per plot, *Tamarindus indica* 29 individuals per plot, *Balanites aegpytiaca* 27 individuals per plot, *Acacia nilotica* and *Acacia seyal* 18 individuals each which are dominant in the woreda (Table 5). Other common species in woodland included: *Ziziphus mucronata Ziziphus absyssinica, Pterocarpus lucens, Grewia mollis, Allophhylus macrobotrys, Crateva adansonii,* and *Euphorbia candelabrum.*

Riverbank included species such as *Ficus sycomorus, Celtis toka, Kigelia africana* and *Diopyros mespiliformis*. These species are found along the bank of Baro river. Some *Acacia* species are also present along the river bank. In the woodland the most abundant species were *Acacia senegal* and *Tamarindus indica* 181/ha individuals each. The less number of individuals in the riverbank may be due to presence of farmland, large size of individual trees and flooding that affect the growth of some tree species.

No	Species	Number of individual species			Percent (%)
		Woodland	Riverbank	Total frequency	
1	*Acacia nilotica*	17	1	18	9.0
2	*Acacia senegal*	29	3	32	16.1
3	*Acacia seyal*	14	4	18	9.0
4	*Allophylus macrobotrys*	8	-	8	4.0
5	*Asparagus flagellaris*	1	-	1	.5
6	*Balanites aegpytiaca*	27	-	27	13.6
7	*Cadaba farinose*	1	1	2	1.0
8	*Celtis africana*	-	1	1	.5
9	*Celtis toka*	-	4	4	2.0
10	*Crateva adansonii*	2	1	3	1.5
11	*Diopyros mespiliformis*	-	3	3	1.5
12	*Euphorbia candelabrum*	3	1	4	2.0
13	*Ficus sycomorus*	-	9	9	4.5
14	*Gardenia ternifolia*	1	1	2	1.0
15	*Grewia mollis*	1	-	1	.5
16	*Kigelia africana*	-	6	6	3.0
17	*Lannea fruticosa*	1	-	1	.5
18	*Mangifera indica*	-	6	6	3.0
19	*Milicia excelsa*	1	-	1	.5
20	*Pterocarpus lucens*	1	-	1	.5
21	*Scelerocarya birrea*	1	-	1	.5
22	*Securidaca longepedunculata*	1	1	2	1.0
23	*Strychnos innocua*	1	-	1	.5
24	*Tamarindus indica*	29	-	29	14.6
25	*Ximenia americna*	1	-	1	.5
26	*Ziziphus abysssinica*	2	-	2	1.0
27	*Ziziphus mucronata*	10	5	15	7.5
	Total	152	47	199	100.0

Table 5: Average number of MPTS per plot in the inventory site (Area=1600m^2)

3.3. Population Structure of MPTS

The MPTS in the woodlands as well as the riverbank have different size classes. The diameter distribution of tree has often been used to represent the population structure of forest (Khan et al ,1987).The height and diameter distribution of the species indicated a reversed J-shape distribution with most of the trees being less than 30cm in diameter and 11m height (Figures 7&8).The maximum frequency of height was observed for height class of 6-10m (83 individuals), and 1-5m (74 individuals), whereas the minimum frequency was observed for class above 16m height (12 individuals),(Table 6). Moreover, the maximum frequency of Dbh was recorded for Dbh 1-5cm (53 individuals) and the minimum Dbh from 91cm 2 individuals, (Figure8).

The large proportion of small trees and shrubs is found in the woodland comprising mainly young trees. The absence of large trees might be due to cutting of mature trees by people for local boat, commercial fuel wood and charcoal making. On the other hand the few individuals left in the riverbank have bigger diameter.

The inventory result indicated that woodlands have three strata. The upper layer includes those individuals whose height exceeds 11m and the middle stratum includes 6 to 11m. The lower stratums are those below 6m height (Figure 7).The inventory also indicated that the highest proportion of the species was found in the lower and the middle storeyes. There are many species, which couldn't attain the middle and the upper storey by their nature; those species are termed as shrubs.

Species	Height class (meters)				
	1-5	**6-10**	**11-15**	**16-20**	**21-25**
Acacia nilotica	5	13	-	-	-
Acacia senegal	12	18	2	-	-
Acacia seyal	6	12	-	-	-
Allophylus macrobotrys	8	-	-	-	-
Asparagus flagellaris	1	-	-	-	-
Balanites aegpytiaca	3	21	3	-	-
Cadaba farinose	2	-	-	-	-
Celtis africana	-	-	1	-	-
Celtis toka	-	-	4	-	-
Crateva adansonii	2	-	1	-	-
Diopyros mespiliformis	1	-	-	-	2
Euphorbia candelabrum	3	-	-	-	1
Ficus sycomorus	1	-	5	1	3
Gardenia ternifolia	1	-	-	-	-
Grewia mollis	1	-	-	-	-
Kigelia africana	1	-	1	4	-
Lannea fruticosa	-	-	1	-	-
Mangifera indica	1	1	4	-	-
Milicia excelsa	-	1	-	-	-
Pterocarpus lucens	-	-	-	1	-
Scelerocarya birrea	1	-	-	-	-
Securidaca longepedunculata	1	-	1	-	-
Strychnos innocua	1	-	-	-	-
Tamarindus indica	7	16	6	-	-
Ximenia americna	-	-	1	-	-
Ziziphus abysssinica	2	-	-	-	-
Ziziphus mucronata	14	1	-	-	-
Total	74	83	30	6	6

Table 6: Height class distribution of the common species (30 plots, Area=1600m^2).

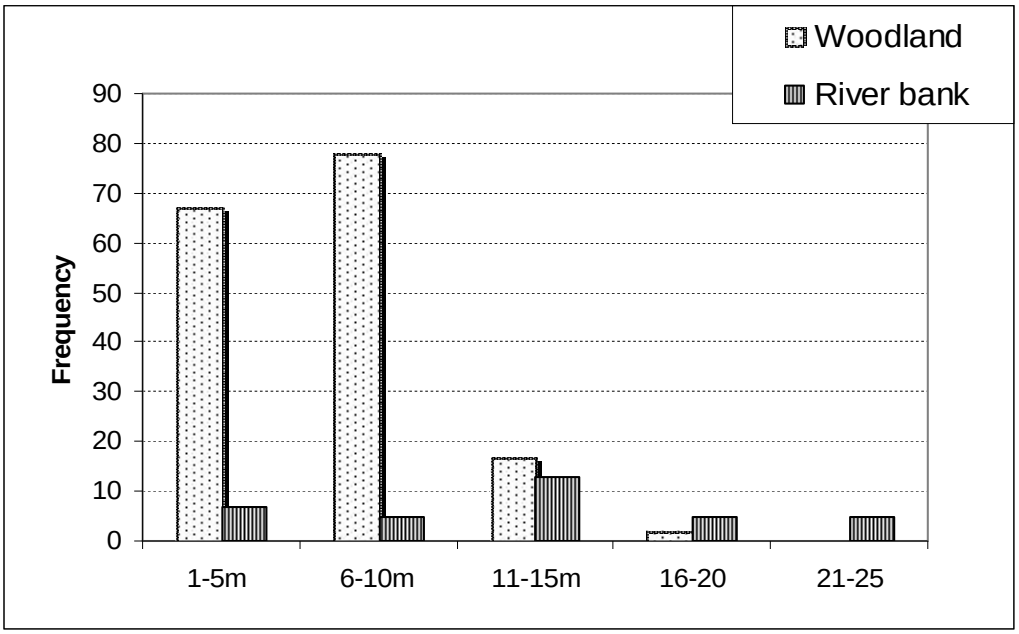

Figure 2: Summary of height distribution of the species in the study area

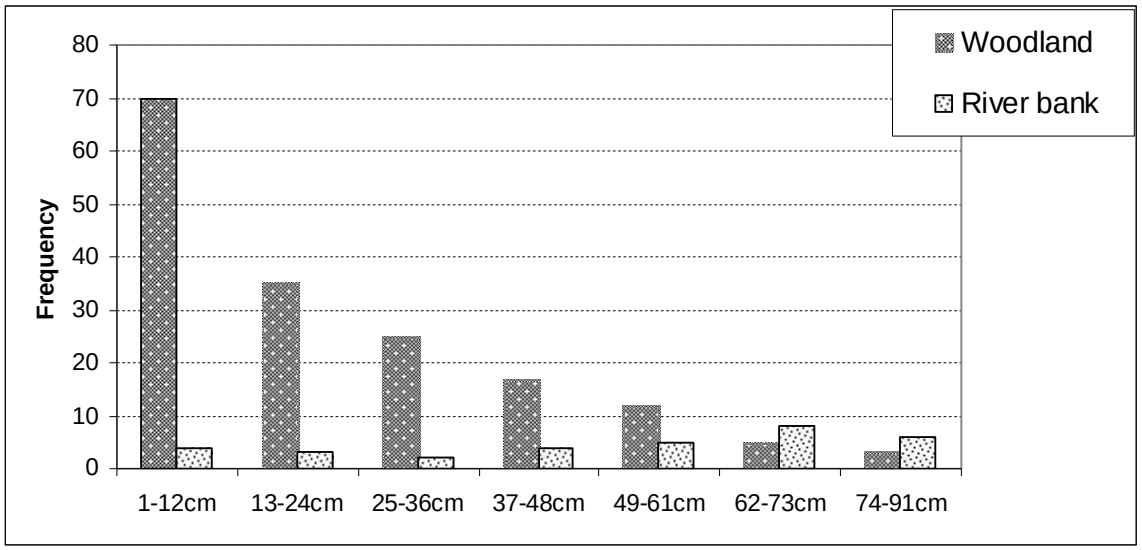

Figure 3: Diameter distributions of the species

The maximum height (25m) was attained by *Celtis toka* and *Diopryos mespiliformis* while maximum Dbh (120cm) was attained by *Celtis toka* and *Ficus sycomorus* (Appendix 4 &5). These three species are found in the riverbank. The mean height and Dbh of *Celtis toka* was 16.75m and 83.25cm, respectively. Similarly, the mean height and Dbh of *Diopryos mespiliformis* was 16.67m and 51cm, respectively.

The minimum height (1m) was attained by woodland species such as *Acacia nilotica, Acacia seya*l, *Allophylus macrobotry*, and *Cadaba farinose,* also the minimum Dbh (1cm) was attained by same species. The mean height and Dbh of all species was 7.8m$\pm$0.36 and 55cm$\pm$0.24, respectively (Table 7).

Other species that attained maximum Dbh and height were *Balanites aegpytiaca, Tamarindus indica* and *Kigelia africana.*

Parameter	Mean $\pm$SE	Minimum	Maximum
Height (m)	7.85$\pm$0.36	1	25
Dbh (cm)	55$\pm$24	0.1	120

Table 7: Mean, maximum and minimum Height and Dbh of trees in the study Woreda (area =40x40m2; number of plots woodland=20 plots and riverbank=10 plots).
SE = Standard error of the mean

3.4. Standing Stock of MPTS

The mean volume of trees and shrubs for all species was 4.58m^3/ha. The larger mean volume was obtained from riverbank (Anuak kebeles) with12.49m^3/ha, whereas the lower mean volume was from woodland (Nuer kebeles) with 2.13m^3/ha (Table 8).

Vegetation Type	N	Mean±SE	Maximum
Woodland	152	2.13±0.34	39.76
Riverbank	47	12.49±2.21	61.36
Total	199	4.58	

Table 8: Mean and maximum volume of trees (m^3/ha) in the woodland and riverbank of Lare woreda
SE =Standard error of the mean N=Number of MPT

When we compare the volume among species the highest mean was observed from *Diopyros mespiliformis* 40.9m^3/ha where as the lowest mean was found from *Acacia seyal* 0.49m^3/ha. When the two vegetation types are compared the density of trees was higher for woodlands but the standing volume of trees was higher in the riverbank. This indicates that the few trees in the riverbank have larger size. Among the woodland species *Balanites aegpytiaca* and *Tamarindus indica* had higher average volume (Table 9).

Species	Vegetation type	N	Mean ±SE	Minimum	Maximum
Acacia nilotica	Woodland	18	.542±.124	.009	1.659
Acacia sengal	Woodland	32	.654±.097	.002	1.659
Acacia seyal	Woodland	18	.492±.124	.004	1.227
Balanites aegpytiaca	Woodland	27	4.741±.596	.002	11.685
Celtis toka	Riverbank	4	23.359±10.226	6.786	49.480
Diopyro mespiliformis	Riverbank	3	40.898±2.455	37.699	45.725
Ficus sycomorus	Riverbank	9	22.995±5.336	9.652	61.359
Kigelia africana	Riverbank	6	18.157±2.216	12.830	25.133
Tamarindus indica	Woodland	29	3.798±.633	.177	15.394

Table 9: Mean volume of Top 9 species in the study woreda (m^3/ha).
SE =Standard error of the mea N=Number of MPTS

3.5. Local Uses of Underexploited MPTS in Lare woreda.

3.5.1. Indigenous Food Producing MPTS

A total of 19 trees and shrubs are used for food in Lare woreda. Edible parts are mainly the fruit and leaves (Table 10). A total of 16 MPTS are used as a source of fresh fruit. Examples include *Tamarindus indica,* locally known as 'Chuwa' (Anuak) and 'Qad' (Nuer); *Ficus sur*, 'Olam' (Anuak), 'Ngop' (Nuer); *Ziziphus mucronata* ('Bow' in Nuer) and *Balanites aegptiaca* ('Sow'in Nuer).

Other edible parts include dry fruit (3 species), gum (2 species) and leaves (1 species). According to the estimate made by Key informants, the average amount of edible materials for all species was 20kg/ha/year, which is 380kg/ha/year. Therefore, woodland and riverbank of the study area are very rich in wild food MPTs that people of Lare are used to eat either as fresh or cooked but most of these species are found in the woodland. These wild edible MPTs species that are also resistant to disease or drought than cultivated crops play an important role as buffer against drought and famine. Besides alleviating food shortage, they are also important food source particularly when people are away from home for honey gathering, hunting and fishing. These potential food producing MPTs can find wide market if improvement is made through further research and genetic improvement. This study confirms other studies on indigenous systems by Padoch and Jong (1987) who indicated species that are commercially unknown but with improvement, they could find wide market.

No	Species	Land use	Edible parts					Other use
			Cooked fruit	Fresh fruit	Leaf as ash salt	Gum	Dry fruit	Water source (Leaf)
1	*Acacia nilotica*	WL				XX		
2	*Acacia senegal*	WL				XXX		
3	*Allophylus macrobotrys*	WL		X				
4	*Balanites aegyptiaca*	WL	XX	XX	XX		XXX	
5	*Cadaba farinose*	WL		XXX				
6	*Diospyros mespiliformis*	RF		XXX				
7	*Ficus sur*	RF		XXX				
8	*Ficus sycomorus*	RF		XXX				
9	*Ficus vasta*	RF		XXX				
10	*Flueggea virosa*	WL		XXX				
11	*Grewia mollis*	WL		XXX				
12	*Grewia tenax*	WL		XXX				
13	*Kigelia africana*	WL	XXX					
14	*Sclerocarya birrea*	WL		XXX				
15	*Strychnos innocua*	WL		XXX				
16	*Tamarindus indica*	WL		XXX			XXX	XX
17	*Ximenia american*	WL		XX				
18	*Ziziphus abyssinica*	WL		XXX				
19	*Ziziphus mucronata*	WL		XX			XXX	

Table 10: Food producing underexploited trees and shrubs in Lare woreda
WL=Woodland RF=Riverbank XXX=Very important XX=important X=less important

Figure 4: Tamarindus indica retained in front yard as food and shade

3.5.2. Introduced Fruit trees

The climate of Gambella region is generally suitable for fruit and vegetable production. The river banks of Lare woreda present an excellent instance of adaptation of the introduced species in general and fruit trees in particular (Appendix 3).

The most important introduced fruit tree is mango (*Magnifier indica*). It does quite well in the hot humid climate of the study area and thus, widely cultivated in Gambella in general and Lare woreda in particular. Improved varieties have fruits with good flavour and little fiber. According to key informants a mature tree can produce about 1000 fruits and it is rich in vitamins A and C. The second most widely cultivated fruit is orange (*Citrus sinensis*) in homestead giving good quality fruits. The climate of Gambella region in general allows orange to be produced throughout the year. These fruit trees are important food source particularly during the year of little production of agricultural crops and hence, contribute to food security and also have contribution to cash income.

3.5.3. Medicinal uses of MPTS

Medicinal MPTS are useful for primary health care and remedy for disease and injury. Multipurpose tree species used traditionally for

food and drinks, are also believed to be good for health. By tradition, people of Lare woreda can identify which MPTs have medicinal value and use them according to traditional practices. For example the root of shrub known as 'Leele' -in Nuer (*Securidaca longepedunculata*) is traditionally used for snake poison treatment. The seed of another tree called *Tamarindus indica* locally known as 'Chuwa' (Anuak) and 'Qad' (Nuer) is used against intestinal parasites and malaria treatment. Here, the seed of the tree is soaked in water for some time and taken as curative (Table 11).

Medicinal trees and shrubs have been curing the people of Lare woreda from different types of ailment. They are especially important for those people who are living far away from towns where clinics are located. One can wonder how many thousands of birr could be spent for pharmaceutical drug, if these trees and shrubs were not available. These non cultivated and underexploited MPTs species have more potential to cure the people from different disease but they are not statistically recorded hence, further research is needed in this direction.

No	Species	Plant Par used for treatment	Type of disease/problem treated							
			Human					cattle		
			Intestinal problem	Cough	Malaria	Broken bone	Snake poison	Sterility of cow	Horn orientation	Wound
1	*Balanites aegyptiaca*	Bark	X							
2	*Calotropis procera*	Root	X							
3	*Kigelia Africa*	Fruit	X			X		X	X	
4	*Saba florida*	Fruit								X
5	*Securidaca longepeduncula*	Root					X	X		
6	*Tamarindus indica*	Fruit	X		X					
7	*Ziziphus mucronata*	Root		X						

Table 11: Traditional medicinal MPTS
X =stand for disease/problem treat

Figure 5: Medicinal shrub known as Calotropis procera (Ait).f.

3.5.4. Fodder Production

Silvopastoral system is the principal form of land use in Lare woreda. Hence, fodder trees and shrubs play an important role by providing livestock with protein, vitamins and minerals, crude fibers, etc, especially for surviving the long dry seasons.

These MPTS also provide shelter, improve the local climate, soil, water availability and growth of fodder grasses and herbs. The trees and shrubs that are indicated by the respondents as most important fodder species are Acacia *senegal, Acacia seyal, Acacia albida, Acacia tortilis, Balanites aegyptiaca, Cadaba farinose* and *Tamarindus indica*

Species	Part consumed		Type of browsing and consuming animals				
	Leave/ twigs	Fruits/ Seeds	Cattle	Sheep	Goats	Wild animals	Bees
Acacia abida	XXX	XXX	XX	XXX	XXX	XXX	XX
Acacia nilotica	XXX	XXX	XXX	XXX	XXX	XXX	X
Acacia senegal	XXX	XXX	XX	XXX	XXX	XXX	XXX
Acacia seyal	XXX	XXX	XXX	XXX	XXX	XXX	XX
Acacia tortilis	XXX	XXX	XX	XXX	XXX	XXX	XXX
Balanites aegyptiaca	XXX	XX	XXX	XXX	XXX	XXX	X
Cadaba farinose	XXX	XX	XXX	X	XXX	XX	X
Diospyros mespiliformis	XX	XX	XXX	X	X	X	XX
Grewia mollis	XX	X	X	X	X	X	X
Tamarindus indica	XXX	XX	XX	XX	XXX	X	XXX

Table 12: Important fodder MPTs species in the study area
XXX =Very important, XX =important X =Less important.

3.5.5. Fuel Wood Production

In general, the woodland is the main source of fuel wood, construction materials and other minor forest products for local community. According to the result of the survey, wood fuel is major source of domestic energy for more than 80% of households in all surveyed kebeles. Crop residue is the second significant source of domestic energy while animal dung is also used in Nuer households (Table 13). The main reason may be due to presence of large cattle herd in the Nuer ethnic community. Fuelwood accounts for 82.5% of the energy supply followed by crop residue (12.5%) and animals' dung (5%). The Anuak households used about 85% of fuel wood and 15% of crop residues as source of domestic energy.

Type of energy	% of respondent				% Average
	Anuak		Nuer		
	N	%	N	%	
Fuel wood	17	85	33	82.5	83.3
Crop reduces	3	15	5	12.5	13.3
Animal dung	-	-	2	5	3.3
Total	20	100	40	100	100

Table 13: Major source of domestic energy in Lare woreda (respondents Anuak =20; Nuer =40)
N=Number of the respondents

Figure 6: Young Girls collecting firewood from woodlands.

About 95% of respondents in the study area said, they do not cut the live trees for firewood but they collect dead branches while 5% of the respondents said, they also cut the standing trees to produce charcoal for sale. This indicates the community's conservation and rational use of natural resources. Almost all respondent indicated that, all of the identified MPTS are used for fuel but Acacia species are preferred especially for charcoal production The result of this study differ from the finding of Raintree and Lundgren (1985) who stressed the role of agro forestry to be the woody components for energy production.

3.5.6. MPTS for Soil Fertility Maintenance

The supply of agricultural inputs is limited in the Gambella region in general and Lare woreda in particular. For this reason, farmers in this area practice traditional shifting cultivation as a major practical land management alternative for maintenance of soil fertility and productivity.

Almost all the respondents of the Nuer households mentioned the potential of *Acacia seyal, Acacia senegal* and *Acacia nilotica* for maintenance of soil fertility in fallow lands (Table 14). They also indicated that, *Balanites aegyptiaca* and *Tamarindus indica* which are retained in home compound as practical means of sustaining soil fertility. However, the respondents in the Anuak households indicated the potential of *Ficus sycomorus* in soil fertility maintenance for both farm and fallow lands.

The difference in the opinions of the respondents on the species for soil fertility maintenance could be due to difference in their land use. The Anuak surveyed households are located on river bank where *Ficus sycomorus* is dominant, whereas the Nuer surveyed households are situated in the woodland where *Acacia* are the dominant natural vegetation. This study is therefore, in agreement with previous studies which indicated the role of trees for soil fertility management and conservation (Nair, 1984; Wiersum, 1984; Lundren and Nair, 1985; Young, 1989).

Species	Land use				Vegetation type
	Woodland		Riverbank		
	Fallow land	Farmland	Fallow land	Farmland	
Acacia nilotica	XXX	X	X		DW
Acacia senegal	XXX	X	X		DW
Acacia seyal	XXX		X		DW
Balanites aegyptiaca	XX	XXX	X		DW
Tamarindus indica	XX	XXX			DW
Ficus sycomorus			XXX	XXX	DR

Table 14: Important MPTS species for soil fertility maintenance in the study area (respondents Anuak =20; Nuer =40).

XXX=Very important, XX =Important, X =Less important DW=Dominant in the woodland DR= Dominant in the riverbank.

Other production and Service role MPTS

In addition to direct product and service role, multipurpose trees and shrubs also serve a range of other purposes. They provide non-timber products such as gum and resin, serve as shade for human and animals, provide environmental amenity and serve as windbreak. Moreover, MPTS serve as boundary marker, improve honey production and have cultural functions.

Most of the respondents said that *Balanites aegyptiaca, Tamarindus indica, Celtis toka* and *Ficus sycomorus* are used as shade and windbreak. They also said that *Acacia senegal, Acacia seyal, Acacia nilotica* and *Ficus sycomorus* are used for both edible parts and soil conservation (Table 15). Only few of the respondents said *Acacia* species are used for windbreak and shelterbelt and this may be due to the thorny nature of *Acacia* species and thus inconvenience in farmland. The important services they also mentioned is religious function in which pole of *Balanites aegyptiaca* is used for different traditional religious gods while the pole of *Acacia nilotica* is used for snake god believers.

Species	Gum	Wind break	Shade	environmental amenities	boundary maker	Soil conservation	religious	Honey production
Acacia nilotica	XXX	X	X	X	X	XXX	XXX	X
Acacia senegal	XXX	X	XX	X	X	XXX		X
Acacia seyal	XX	X	X	X	X	XXX		X
Balanites aegyptiaca	X	XXX	XXX	XX	XX	XX	XXX	X
Tamarindus indica	X	XXX	XXX	XXX	XXX	XX		X
Ficus sycomorus		XXX	XXX	XX	XXX	XXX		XXX
Celtis toka		XXX	XXX	X	XXX	X		XX

Table 15: Major service and production function of MPTS in Lare woreda.

XXX =Very important serve XX =Important X = Less important

Figure 12: Poles of Balanites aegyptiaca used as Religious function

Here presence of poles indicates that the place is used for worship and sacrifice.

MPTs Species	Place of grown	Production roles					Service roles					
		Fuel	Timber	Fodder	Food	Medicine	Gum	Bee forage	Soil conservation	Shade	Wind break	Religious
Acacia seyal	WF	5	2	3			1		4			
Acacia senegal	WF	3	5	2	4		4	2	3	2		1
A. nilotica	WF	5	2	3			1		4			2
Allophylus macrobotrys	W	3	4	5	4							
Asparagus flagellaris	W	5		4								
Balanites aegpytiaca	WFL	2	5	2	4	1			2	3		1
Flueggea virosa	W	2	5	3	4							
Gardenia ternifolia	W	2	1	3	5			4				
Tamarindus indica	WFL	3	1	2	5	4		1		5	3	1
Ziziphus abyssinica	W	3		4	5							
Ziziphus mucronata	W	3	5	3	4	2						1

Table 16: Summary of production and serve role MPTs in Lare woreda

WF =Woodland and Fallow land W=Woodland WFL= Woodland and Farmland
1=Very important 4= Important 3= Relatively important 2= Less important 1= Not important

MPTs Species	Place of growth	Production and Service of MPTs										
		Fuel	Timber	Fodder	Food	Medicine	Gum	Bee forage/ Beehives	Soil conservation	Shade	Local Boat	Religious
Cadaba farinose	W	4	5	4								
Calotropis procera	W	4	2	3		5						
Celtis toka	RF	1	3	2	3					4	5	
Cordia africana	RF	4	4	2	2	2		3		3	5	
Diospyros mespiliformis	RF	1	4		3	1		2		4	5	
Ficus sycomorus	RF	1	3		2	1		3	2	5	3	
Grewia mollis	W	4	5	3	2							
Kigelia africana	RF	2	5	1	2	2		1		3	4	
Lannea fruticosa	RF	4	5	3								
Securidaca longepeduncula ta.	W	4				5		2				

Table 17: Ranking of MPTs species by their major use.

W=Woodland RF=Riverbank

1.= Very important 4 = Important 3=Relatively important 2 = Less important 1= Not important

3.6. Local Tree Management and Utilization Practice

Different management practices allow tree growers to optimize MPTS products and services. Management may also be applied to reduce negative effects of trees and shrubs such as shading effect on adjacent crops. The most common management practices are pruning of branches, pollarding and coppicing and protection of fallow species. The other important management technique that is used by the community is the use of dead branches in the woodland and riverbank for firewood. Farmers select and retain some species that they consider most important on their farmland, the typical example of these species were *Balanites aegpytiaca* and *Tamarindus indica*. They also plant exotic species such as *Azadirachta indica, Mangifera indica, Citrus sinensis* and *Melia azedarach.* The dominant species retained, managed and used in the Nuer villages were *Acacia* species, *Balanites aegpytiaca*, and *Tamarindus indica* while introduced species include *Azadirachta indica* and *Melia azedarach.* On the other hand the dominant species retained, managed and utilized in Anuak villages were *Ficus sycomorus, Kigelia africana, Celtis toka, Diospyros mespiliformis* and introduced species were *Magnifier indica* and *Citrus sinensis* (Table 18).

With regard to their utilization, planting and retention on the farms, most of Anuak farmers prefer to have trees planted around homesteads, farm boundaries and roadside while most of Nuer farmers prefer to have trees retained in the farm, home compound and fallow land.

Knowledge about propagation, tree management (E.g. pollarding and pruning) and utilization of trees is common among farmers of all ethnic groups especially in respect to use for construction, tool handles, firewood, charcoal and edible parts. The knowledge is based on what they have learnt from their fathers and grandfathers, skilled neighbors and their own experience.

The trees left in the farm therefore, serve specific purposes, although every tree is multi- purposes by nature. Even valuable tree species may be used for fuel when less valuable species are not available, or only their branches and leaves are used. This knowledge of farmers on the durability or specific quality of specific wood for particular purpose is distributed almost equally among farmers in all ethnic groups. Knowledge of using fodder trees is more common among the Nuer, although it is also practiced by Anuak farmers. This can be explained by agropastoral livelihood system of the Nuer.

Preference for certain MPT species differs between the two ethnic groups. Most of the woodland species such as *Acacia* species, *Balanites eagyptiaca, Tamarindus indica* and *Ziziphus mucronata* are intensively managed and utilized by the Nuer farmers while *Celtis toka, Diospyros mespiliformis, Ficus sycomorus* and *Kigelia africana* are managed and utilized by Anuak

No	Species	Anuak	Nuer	Remark
1	*Acacia nilotica*	Fire wood, charcoal, poles, tools handle	Fire wood, charcoal, poles, tools handle, fodder (leave, pods), soil conservation , gum, tooth brush Religious for snake believers and dried fence	Dominant in the Nuer village (woodland)
2	*Acacia Senegal*	Fire wood ,pole and gum	Fire wood, posts ,poles tools handle fodder Grinding maize& sorghum, Soil conservation, Soil improvement high quality edible gum, gun pole, shade	Dominant in the Nuer village (woodland)
3	*Acacia seyal*	Fire wood and charcoal	Fire wood, charcoal, shade, nitrogen fixation soil conservation poles, posts gum, fodder shade	Dominant in the Nuer village (woodland)
4	*Azadirachta indica* (exotic)	Fire wood, timber and ornamental	Fire wood, timber and ornamental and medicine	Drought resistant
5	*Balanites aegpytiaca*	Fire wood, timber, food (fruit), Salt Substitute charcoal Shade, meeting place, wind break, oil, and soap.	Fire wood,timber,fodder, food (fruit), Salt Substitute charcoal Shade, Soil conservation, meeting place, wind break, oil, soap and Religious function	Dominant in the Nuer village (woodland)
6	*Celtis toka*	Firewood, timber, conservation, fodder,handle tools, food (fruit) ,local boat and shade	Firewood, timber, fodder, fruit shade and local boat	Dominant in Anuak village (Riverbank)
7	*Citrus sinensis*	Food (fruit) and Juice (fruit)	Food (fruit)	Dominant in Anuak village (Riverbank)
8	*Diospyros mespiliformis*	Fire wood, timber (conservation, furniture), food(fruit) bee forage and beehives , local boat and shade		Dominant in Anuak village (Riverbank)
9	*Ficus sycomorus*	Firewood, Mortar beehives, food (fruit),ornamental, mulch, shade soil conservation, soil improvement and local Boat	Shade and fire wood	Dominant in Anuak village (Riverbank)
10	*Kigelia africana*	Fire wood, timber, Local boat, Local honey beer, soaps, fruit for play game medicine fodder	Fire wood, timber, soaps, fruit for play game medicine fodder	Dominant in Anuak village (Riverbank)
11	*Mangifera indica*	Fire wood, food (fruit),bee forage	Fire wood, food (fruit	Dominant in Anuak village (Riverbank)
12	*Melia azedarch* (exotic)	Fire wood, timber, tool handles, poles, posts	Fire wood, timber, tool handles, poles, posts, medicine shade ornamental, windbreak	Dominant in the Nuer village (woodland)
13	*Tamarindus indica*	Firewood, timber Charcoal, tool handle, food(fruit)fodder(leave),local boat,medicine,poles,root,(fruit),Shade, ornamental, windbreak juices	Firewood, timber Charcoal, handle tools, food,(fruit)fodder(leave),localboat,medicine,poles,fodder(bark,leaves,root,(fruit),Shade,ornamental,windbreak, and juices	Dominant in the Nuer village (woodland)
14	*Ziziphus mucronata*	Fire wood, timber (local construction), food(fruit),	Fire wood, timber (local construction), food(fruit), medicine	Dominant in the Nuer village (woodland)

Table 18: Use of common MPTs by Nuer and Anuak

No	Species	Propagation		Management		Remark
		Anuak	Nuer	Anuak	Nuer	
1	*Acacia nilotica*	Wilding	Wilding		Protect young seedlings from animals in the fallow land	Dominant in the Nuer village
2	*Acacia senegal*	Wilding	Wilding		Protect young seedlings from animals in the fallow land	Can be intercropped with Sorghum and produce high Quality gum
3	*Acacia seyal*	Wilding	Wilding		Protect young seedlings from animals in the fallow land	Long thorns and gum is not good as that of *Acacia senegal*
4	*Azadirachta indica* (exotic)	Seedlings	Seedling/direct sowing		Pollarding	Shade and windbreak
5	*Balanites aegyptiaca*	Wilding	Wilding, direct sowing at site.		Pollarding, coppicing and retain on farms	The wood is termite-resistant and more preferable for local construction
6	*Celtis toka*	Wilding	Wilding	Coppicing and Retain on the farms	Retain in the Villages for shade	Leaves are eaten by Goat and Cattle and good for shade
7	*Citrus sinensis*	Seedlings		Pruning		Fruit crop
8	*Diospyros mespiliformis*	Cutting	Cutting	Pruning pollarding and coppicing	Pollarding	Resistant to termite
9	*Ficus sycomorus*	Cutting	Cutting	Pruning.		Grows well with crop If its shade is controlled by pruning
10	*Kigelia africana*	Wilding and Direct sowing	Wilding	Coppicing		Long and huge fruit
11	*Mangifera indica*	Seedlings, direct sowing	Seedlings, direct sowing	Lopping		Popular introduced fruit tree
12	*Melia azedarch* (exotic)	Seedlings,	Seedling, Wilding and direct sowing		Pollarding,coppicing, pruning and lopping	Leaves are not eaten by animals
13	*Tamarindus indica*	Wilding	Wilding and direct sowing		Pollarding ,coppicing and retain on farms	Its fruit has many uses
14	*Ziziphus mucronata*	Wilding	Wilding		Pollardingandcoppicing	Termite resistant

Table 19: Propagation and Tree management practices

3.7. Attitudes of People towards Different Trees and Shrubs

The attitude of people towards different MPTs is generally positive. Attitude of the two ethnic groups towards specific tree is mainly based on its utility. For instance, the Anuak farmers have negative attitude towards *Asparagus flagellaris* shrubs where as the Nuer farmers have positive attitude towards it. This may be explained by presence of large number of goats among the Nuer for which *Asparagus flagellaris* is an important fodder.

People's view regarding the future prospects of trees was negative for all households. This may be due to decreasing of trees and shrubs in communal land and expectation of further decrease in the future. For trees on farm fields, some of the farmers do not support it at all while the others said it depends on species. Trees like *Balanite aegyptiaca, Tamarindus indica, Ficus sycomorus,* and *Celtis toka*, etc. are welcome.

Many respondents are not planting trees. For farmers who don't like to plant trees in farm, it may be due to presence of native trees retained in their farms and fallow land and may also be due to lack of seedlings. Therefore, given soil enriching and multipurpose tree species and proper extension, their attitude could be changed. Generally, farmers in the Anuak households are interested in tree planting, particularly around homes and farm fields. All of them prefer *Mangifera indica* and private tree planting than their Nuer counterpart who prefers trees in the communal lands.

3.8. Domestication of Underexploited Trees

The survey on the woodland has shown that, the indigenous species for, example *Balanites aegyptiaca* and *Tamarindus indica* are either planted or retained in the farm fields. Similarly households on the riverbank had also indicated *Ficus sycomorus*, *Celtis toka* retained and planted in the farmland. This shows that, those trees have more potential and have more contribution to the local economy. Therefore, they could be listed as candidate trees for domestication. Further research is needed in this direction to facilitate domestication and expansion of planting of indigenous MPTS. This study deals with observation of trees retained in farmer's fields and may be different from other studies of Wojtkowski, (1998) who list the desirable characteristics needed for specific application.

4. Conclusion

It can be concluded that, the species richness was high in the woodland than riverbank but the woody biomass was higher in riverbank than woodland. The woodland in the study woreda is dominated by *Acacia* species followed by *Tamarindus indica*, *Balanites aegyptiaca* and *Ziziphus mucronata*. Riverbank of the study area included species such as *Ficus sycomorus*, *Celtis toka*, *Kigelia africana* and *Diopryos mespiliformis* community. Moreover, the highest abundance of MPTS was observed in the woodland than riverbank. The large proportion of small trees and shrubs is an indication of over utilization of the woodland for different wood products and land clearance for shifting cultivation. The species which attained maximum height were *Celtis toka* and *Diopryos mespiliformis* and that attained maximum Dbh were *Ficus sycomorus* and *Celtis toka*. The mean volume for all species in the study sites was 4.58m^3/ha. Among the species the highest biomass was from *Diopryos mespiliformis* 40.9m^3/ha whereas the lowest biomass was obtained from *Acacia seyal* 0.49m^3/ha.

The most important food MPTS species are *Balanites aegyptiaca*, *Tamarindus indica* and *Ziziphus mucronata*. Mango (*Mangifera indica)* and Orange (*Citrus sinensis*) are widely cultivated throughout the Gambella plain. By tradition people of the woreda can identify MPTS that have medicinal value and use them according to traditional practices. It was found that, the wood fuel is major source of domestic energy for more than 80% of households in all surveyed kebeles followed by crop residue and cow dung. The management and utilization practices differ with MPTS species between two ethnic groups, with most of the species in the woodland such as *Acacia* species, *Balanites aegyptiaca*, *Tamarindus indica* and *Ziziphus mucronata* being managed and utilized by Nuer farmers whereas trees on the river bank such *Celtis toka, Diospyros mespiliformis* and *Ficus sycomorus* managed by Anuak farmers. Attitude of the farmers towards different MPTS is generally positive but people's view regarding futurity of the trees was gloomy for all survey households.

5. Recommendation

- As rural community in the study area managed and utilized indigenous trees and shrubs which are seldom cultivated, seedlings of these species should be raised in the nursery and community should be encouraged to plant the seedlings.
- Research on indigenous MPTs such as important food producing MPTs, medicinal, fodder and soil fertility improvement species should be done by regional agricultural institute, agricultural bureau or interested NGO or academic researchers, therefore, it could enhance better management and utilization at local community level even introduction of those species to other habitat.
- MPTs on communal lands should be managed by local organization/Kebeles and rules or regulations should be laid out on obligations and expectations of members.
- All soil fertility improving MPTs species should be integrated with agricultural crops.
- Private tree planting should be encouraged.
- Further research should focus on the,
  - Assessment of underexploited MPTs species and the way to introduce them to other habitat.
  - Agroforestry practices combination of trees and crop/animals should be promoted in order to sustain production and maintaince of the environment.

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