Shea Forest Stands Mapping and Inventory in Yei County, South Sudan

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Introduction

In Sudan, the shea tree (*Vitellaria paradoxa* ssp. *nilotica*) is called by its Arabic name, *lulu*. Shea is a deciduous savanna hardwood growing naturally and abundantly in Yei County and other counties in South Sudan. The fruit of the tree is edible and the oil that is extracted from the kernels has a wide range of local uses such as food, soap and body oil. Shea in Yei County has never been investigated for commercial purposes. This study is the first attempt to determine the potential of shea in the county. The Forestry Working Group survey and inventory team, which is one of six Strategic Analysis/Capacity Building (SACB) working groups sponsored by the U.S. Department of Agriculture and also part of the SPLM's Natural Resource Technical Committee (NRTC), assessed the economic potential of the resource using participatory learning and action tools in addition to mapping and inventorying the stands. The study was conducted during the months of February and March 2004. Prior to the survey and inventory work, information on location, tree species/forest stands were gathered using participatory learning and action (PLA) exercises. A total of 11 shea trees stands were mapped and inventoried. For each forest stand the team described the forest type, tree species composition and density per hectare, land use and damages.

From the baseline data, estimates of productive capacities and sustainable harvest levels will be made. The potential for future development, forest uses and forest operational action plans will also be derived from this baseline information. The rationale behind this is to quantify the resource, assess harvest sustainability and its viability for market opportunities and contribution to the livelihoods of the local communities.

The Study Area

The study area lies between latitudes 03° 46' N and 04° 25' N and longitudes 030° 15' E and 031° 57' E. Bomas visited are located in the east, west and north of Yei County. These bomas have known stands of shea trees, as a result, the communities benefit from the economic, and food security gains associated with harvesting shea fruits and nuts. Bomas visited include Nuni, Lainya, Adio, Mugo, Panyume, Kupera, Dimu 1, Avukaya and Alero.

The inhabitants of the study area include the Kakwa, Pajulu, Makaraka, Avukaya and Mundu who dependent on subsistence farming as main source of livelihoods. Other means of livelihoods include collection of wood products and hunting.

Methodology

Information on shea tree stands was gathered prior to the survey and inventory exercises using participatory learning and action (PLA) tools. The PLA tools used in collecting information from the local communities included focus group discussion and participatory forest mapping and transect walks. A two-week training session was first conducted to ensure that the team members were familiar with the PLA tools and the use of the global positioning system (GPS) devices used in surveying the forests. In using the

PRA tools, the team was able to gain insight into a wide range of information related to shea nut collection, yield, location, processing, marketing, ownership and management of the resource.

Local guides knowledgeable about the location of each shea forest stand were recruited during the mapping and inventory exercises. All the shea stands were mapped using GPS. The data collected using the device was computed to produce maps of the shea tree stands. (Appendix 3)

The inventory team used systematic sampling with a random start and post-stratification of sample plots based on area survey information collected earlier using the GPS. The basic plot configuration and layout was 20 metres wide by 100 metres long and was 0.2 ha in size. From the plot, trees of species other than shea and measuring 10 cm and above in diameter were tallied. For shea trees, elderly members of the community were contacted to gauge the age category of each individual tree. The following codes for the age of shea trees were used:
R/S = Regeneration/Sapling = < 5 Years
Y = Young = 5 – 25 Years
Me = Medium = 26 – 45 Years
M = Mature = 46 – 65 Years
O = Old = > 66 Years

In this study, measurement of tree heights and diameter to calculate tree volumes have been omitted simply because the product under investigation is the fruit, the exact size of the trees is less important as long as the trees are sufficiently mature to produce fruit. The systematic sampling method used enabled the team to identify zones, contrasts, changes, conditions and physical features. An inventory data collection sheet was used to record the number of different tree species in each sample plot. The average number of tree species per hectare was determined by dividing the total number of trees in the sample plots in each forest stand by the number of sample plots and the product was multiplied by five.

Data Analysis and Result

An important feature of the mapped forests is their diversity per hectare. In the stands visited, shea tree species ranked the highest in terms of density.

During sampling, the inventory team observed along transect lines dense clusters of shea trees. Some shrubs were also observed. All the mapped shea stands have flat topographies. Nyori and Mbado shea stands have streams flowing through them. Table 1 shows the names, areas and distance from Yei town of the mapped shea forest stands.

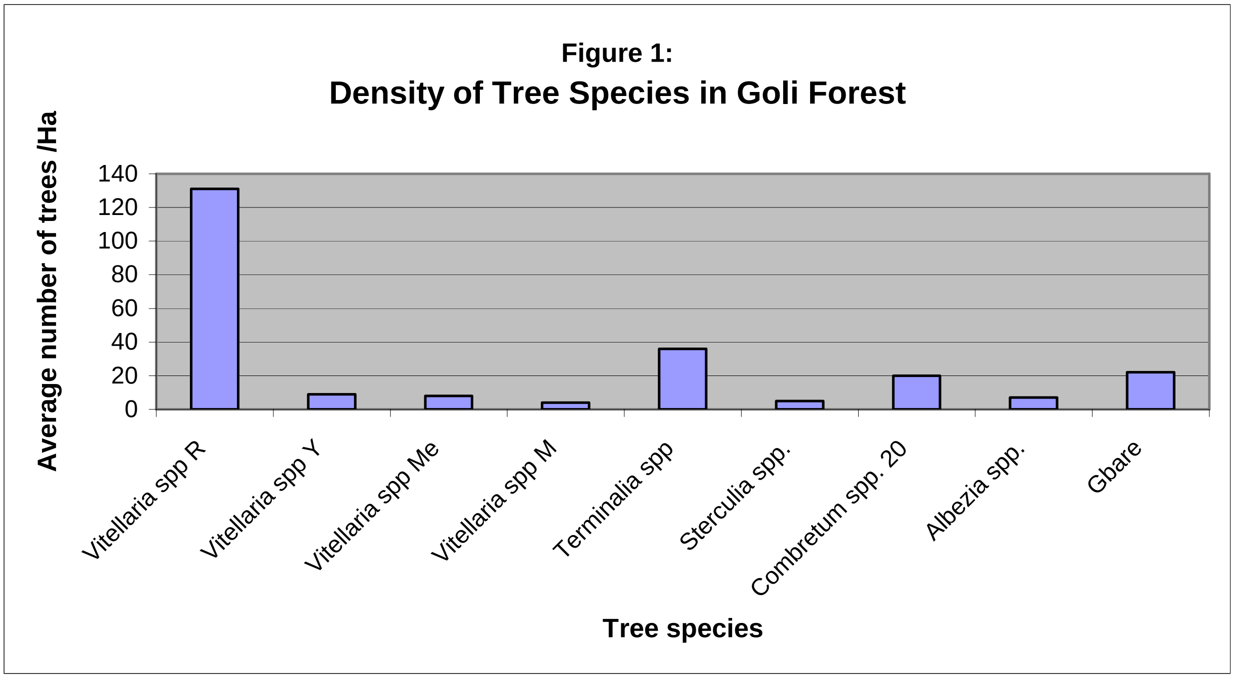
Table 1: Names, Areas and Distance from Yei Town of Mapped Shea Forest Stands

Name of forest stand	Area in Km^2	Boma	Payam	County	Distance from Yei town
Alero	2.8	Mugo	Mursak	Yei	10.2 Km
Goli	2.6	Adio	Tore	Yei	31.5 Km
Jamara	0.8	Kupera	Lainya	Yei	33 Km
Kurilo	0.6	Lainya	Lainya	Yei	40.5 Km
Kuturjo	2.6	Lainya	Lainya	Yei	34 Km
Logobero	3.8	Dimu 1	Lainya	Yei	14 Km
Masidada	1.5	Avokaya	Tore	Yei	69.5 Km
Mbado	7.3	Adio	Tore	Yei	61 Km
Nyori	76.8	Panyume	Morobo	Yei	64 Km
Rijongu	7.0	Lainya	Lainya	Yei	48.8 Km
Yondoru	11.8	Nuni	Lainya	Yei	27 km

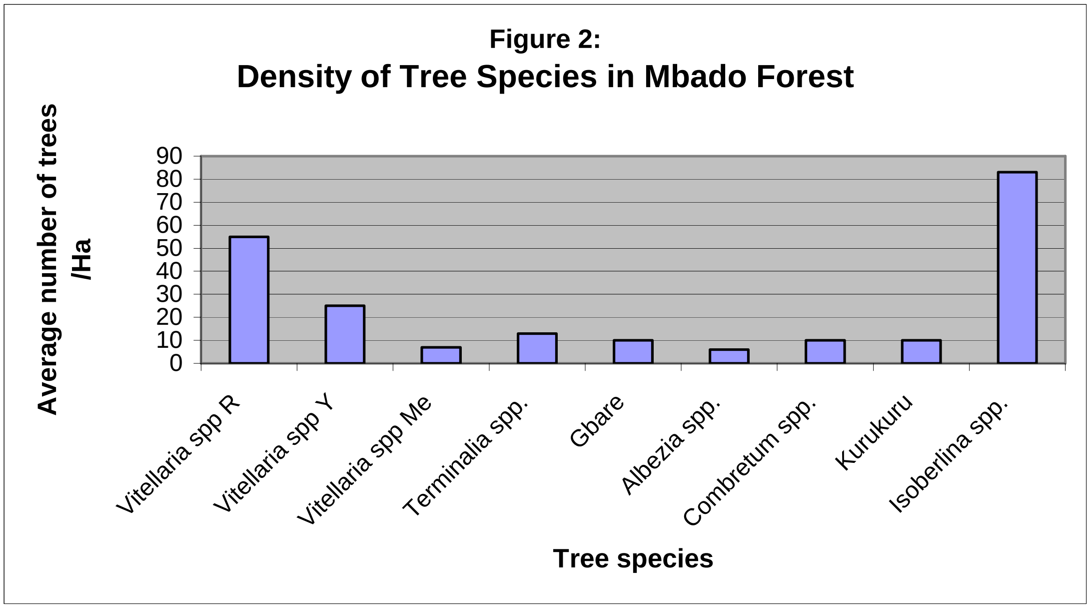
Figures 1 – 11 below show the density per hectare of tree species in the mapped shea forest stands. Note that the average number of shea trees in the graphs is categorized in terms of age as indicated in the methodology above. In all stands, the average number of shea saplings per hectare exceeds the other age groups. The shea forest stands with a high number of saplings per hectare include Goli, Jamara, Kurilo, Logobero and Masidada, while those with a lower number of saplings per hectare are Mbado, Nyori, Kuturjo, Rijongu, Yondoru and Alero. Kurilo has the highest number of saplings with more than 400 per hectare, while Alero has the lowest number of saplings with only 20 saplings per hectare. The sample and population standard deviations for the various age groups of shea trees are shown in Appendix 1.

In each stand, there is at least one to two tree species with high density growing in association with shea trees. Shea stands with higher tree density and age groups include Mbado, Nyori and Jamara, while Kurilo, Kuturjo and Logobero have the lowest density of older shea trees. Common tree species with high numbers of trees per hectare include *Terminalia glaucesence* and *Terminalia laxiflorus*, *Isoberlina doka*, *Lophira alata*, *Combretum spp*., *Maytenus spp*., *Bridelia scleroneuroides*, *Grewia mollis*, *Piliostigma spp*. and *Hymenocardia acida*. (See Appendix 2 for list of tree species).

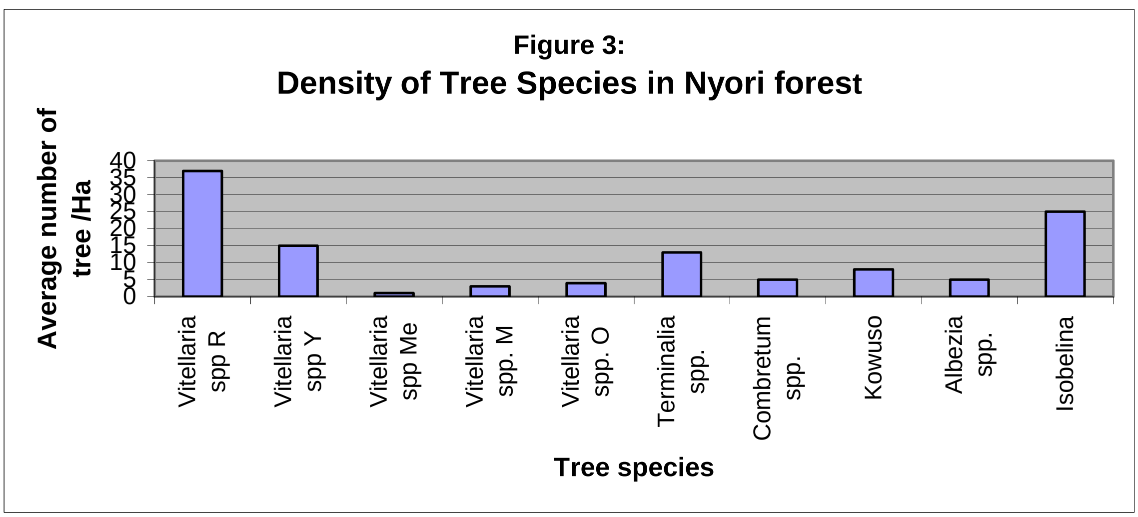
A careful study of some of the graphs shows that shea forest stands with high regenerations have fewer higher age group shea trees and vice-versa. The graphs present tree species ranging from five trees per hectare and above. Those below five trees per hectare are shown in Appendix 2. During the process of tree species tallying, the team could not identify some of the tree species botanically but their local names have been noted. The list of tree species can be found in Appendix 3.



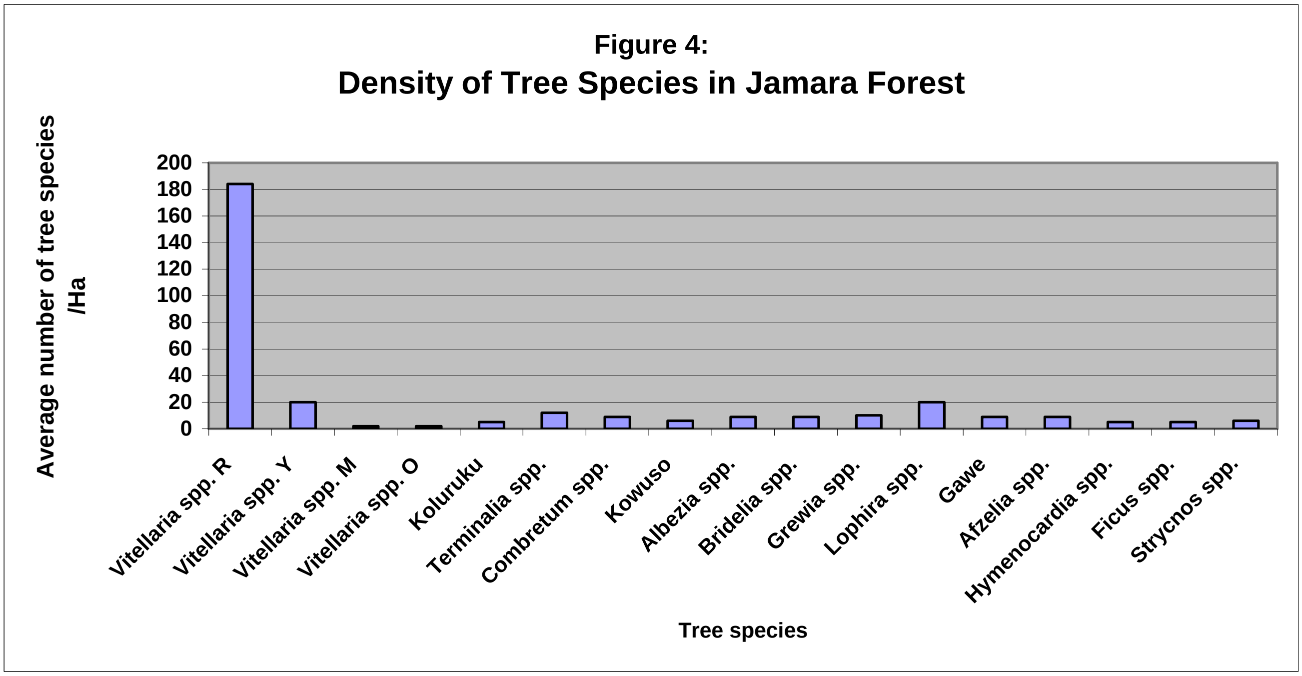
Goli shea forest has an area of 208.9 hectares and is located 31.5 kilometres west of Yei town. From Figure 1, the dominant tree species growing in association with shea include *Terminalia spp*. Gbare and *Combretum spp*. Sampled plots in this forest are covered by trees. The land is flat in topography with a few swampy areas. It is primarily used for forestry. The land is not damaged and the percentage crown cover of sampled plots in terms of tree density range from 11 – 50. The soil type in this forest can be described as sandy loam. Fallen leaves cover the forest floor.



Mbado shea forest has an area of 727.9 hectares and is located 61 kilometres west of Yei town. Figure 2 shows some of the tree species growing in association with shea. The most dominant tree species is *Isoberlina doka*, followed by shea. Sampled plots in this forest are covered with trees. The land is primarily used for forestry and grazing. The land is not damaged and the percentage crown cover in terms of tree density of sampled plots ranges from 31 – 50. The soil is mostly sandy loam and fallen leaves and grasses dominate the forest floor.



Nyori shea forest has an area of 7,675.8 hectares and is located 64 kilometres east of Yei town. In this forest, the dominant tree species, other than shea, include *Isoberlina doka* and *Terminalia spp*. The land is mostly covered with trees and its primary use is forestry, grazing and cultivation. The land is not damaged and the percentage crown cover in terms of tree density of sampled plots ranges from 1 – 40. The soil type in the forest is sandy loam. The forest floor is covered with fallen leaves and grass.



Jamara shea forest has an area of 76.8 hectares and is located 33 kilometres east of Yei town. As Figure 4 shows the dominant species after shea include *Lophira alata* and *Terminalia spp*. The land is primarily used for forestry. The land is not damaged and the percentage crown cover in terms of tree density of sampled plots ranges from 21 – 50. Sandy loam is the dominant soil type found in the forest. The forest floor is covered with grass, fallen leaves and litter.

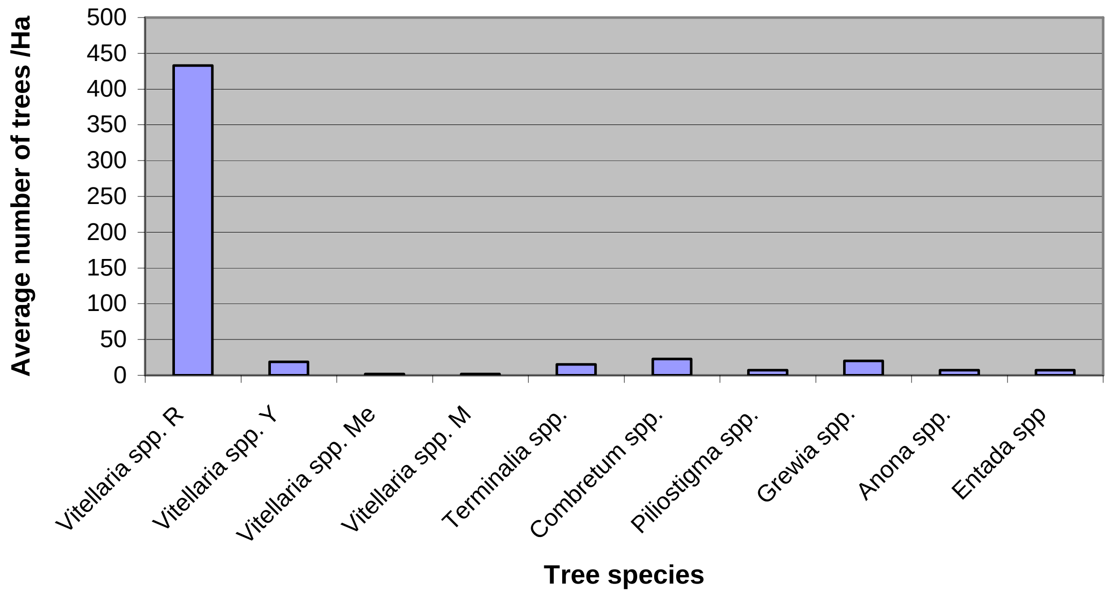
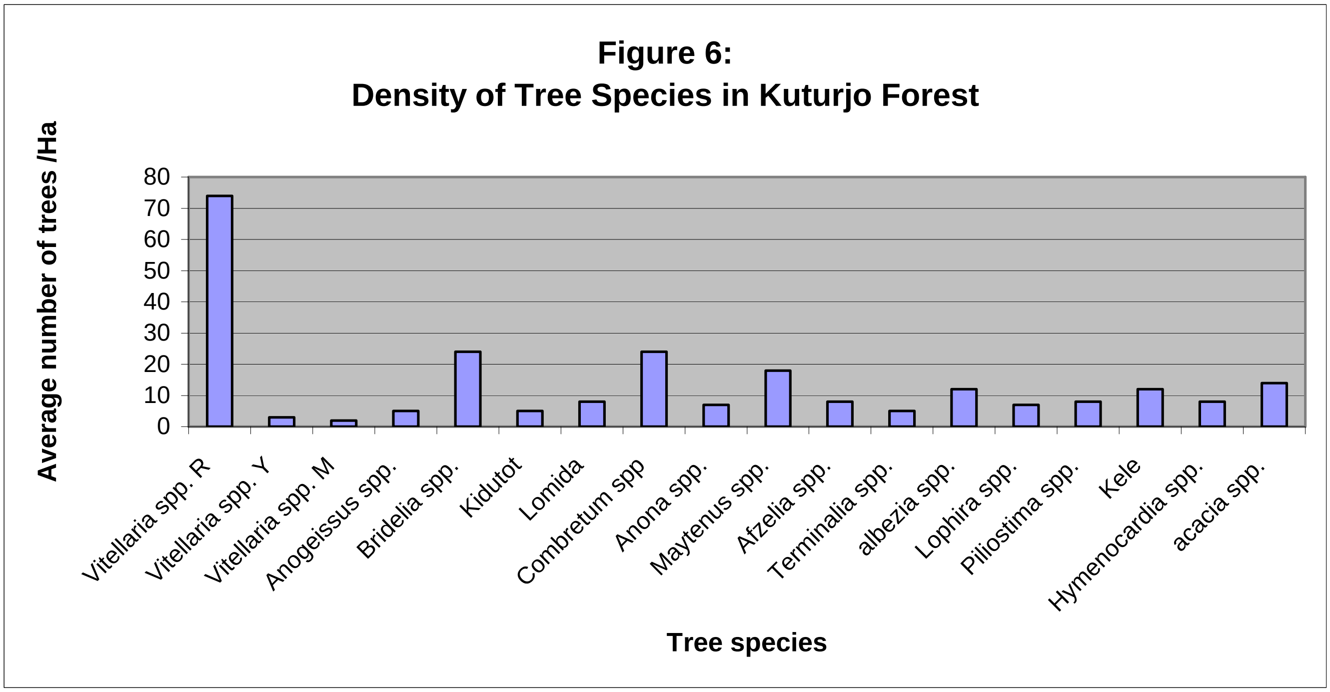
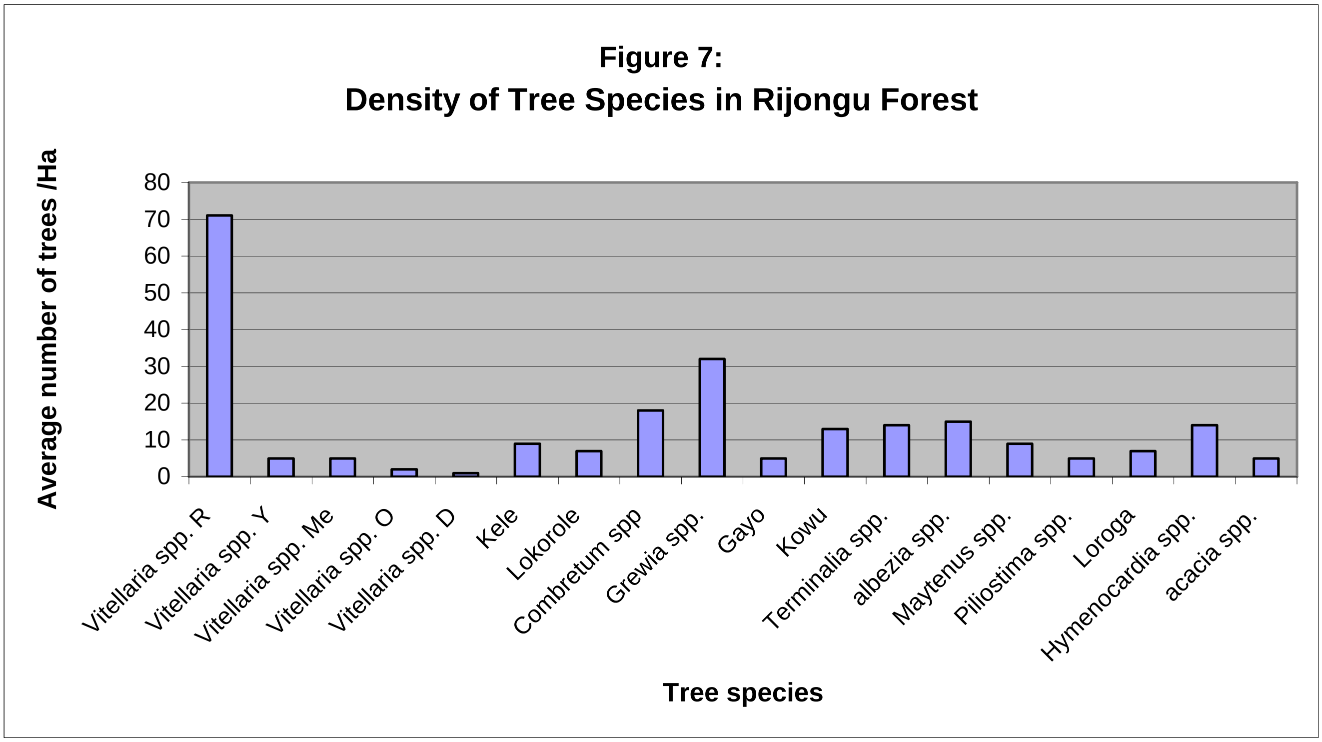


Figure 5:
Density of Tree Species in Kurilo Forest

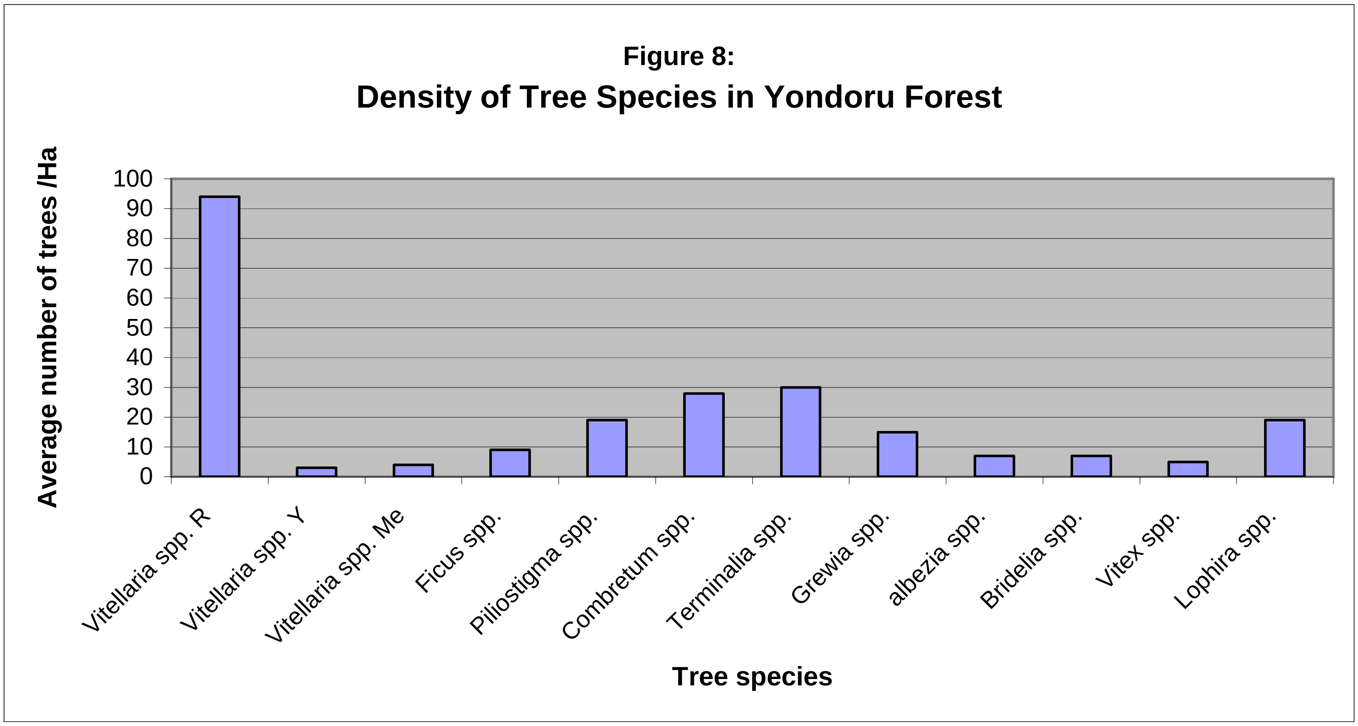
Kurilo shea forest has an area of 56.6 hectares and is located 40.5 kilometres north of Yei town. As Figure 5 shows *Combretum spp*. and *Grewia mollis* rank after shea in terms of tree density. Sampled plots in the forest are covered with trees. The land is primarily used for forestry and grazing. The land is not damaged and the percentage crown cover in terms of tree density of sampled plots ranges from 1 – 50. Sandy loam is the dominant soil type in the forest. Fallen leaves, litter, grass and rocks cover the forest ground.



Kuturjo shea forest has an area of 257.1 and is located 34 kilometres north of Yei town. Figure 6 shows that after shea, *Bridelia scleroneuroides* and *Combretum spp*. have the next highest densities in this forest. The sampled plots were covered with trees. The land is primarily used for forestry and grazing. The land is not damaged and the percentage crown cover in terms of tree density of sampled plots ranges from 21 – 40. Sandy loam is the dominant soil type in the forest. The forest floor is covered with litter, leaves and grass.

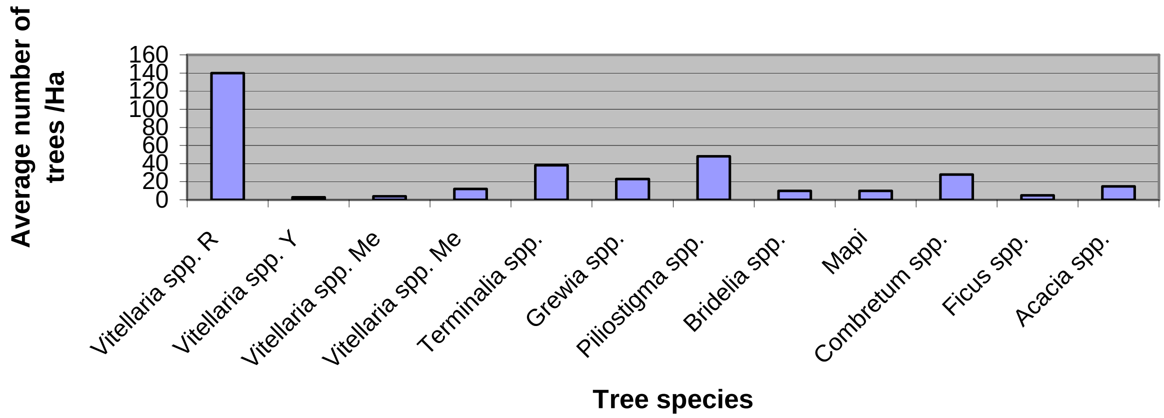


Rijongu shea forest has an area of 696.5 hectares and is located 48.8 north of Yei town. Figure 7 shows tree species with the high densities in the forest after shea; include *Grewia mollis*, *Combretum spp*. and *Albezia spp*. Most of the sampled plots in the forest are covered with trees and a few shrubs. The land is primarily used for forestry and cultivation. The land is not damaged and the percentage crown cover in terms of tree density of sampled plots ranges from 1 – 50. The dominant soil type in the forest is sandy loam. The forest floor is covered with rocks, litter, fallen leaves and grass.

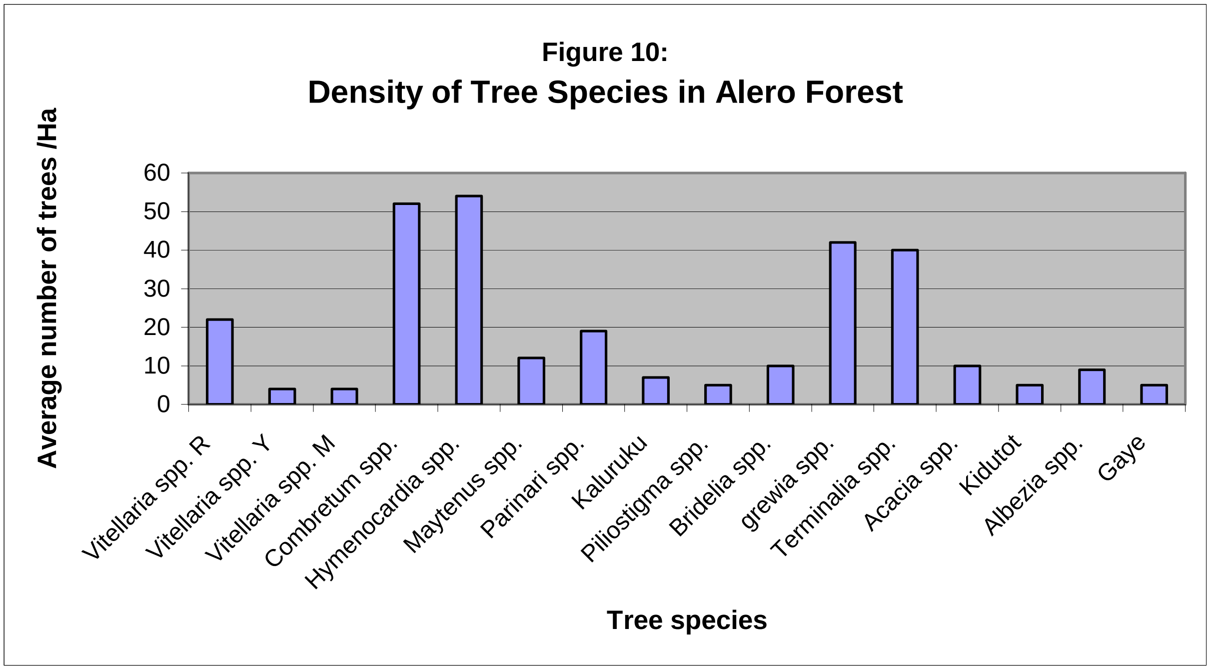


Yondoru shea forest has an area of 1,175.5 hectares and is located 27 kilometres north of Yei town. Here, tree species with higher densities after shea include *Terminalia spp*., *Combretum spp*., *Piliostigma thoningii* and *Lophira alata*. The sampled plots are covered with trees except one, which was covered with shrubs. The land is primary used for forestry, grazing and cultivation. The land is not damaged and the percentage crown cover in terms of tree density of sampled plots ranges from 21 – 40. Sandy loam is the dominant soil type in the forest. The forest floor is covered with grass, fallen leaves and litter.

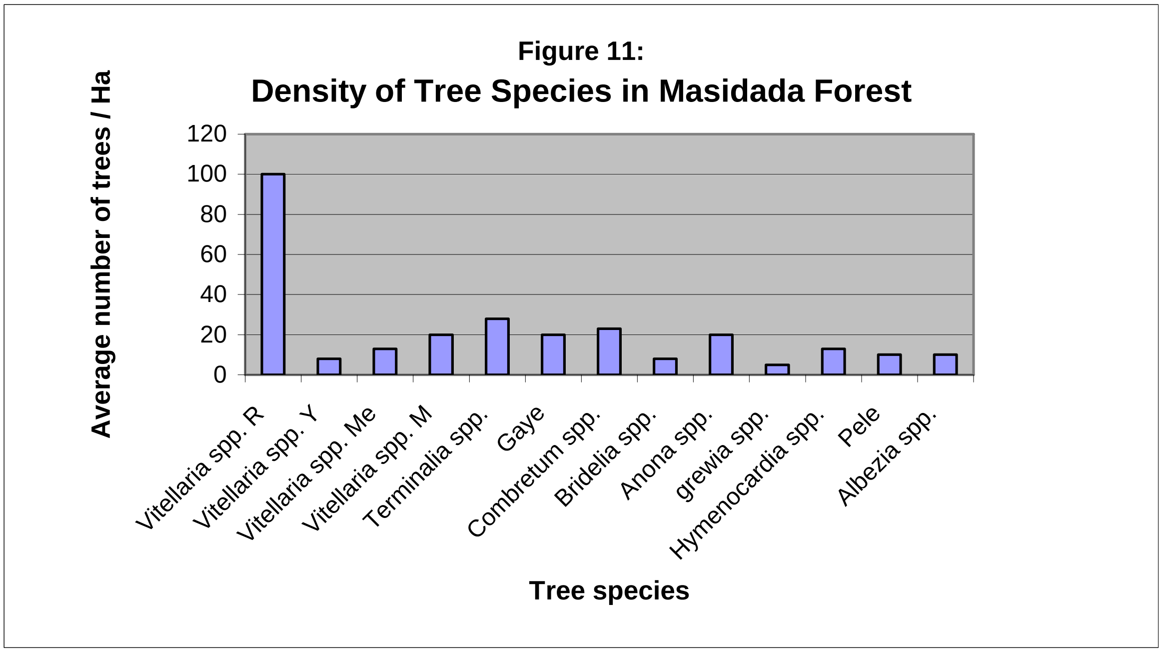
Figure 9:
Density of Tree Species in Logobero Forest



Logobero shea forest has an area of 377.9 hectares and is located 14 kilometres north of Yei town. Here, tree species with higher densities after shea include *Piliostigma thoningii*, *Terminalia spp*. *Combretum spp*. and *Grewia mollis*. Sampled plots in the forest are covered with trees. The land is primarily used for forestry grazing and cultivation. The land is not damaged and the percentage crown cover in terms of tree density of sampled plots ranges from 21 – 40. Sandy loam is the dominant soil type. The forest floor is covered with grass, fallen leaves and litter.



Alero shea forest has an area of 281.3 hectares and is located 10.2 kilometres southeast of Yei town. Some of the tree species with higher densities include *Hymenocardia acida*, *Combretum spp*., *Grewia mollis* and *Terminalia spp*. Sampled plots were covered with trees. The land is primarily used for forestry. The land is not damaged and the percentage crown cover in terms of tree density of sampled plots ranges from 31 – 50. Sandy loam is the dominant soil type in the forest. The forest floor is covered with grass, fallen leaves and litter.



Masidada shea forest has an area of 149.2 hectares and is located 69.5 kilometres west of Yei town. Some of the tree species with higher densities include *Terminalia spp*., Gaye, and *Anona senegalensis*. Sampled plots were covered with trees with exception of some areas which are covered with shrubs. The land is primarily used for forestry. The land is not damaged except that water erosion is starting to occur. The percentage crown cover in terms of tree density of sampled plots ranges from 31 – 50. Sandy loam is the dominant soil type in the forest. The forest floor is covered with fallen leaves and litter.

Climate, Vegetation and Soils of the Study Area

In Sudan, rainfall amounts increase as one moves southwards. The study area being in the extreme southwest is noted for its high rainfall with a mean annual rainfall ranging from 1,000 – 1,400 mm. Soil water deficit is available for nine to ten months alternating with a period of three to four dry months. Mean annual temperature is not more than 28°C. *Vitellaria paradoxa sub. spp nilotica* here occurs on fertile sandy loam that has an underlying laterite rock in some places.

Like rainfall, both soils and vegetation follow a similar pattern. The vegetation is denser (high woodland savannah) with the deeper soils in the south than in the north of the county. Shea tree populations are more uniform in the south than in the north of the county. In northern Yei County, shea trees occur as irregular patches distributed over a wide area.

The complex interaction of rainfall, vegetation and soil could explain the differences in stocking within the two zones. More rainfall and deeper soils in the north of Yei county encourages the establishment of more vigorous tree species which compete and grow in association with shea trees. Shea trees, however, thrive well in areas where competition is lowest. The southern portion of the county has less diverse vegetation. Therefore, shea trees have only a minimum of competition from other tree species in this area. The result is the occurrence of patchy natural stands in the north in contrast to the more uniformly distributed trees in the south.

The tree species, growing in association with shea trees, have an influence on both shea population distribution and its physical form. Among the tree species observed growing in association with shea trees, *Terminalia spp*., *Isoberlina doka*, *Combretum spp*., *Grewia spp*., and *Lophira alata* are more prominent. Of all the tree species growing in association with shea trees, *Isoberlina doka* has the most destructive effect on shea tree form. Shea trees growing together with *Isoberlina doka* are weak with smaller tree crowns and stem diameter. *Isoberlina doka* is especially noted for its formation of fairly large monoculture stands. *Lophira alata*, another tree which also produces oil, influences shea tree distribution while the other tree species appear to co-exist well with shea trees.

Overall Status of Shea Trees in the Study Area

In addition to natural factors, a number of artificial factors are known to interfere with shea tree distribution and form. These include hunting, farming, honey collection and charcoal production. Hunting and farming are among the human activities that inflict great damage as they both kill and distort the form of saplings and mature trees. At the start and end of the dry season hunters burn grasslands and forests to find their prey more easily and to encourage the growth of tender new grass. This tradition is responsible for the death and distortion of shea saplings. Trees subjected to regular fires are barely 10 – 15 m high and the development of saplings into trees is delayed or retarded.

Farming also damages regeneration albeit on a smaller scale than that inflicted by fire. Farmers, while digging or weeding, are likely to uproot saplings from the soil. Farmers also use fire to kill mature trees to relieve pressure on crops competing with shea trees. Uprooting and killing shea trees to minimise competition with crops and to allow space for mechanized ploughing was observed in Logobero. Even so, a number of trees remained on the farm.

Despite the negative impact, farmers appear to influence form and fruit yield positively. Taller trees, 15-20m, are more common in annually cultivated fields as compared with trees that are subject to regular fires which have heights of 10-15m. Fruit yield is also higher in trees on farms than in those annually subject to fire.

Charcoal production simply removes mature trees, but the activity is limited to a 10 km radius around the town centre. Alero and Logobero are among the most damaged areas due to their proximity to Yei town and charcoal dealers' preference for shea trees for high quality charcoal.

Honey collection inflicts little damage to shea trees except when the tree contains hives that are 3-4m above the ground. Such trees are typically cut down to reach the hive.

Honey located lower on the tree trunk is harvested without felling the tree, though considerable injury is inflicted on the tree as a hole is bored into the trunk of the tree.

During the mapping and inventory process for this study it was observed that in Goli and Yondoru a number of shea trees were felled to facilitate the collection of honey. In Kuturjo, Rijongu and Nyori farmers burned several shea trees when preparing land for subsistence farming.

Another factor that interferes with the healthy growth of shea trees is the parasitic mistletoe. The team observed that most of the shea trees, especially those found on homesteads, suffer from the parasite.

Customary Laws for Shea Trees in the Study Area

Communities in the study area observe a variety of customary laws related to the use of natural resources. However, no records of the laws are available for reference as they are verbally passed from one generation to another or learned by observation.

There is a sharp contrast between the customary laws governing the protection of shea trees and that for the use of other natural resources, for example water. In the case of water, fishing rights along a river are defined by partitioning the river into a number of sections, each of which is owned by a clan that is a part of the local community; water, therefore, is a communal property.

Like water, shea is a communal property, i.e., individuals of the community are entitled to collect and use shea products. Authority over forest stands, however, is vested with the chiefs, rainmakers or landlords who hail from particular clans. Bari speakers particularly have this type of organization. The community leaders claim an inherited ownership of the land and other valuable local resources from their ancestors. The duties of the community leaders are to sensitize communities on issues related to the protection of shea trees, to perform traditional and management functions such as blessing and early burning and to time the start of shea nut collection.

The customary law for the protection of shea trees forbids the killing or culling of trees at all times. This law is only observed up to a certain extent despite the existence of a limited law enforcement agency for it. According to community members, punishments range from a curse to imprisonment. It is said that a person who kills a shea tree can be cursed to vomit every time s/he eats shea oil. However, the greatest incentive to abide by the law appears to be the value the community attaches to shea trees. Thus, in most of the areas visited, farmers tolerate the presence of the trees on their farms. The reason given for not killing the trees, according to farmers, is that the trees do very little damage to field crops.

Deviation from the Shea Protection Customary Law in the Study Area

Despite a community's claim of strict observance of shea customary law, enormous evidence, indicating a serious erosion of certain aspects of the law, exists. There is less adherence to the decisions made by a community's traditional leaders and the laws protecting shea trees are not abided by, especially in dense shea stands. In the past, every household had the obligation of giving part of the shea nuts collected to the village chief, landlord or rainmaker in exchange for the traditional and management functions these leaders perform. This practice is being abandoned nowadays as young people, with little respect for village leaders, ignore their duty. At the moment payment to village leaders is made out of the tax levied on shea nuts buyers.

The admonishments handed down in accordance with customary law have the negative implication that an individual has the freedom of choice of abiding by the law or not. This also means that the community has little leverage in protecting natural resources from outsiders or insiders who intend to pursue a type of livelihood that is incompatible with the sustainability of the resource. This action, however, is often dictated by the availability of other better livelihoods or economic options.

Thus, under circumstances in which the need for other resources overrides the preservation of shea trees, decisions are made by both insiders and outsiders to destroy the trees. More lucrative and beneficial activities include the fuel wood trade, clearance for subsistence farming and honey collection.

Requirements for fuel wood and other wood products have put pressure on all trees in and near town centers. Both local and town entrepreneurs who claim that the shea tree produces high quality charcoal have subjected stands of shea and other tree species within 10 km radius of Yei town to indiscriminate cutting for charcoal production. In Alero, villagers say between 55 to100 shea trees have been removed along with many other tree species for charcoal production.

The decisions of farmers and town dwellers to destroy shea trees cannot, however, be regarded as completely destructive. It can be justified if one considers the economic return farmer gain for cutting down a tree in comparison to the benefit received when the tree is kept. Furthermore, in activities such as cultivation, the condition of the tree before death is not clear. Farmers may cull old unproductive trees on farms as a management strategy to maximize crops and shea nuts yielded on the farm. This might explain why farmers still retain some trees on their farms. Thus, the decision to destroy or protect shea trees is shaped by local economic considerations, and this requires that customary law be flexible.

Traditional Land Tenure Systems and Resource Ownership

In the areas visited during the shea mapping and inventory exercises there is a minimum of conflict with the state over land use. The possibility of unforeseen future inter-and

intra-communal conflicts cannot be ruled out. Disputes over the ownership of land and shea trees are for now contained by the lack of market opportunities for shea nuts and oil. Communities in the study area foresee conflicts between powerful individuals or groups in the event of an opening up of local and external markets for shea nuts and oil.
In areas where shea trees occur in large number, traditional land tenure is not clearly defined and all individuals in the community are entitled to collect shea nuts with the chiefs, rainmakers and landlords simply maintaining a supervisory role over the activity.

The traditional leaders claim an ancestral heritage of land and its resources which was acquired through token payment of cattle or some valuable objects to previous owners. But it is not clear whether other clans, with no hereditary leadership, still recognise this arrangement. With the realization of more lucrative economic benefits, chiefs, rainmakers and landlords may be tempted to reassert full control on shea stands; the immediate result is the marginalization of the rural poor who rely on free access to the shea trees and nuts. This may not be the case at settlements where ownership of the resource is clearly defined. On farms and homesteads, shea nuts belong to the home or farm owner. This right is extended to trees on previous settlements and farms. In both cases, harmony is maintained, and this gives the community as a whole a sense of ownership of the land and its resources.

Fruit/Nut Collection and Oil Processing in the Study Area

The customary law of the community endows every member with the right to collect shea fruits. Shea fruit is collected in April, May and June concurrently with farming activities carried out during the first cultivation season. Despite its seeming interference with cultivation, farmers value fruit collection, as during years of good shea fruit yield, the resource makes a significant contribution to farmers' food economy shortly after the start of rains. The fleshy shea fruit and the oil extracted from the dried kernels can be eaten.

Women and children are mainly involved in the collection of shea fruits. The collection process starts under trees that are growing beyond fields and fallows, in areas where competition from other collectors is the highest. Trees within family fields and fallows, where harvest ownership is guaranteed, are left until later. Uncultivated plots are open to all, while fallow plots, farms and homesteads belong to the owners.

Collection time ranges from a few hours to several days depending on the distance of trees from home. In the case of extremely distant trees, men become more involved by providing their wives with company and erecting shelters in the forest for the collection of fruits. In this case de-pulping and drying are done on the spot to avoid the burden of carrying heavy, moisture-laden fruits. This means that much of the fleshy fruit is wasted due to the difficulty of moving it over long distances. However, some women carry out preservation of the fruit, carefully peeled off the seed and dried. The preserved fruit is brought back home for the children to eat.

Shea Nut Collection per Household in the Study Area

An attempt was made during the PRA exercises to estimate the average quantity of fruit collected per household. As the exercise was carried out prior to the fruit collection season and fruit ripening, it is hard to ascertain the accuracy of the average quantities collected per household as the figures obtained were based on individual judgement. This is further complicated by the fact that the conversion of local units of measures (basins, buckets, sacks, *wenges*) into the standard units of measure such as the kilogram could not be relied upon. In addition, the condition of kernels in relation to their moisture content could not be absolutely clear, although effort was made to give villagers the impression that weight measures for dry and de-husked kernels were required.

Table 2 indicates that, of all the bomas visited, Lainya Boma has the highest average quantity of kernels collected per household, with 96 kg collected per household. The reason for high per household collection could be due to the observed abundance of shea trees within reasonable distances from settlements. Dimu 1, with the lowest average collected per household despite the availability of a sizable number of trees near the settlements, heavily relies on trees extremely far away. The collection time for these distant trees ranges from two weeks to one month. There is high competition for both fruit collection and farming with the result that shea nuts collection is poor.

Table 2. Collection of Shea Fruits per Household and Yield per Tree

Payam	**Boma**	**Quantity collected / HH in Kg (De-husked and dry kernels**	**Yield per tree in Kg**	
			Large crown	Small crown
Tore	Adio	60	32	-
Lainya	Kupera	60	-	-
Morobo	Panyume	60	26	18
Tore	Avokaya	36	-	-
Lainya	Dimu 1	16	-	-
Lainya	Lainya	96	32	-

De-husking and Preservation of Kernels in the Study Area

Children and/or old women mainly do de-husking. This task is accomplished by pounding the shea nut in a pestle and mortar and then cracking the nut between two stones after sun drying for a week or so. Villagers have expressed the need of taking precautionary measures to ensure that the kernel does not become spoiled. The appearance of black shoots, probably due to some kind of fungus, is a cause for concern among shea nut dealers. Women say kernels, infected in this way, have lower oil yields. Women’s groups involved in the manufacture of oil-related products place them in a Grade 3 category and use the oil pressed from this grade for manufacturing body lotion and soap.

In an attempt to prevent spoilage, villagers have devised a traditional strategy of putting kernels in a granary, specially made for them, and maintaining heat under the granary during periods of heavy rains. This measure has the effect of reducing the moisture content of kernels. Kernels, carefully preserved in this way, last in good condition for one year.

Shea Nut Grading in the Study Area

Depending on size and quality, there are three grades of shea nuts. Grade 1 or small nuts produce the most oil. However, despite this fact, farmers have made no effort to grade kernels or identify the shea trees bearing them. It is only in the women's groups that segregation of kernels into grades is practiced. Grade 2 nuts are larger and light brown in color and produce less oil than Grade 1. Grade 3 are kernels in which fungus had developed. While the preceding grades described above are in the state of dormancy, another important category of kernels is Grade 4, the germinating kernels. The claim by villagers that germinating nuts produce more oil than dormant ones could not be substantiated, although they have confirmed that the oil is bitter.

Oil Extraction

This is the final stage of the traditional shea industry. Preparation for extraction has marked contrast between the traditional oil extraction technique and the mechanical cold press technique introduced in women empowerment projects. In the latter, sun-dried kernels are pounded in pestle and mortar, ground and the resulting cake is cold pressed using mechanically operated hand-press. The traditional technique involves baking or roasting kernels in ashes or sand until the kernels become dark in color and glisten with oil. Care is taken to avoid charring as this greatly reduces the fat content. The roasted kernels are then pounded in a pestle and mortar and then ground on a special stone until a smooth black paste is formed. This black paste is mixed with boiling water and then continuously warmed and stirred until oil appears above the black suspension. The oil is then ladled out and the black paste known locally as *bibiyo* (*fajulu*) is disposed of after the oil extraction process is completed.

Problems Associated with Nut Collection and Oil Extraction

A number of problems have been cited by shea nut dealers as hampering the efficiency of nut collection and oil extraction. Difficulties encountered during nut collection influence both physical and emotional well-being. These include long distances from major shea stands, hunger, fear of renegade soldiers, the possibility of getting lost, the untimely occurrence of rains, snakes and biting insects. Time and maintenance of reasonable kernel quality are also of great concern to shea nut and fruit collectors. The competition between fruit collection and farming requires that time and labor be allocated for the two activities. Thus, as farming intensifies, less time and labor are set aside for shea nut and fruit collection.

The efficiency of the oil extraction process is also another cause for concern. Women have particularly complained of the cumbersome work undertaken during the oil extraction process as this involves pounding and grinding of kernels as well as boiling the paste.

Marketing of Shea Products

Both shea butter and kernels are marketed locally in Yei and Uganda. The condition of kernels in relation to water content during selling is advantageous to sellers, but puts buyers at a disadvantage on account of kernels weighing more than their weight when properly dried. Buyers are thus careful to pay for only well-dried kernels.

Prices of kernels vary depending on where they are sold. The average price for sale within Yei County of a kilogram of kernels is Ugandan shillings (Ushs) 400 (US$ 0.20) to Ushs 600/Kg (US$ 0.30). In Ugandan markets, which are mainly accessed by residents of Panyume, Kupera and Alero bomas, a kilogram of kernels costs Ushs 2,000 (US$ 1.00). Butter is sold in the liquid state for Ushs 2,000/liter.

Suggestions and Recommendations

1. Traditional forest management must be revived and supported in all shea tree stands in South Sudan.
2. The local communities in shea areas should be educated on the importance of shea trees.
3. Every shea forest must be protected from damage. Shea trees should not be damaged or destroyed for any reason, including more valuable economic alternatives such as the production of charcoal, collection of honey or the clearance of fields for crop production.
4. As part of community's common property management, parasitic plants growing on shea trees should be cut off as soon as they are observed. Left uncut, the parasite will lead to a decline in shea nut yield and, ultimately, lead to the death of the shea tree.
5. Bomas and/or payams with vast tracts of shea trees should be provided with shea nut grinding mills, presses and other necessary equipment for the production of shea butter. This will reduce the heavy workload currently experienced by women's groups which process shea butter. In addition, presses and other equipment help in the production of quality butter.
6. The productive capacity per shea tree and per hectare of mapped forests must be conducted to determine their economic viability.
7. Although there are other forest products upon which local communities are dependent, annual burning of shea tree stands should be controlled during given times to allow for regeneration. It could take five to fifteen years for saplings to develop resistance to the effects of fire.
8. Training forest extension personnel to assist local communities in the management of common property resources.

9. Investigate the economic potential of *Lophira alata* to determine its contribution to rural livelihoods.
10. *Isoberlina doka* is a timber species growing naturally and abundantly in the study area. It should be exploited to provide some income, which could be used for developing social amenities in the area.

Limitations Encountered

In this study, several constraints were encountered which could influence the results of the work. These include the following:

- In some locations, individuals from the community who were guiding the team had limited knowledge of the extent of shea forest stands.
- With virtually no payment, villagers are unwilling to show the team some shea forest stands. Normally, an individual would volunteer for one day and then reject a second trip the following day. Other members of the community, thereafter, also became unwilling when told about the harshness of the whole exercise by those who experienced it. The result was that forests that could have been surveyed and inventoried were not visited. This happened in Lainya and Nyori.
- Every survey and inventory exercise was cumbersome leaving team members so exhausted that early analysis of information collected could not be done. Similarly, the enormity of the task to be performed could influence the performance of the recorder and, therefore, the quality of information recorded.
- Due to limited time, logistics and poor road infrastructure, the team was unable to send word earlier to respondents. This influenced the type of respondents targeted for the participatory mapping and the focus group discussion tools employed in the research. In Nyori, a greater proportion of the respondents were composed of people who were not native to the area.
- Volunteers involved in the inventory mixed the local names of closely related tree species. In most cases, these tree species are given a blanket local name.

Conclusion

The shea mapping and inventory in Yei County was by and large successful although a few forest stands were not investigated due to limitations caused by lack of time, distance, poor road infrastructure and unwillingness of community members to guide the team to far away shea stands. The information gathered provides baseline data for stakeholders in the shea business upon which planning and development of the resource would be based. The information is expected to especially benefit the women's groups extracting oil from shea nuts in Yei County. However, the baseline data gathered is not enough, as it only reveals the stock quantity and not the productive capacity of the resource. Thus, there is a need to conduct productivity measurement of individual trees according to tree crown sizes per hectare during shea nut collection season if the resource is to become an economic base for rural communities in the area.

Appendix 1

Forest stand	Vitellaria paradoxa age group	Sample standard deviation /Ha	Population standard deviation/Ha
Goli	Regeneration/Sapling	179.0	160.0
	Young	10.0	9.0
	Medium	9.0	8.0
	Mature	6.5	6.0
	Old	2.5	2.0
Mbado	Regeneration/Sapling	66.5	59.5
	Young	29	26.0
	Medium	7.5	7.0
Nyori	Regeneration/Sapling	63.5	61.0
	Young	12.0	11.5
	Medium	2.0	2.0
	Mature	5.0	4.5
	Old	9.0	8.5
Jamara	Regeneration/Sapling	140.5	114.5
	Young	18	14.5
	Mature	3.0	2.5
	Old	3.0	2.5
Kurilo	Regeneration/Sapling	409.5	354.5
	Young	14.0	12.0
	Medium	2.5	2.0
	Mature	2.5	2.0
Kuturjo	Regeneration	108.5	94.0
	Young	3.0	2.5
	Mature	2.5	2.0
Rijongu	Regeneration/Sapling	69.0	64.5
	Medium	6.0	5.5
	Mature	4.0	4.0
	Old	2.5	2.5
	Dead	2.0	1.5
Yondoru	Regeneratio/sapling	126.5	109.5
	Medium	7.5	6.5
	Mature	3.0	2.5
Logobero	Regeneration/Sapling	216.0	187.0
	Young	3.0	2.5
	Medium	5.0	4.0
	Mature	13.0	11.5
Alero	Regeneration/Sapling	21.0	17.0
	Young	3.0	2.5
	Mature	3.0	2.5
Masidada	Regeneration/Sapling	106.0	75.0
	Young	10.5	7.5
	Medium	17.5	12.5
	Mature	21.0	15.0

Appendix 2

Name of forest	Botanical name	Local name	Density of trees per hectare
Goli	*Anona senegalensis*		1
	?	Zaziri	1
	?	Titawido	2
	Anogeissus leiocarpus		4
	Strycnos spinosa		2
	Lonchocarpus laxiflorus	Angboro	4
	?	Doma	2
	Vitex doniana		1
	?	Lorima	1
	?	Bondoni	1
Mbado			
	?	Madada	1
	Piliostigma spp.	Onzo	1
	?	Bandoni	2
	Anona senegalensis	?	2
	Lophira alata	Aliku, Liku	1
	Ximenia americana		4
	?	Banga	2
	Grewia mollis	Nzugu, Tire	2
	Ficus spp.	Pemve	3
	Tamarindus indica		1
	Zizyphus spp.	Puruti	1
	Acasia spp.	Macha, Reriaso	1
	Anogeissus leiocarpus	Nyangilo	1
Nyori			
	?	Bongotet	1
	Piliostigma spp.	Pepe	3
	Grewia mollis	Tire	4
	Bridelia scleroneuroides	Dini	3
	Vitex doniana	Konyukwi	2
	Entada abyssinica	Mokiok	2
	Acacia spp.	Reriaso	2
	Anogeissus leiocarpus	Nyangilo	1
	?	Kaloruku	2
	Maytenus spp.	Biliti, Kasarami	2
	Afzelia africana	Kulutet, Kidutot	2
	Anona senegalensis	Lomudi	2
	?	Lekebe	1
	Hymenocardia acida	Kiriryet	2
	?	Druba	2

	?	Kuji	1
	?	Gogi	2
	?	Gawe	2
	?	Pido	1
	?	Jeli	1
Jamara			
	?	Kili	4
	Piliostigma spp.	Pepe	2
	Maytenus spp.	Kasoromi	4
Kurilo			
	Albezia spp.	Kizikizik	4
	Sterculia setigera	Woriong	3
	?	Museru	3
	Afzelia africana	Bito, Bilingi	4
	?	Gawe	3
	Maytenus spp.	Biliti Kasoromi	4
	Hymenocardia acida	Kiriryet	2
	Acacia spp.	Reriaso, Ryanti	2
	Ficus spp.	Wotorot	3
	Anogeissus leiocarpus	Nyangilo	2
	Zizyphus spp.	Longi	3
	?	Kowu	3
	Ximenia americana	Lamat	2
	?	Lomida	2
Kuturjo			
	?	Gawe	4
	Ficus spp.	Kolungwi?	3
	?	Gwongoti lo tome	2
	Ximenia americana	Lamat	2
	?	Kowu	2
	Vitex doniana	Konyukwi	4
	?	Dungi	2
	?	Kidu	2
	?	Lukir	2
Rijongu			
	Anogeissus leiocarpus	Nyangilo	4
	Strycnos spinosa	Kulungwi	1
	Zizyphus spp.	Puruti	3
	Vitex doniana	Konyukwi	2
	Anona senegalensis	Lomudi	2
	Tamarindus indica	Kite	1
	Lophira alata	Liku	3
	Afzelia africana	Bito, Bilingi	2
	Khaya senegalensis	Kiruwot	2

Yondoru			
	?	Gaye	3
	Acacia spp.	Ryanti	4
	Parinari spp.		3
	Khaya senegalensis	Kiruwot	2
	Maytenus spp.	Kasoromi	2
	?	Julugwo	4
Logobero			
	Afzelia africana	Bito, Bilingi	2
	?	Lekebe	4
	?	Gaye	3
	?	Lorime, Bulutor	2
	?	Julugwo	2
	Albezia spp.	Montome, Jingili	3
	?	Kidutot	2
	Tectona grandis	Tiik	2
	Hymenocardia acida	Kiriryet	3
	Maytenus spp.	Biliti	3
	Strycnos spinosa	Moring na lotole	2
Alero			
	Vitex doniana	Konyukwi	4
	?	Ziga	2
	Zizyphus spp.	Puruti	2
	Ximenia americana	Mototi, Lamat	2
	Afzelia africana	Kebele	4
	Ficus spp.	Kolugwi?	4
	Lophira alata	Liku	2
Masidada			
	Piliostigma spp	Mara	3
	?	Mupi	3
	Acacia spp.	Asopa, Ryanti	3
	Lophira alata	Aliku, Liku	3
	?	Liba	3
	?	Aide, Koruluku	3

Appendix 3

Botanical and Local Names of Tree Species in the Study Area

Botanical name	**Local name**
Acacia spp.	Reriaso, Rianti (Kakwa), Macha, Asopa (Avukaya)
Afzelia africana	Bilingi, Bito (Pajulu?), Kebele (Kakwa), Kulutet, Kidutot (Bari?)
Albezia spp	Jingili,Adama, Girimi, Kizikizik, Morogonge (Kakwa) Ange (Makaraka), Nugili, Anyahuha (Avukaya)
Anona senegalensis	Lomudi (Kakwa), Omi (Avukaya)
Anogeissus leiocarpus	Kambilo, Nyangilo (Kakwa)
Bridelia scleroneuroides	Dini (Kakwa), Njugu (Avukaya)
Combretum spp.	Nyalibi, Lusuri, Gwogwe (Kakwa), Dakadia, Gbaza (Makaraka) Lipi, Nyalibi (Avukaya)
Entada abyssinica	Mokiok (Kakwa)
Ficus spp.	Loruki, Alisoro, Wotorot (Kakwa), Pemve (Avukaya)
Grewia mollis	Dini (Kakwa), Nzugu (Avukaya)
Hymenocardia acida	Kiriryet (Kakwa?), Likarago (Avukaya)
Isoberlina doka	Kovo (Kakwa? Avukaya)
Khaya senegalensis	Kiruwot (Kakwa)
Lonchocarpus laxiflorus	Angboro
Lophira alata	Liku (Kakwa), Aliku (Avukaya)
Maytenus spp.	Biliti, Kasarami (Kakwa)
Parinari spp.	Kele (Kakwa)
Piliostigma spp.	Pepe (Kakwa), Onzo (Avukaya)
Sterculia setigera	Woriongo (Kakwa)
Strycnos spinosa	Kulungwi (Kakwa)
Tamarindus indica	Kite
Tectona grandis	Tiik
Terminalia spp	Kobe, Loso, Kurila (Bari), Bokaiko, Bazerenga (Makaraka), Lokwo (Avukaya)
Vitellaria paradoxa ssp nilotica	Kumuri (Kakwa, Bari), Kpakari (Makaraka), Awa (Avukaya)
Vitex doniana	Konyukwi (Kakwa)
Ximenia Americana	Lamat (Bari), Mototi (Kakwa)
Zizyphus spp.	Longi (Kakwa), Puruti (Avukaya?)
?	Zaziri (Makaraka)
?	Titawido (Makaraka)
?	Gayo (Kakwa), Gbare (Makaraka)
?	Doma (Makaraka)
?	Lorima (Makaraka)
?	Bondoni (Makaraka)
?	Madada (Makaraka)

?	Aliku (Avukaya)
?	Kurukuru (Avukaya)
?	Banga (Avukaya?)
?	Bongotet (Kakwa)
?	Kowuso (Kakwa)
?	Lekebe (Kakwa), Pele (Avukaya)
?	Druba (Kakwa)
?	Kuji (Kakwa)
?	Gogi (Kakwa)
?	Gawe (Kakwa)
?	Pido (Kakwa)
?	Jeli (Kakwa)
?	Koluruku (Kakwa), Aide (Avukaya)
?	Kili (Kakwa)
?	Museru (Kakwa)
?	Lomida, Lokorole (Kakwa)
?	Gwogwoti lo tome (Kakwa)
?	Dungi (Kakwa)
?	Kidu (Kakwa)
?	Lukir kakwa)
?	Loroga (Kakwa)
?	Julugwo (Kakwa)
?	Mapi (Pajulu?)
?	Moring na lotole (Pajulu?)
?	Ziga (Kakwa)
?	Mupi (Avukaya)
?	Liba (Avukaya)

Appendix 4

Mbado forest

Station (waypoint	**Azimuth**		**Distance (Km)**	**Coordinates**
A	30°	210°		004° 31' 697'' N 030° 25' 432'' E
			4.01	
B	185°	005°		004° 31' 524'' N 030° 25' 418'' E
			0.32	
C	88°	268°		004° 31' 536'' N 030° 25' 723'' E
			0.56	
D	47°	207°		004° 33' 582'' N 030° 26' 628'' E
			3.73	
E	335°	155°		004° 33' 587'' N 030° 26' 517'' E
			0.48	
A	30°	210°		004° 31'697'' N 030° 25'432'' E

Nyori forest

Station (Waypoint)	**Azimuth**		**Distance (Km)**	**Coordinates**
A	226°	046°		003° 52' 033'' N 031° 01' 146'' E
			11.4	
B	42°	222°		003° 52' 134'' N 031° 01' 236''
			0.25	
C	143°	323°		003° 49' 324'' N 031° 03' 342'' E
			6.48	
D	248°	068°		003° 46' 843'' N 030° 57' 074'' E
			12.5	
E	340°	160°		003° 47' 771'' N 030° 56' 741'' E
			1.82	
A	226°	046°		003° 52' 033'' N 031° 01' 146'' E

Jamara forest

Station (waypoint	**Azimuth**		**Distance (Km)**	**Coordinates**
A	257°	077°		004° 02’ 581’’ N 030° 58’ 294’’ E
			1.44	
B	138°	318°		004° 02’ 370’’ N 030° 58’ 484’’ E
			0.53	
C	202°	022°		004° 02’ 113’’ N 030° 58’ 382’’ E
			0.51	
D	299°	109°		004° 02’ 403’’ N 030° 57’ 536’’
			1.65	
A	257°	077°		004° 02’581’’ N 030° 58’294’’ E

Kurilo forest

Station (waypoint	**Azimuth**		**Distance (Km)**	**Coordinates**
A	356°	176°		004° 20’ 104’’ N 031° 05’ 867’’ E
			0.51	
B	308°	028°		004° 20’ 028’’ N 031° 05’ 827’’ E
			0.16	
C	160°	340°		004° 19’ 778’’ N 031° 05’ 920’’ E
			0.49	
D	84°	264°		004° 19’ 802’’ N 031° 06’ 149’’ E
			0.43	
E	50°	230°		004° 19’ 943’’ N 031° 06’ 316’’ E
			0.41	
F	325°	145°		004° 20’ 374’’ N 031° 06’ 019’’ E
			0.97	
A	356°	176°		004° 20’ 104’’ N 031° 05’ 867”

Kuturjo forest

Station (waypoint	Azimuth		Distance (Km)	Coordinates
A	134°	314°		004° 20' 847" N 031° 03' 025" E
			0.87	
B	333°	153°		004° 21' 503" N 031° 02' 698" E
			1.35	
C	053°	233°		004° 21' 777" N 031° 03' 044" E
			0.82	
D	091°	271°		004° 21' 766" 031° 03' 483" E
			0.81	
E	172°	352°		004° 20' 700" N 031° 03' 628" E
			1.98	
F	235°	055°		004° 20' 5162 N 031° 03' 363" E
			0.60	
A	134°	314°		004° 20' 847" N 031° 03' 025" E

Yondoru forest

Station (waypoint	Azimuth		Distance (Km)	Coordinates
A	120°	300°		004° 13' 371" N 030° 45' 687" E
			2.02	
B	110°	290°		004° 13' 667" N 030° 45'332" E
			0.85	
C	223°	043°		004° 12' 326" N 030° 44' 071" E
			3.40	
D	147°	327°		004° 10' 938" N 030° 44' 966" E
			3.05	
E	042°	222°		004° 12' 828" N 030° 46' 828" E
			4.66	
A	120°	300°		004° 13' 371" N 030° 45' 687" E

Logobero forest

Station (waypoint	Azimuth		Distance (Km)	Coordinates
A	035°	205°		004° 11’ 929” N 030° 41’ 027” E
			1.38	
B	191°	011°		004° 11’ 769” N 030° 40’ 983” E
			0.41	
C	120°	300°		004° 11’ 367” N 030° 41’ 567” E
			1.25	
D	080°	260°		004° 11’ 502” N 030° 42’ 288” E
			1.36	
E	170°	350°		004° 12’ 494” N 030° 42’ 108” E
			1.86	
F	128°	308°		004° 12’ 723” N 030° 41’ 817” E
			0.68	
G	257°	077°		004° 12’ 609” N 030° 41’ 341” E
			0.91	
A	035°	205°		004° 11’ 929” N 030° 41’ 027” E

Rijongu forest

Station (waypoint	Azimuth		Distance (Km)	Coordinates
A	127°	307°		004° 19’ 807” N 030° 57’ 946” E
			2.43	
B	188°	368°		004° 20’ 586” N 030° 58’ 054” E
			1.45	
C	083°	263°		004° 20’ 742” N 030° 59’ 4132 E
			2.53	
D	155°	335°		004°20’ 203” N 030° 39’ 664” E
			1.10	
E	202°	022°		004° 19’ 203” N 030° 59’ 272” E
			1.97	
F	235°	055°		004° 19’ 009” N 030° 58’ 988” E
			0.64	
A	127°	307°		004° 19’ 807” N 030° 57’ 946” E

Alero forest

Station (waypoint	Azimuth		Distance (Km)	Coordinates
A	244°	064°		004° 00’ 532” N 030° 45’ 987” E
			3.08	
B	309°	129°		004° 00’ 079” N 030° 46’ 551” E
			1.33	
C	015°	195°		003° 59’ 573” N 030° 46’ 417” E
			0.96	
D	058°	238°		003° 59’ 203” N 030° 45’ 836” E
			1.27	
E	105°	285°		003° 59’ 496” N 030° 44’ 7202 E
			2.14	
F	142°	322°		003° 59’ 786” N 030° 44’ 495” E
			0.68	
A	244°	064°		004° 00’ 532” N 030° 45’ 987” E

Goli forest

Station (waypoint	Azimuth		Distance (Km)	Coordinates
A	377°	197°		004° 17’ N 030° 28’ E
			0.76	
B	234°	054°		004° 17’ N 030° 28’ E
			1.93	
C	147°	327°		004° 17’ 220” N 030° 26’ 751” E
			0.82	
D	222°	042°		004° 17’ 748” N 030° 27’ 184” E
			1.30	
E	289°	369°		004° 17’ 474” N 030° 27’ 184” E
			1.46	
F	012°	192°		004° 17’ 567” N 030° 28’ 138” E
			0.4	
A	377°	197°		004° 17’ 468” N 030° 28’ 262” E

Masidada forest

Station (waypoint	**Azimuth**		**Distance (Km)**	**Coordinates**
A	127°	307°		004° 25’ 241” N 030° 16’ 704” E
			0.36	
B	117°	297°		004° 25’361” N 030° 15’ 472” E
			0.48	
C	060°	240°		004° 25’ 486” N 030° 15’ 685” E
			0.46	
D	135°	315°		004° 25’ 245” N 030° 15’ 923” E
			0.63	
E	206°	026°		004° 25’ 124” N 030° 15’ 861” E
			0.25	
A	127°	307°		004° 25’ 241” N 030° 16’ 704” E