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Contribution of Participatory Forest Management Program in Non-Timber Forest Products to balance Livelihood Improvement and Conservation: a case of Sera Forest, Amigna District, Southern Ethiopia

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ABSTRACT

Non-Timber Forest Products (NTFPs) have a significant role as a local source of medicine, fiber, forage, and sustenance and offer income opportunities mainly in rural families. As sustainable use of NTFPs is imperative to provide ecosystem services and biological resources, this study focused on the identification and documentation of plant species used for NTFPs, their availability, and conservation status in Sera Forest, Oromia Regional State, Ethiopia. The study applied a combination of plant ecological and ethnobotanical methods. Ethnobotanical data were gathered through semi-structured questionnaires and interviews which involved 206 randomly sampled general and 24 purposively selected key informants, group discussions, guided field walks, and market surveys. Data were analyzed and presented using analytical methods of ethnobotany, including descriptive statistics, informant consensus factor (ICF), and ranking. Species diversity, richness, and evenness were also computed using Shannon–Wiener diversity indices. A total of 137 plant species belonging to 49 families used as a source of NTFPs were documented from the study area. Eleven major use categories of the NTFPs were identified. Out of these, medicine, firewood, charcoal making, and construction materials were the most dominant uses requiring large volumes of NTFPs. Direct matrix ranking of plant species with multipurpose use revealed, that Hagenia abyssinica was ranked highest, followed by Olea europaea ssp cuspidata, Grewia mollis, Croton macrostachyus, Ximenia americana and Carissa spinarum. Local communities of the study area possess rich indigenous knowledge in the regulation of grazing and extraction of forest products, forest patrolling, firebreak clearance and maintenance, selective preservation of tree species and nursery activities focused on the restoration of indigenous woody species, which all help in using their natural resources for sustainable livelihood. Sera forest is rich in NTFP-bearing plants and associated indigenous conservation knowledge. However, nowadays illegal timber extraction, grazing, over-harvesting of NTFPs, farm expansion, and fire hazards are found to be threatening the plant resources, irrespective of the Participatory Forest Management (PFM) principles. Therefore, it is important to have strong evaluation and monitoring mechanisms for setting harvesting quantities and regulating types of collection. Besides developing a sense of ownership and responsibility, integrating their traditional forest management practices with modern conservation approaches is desirable for higher livelihood outcomes with lower environmental impacts.

Keywords: Biodiversity, Conservation status, Ethnobotany, Indigenous knowledge, Over-harvesting, PFM, Ethiopia.

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1. INTRODUCTION

Ethiopia has a rich biodiversity of plant and animal species that occur in variable and unique ecosystems in both domesticated and wild forms (FAO, 1996). Even though most of this biodiversity is in common with other countries, some species are endemic to the country (FAO, 1996; NBSAP, 2005). There are about 6,000 species of higher plants, of which about 10% are endemic (Vivero et al., 2006). Forests are the most important storehouses of terrestrial biological diversity, especially in the case of tropical forests (Vivero et al., 2006). Besides their environmental services, forests provide a wide range of goods and services to the human society and play a vital role for a sustainable livelihood of the indigenous community, through production of different commodities and services (Vivero et al., 2006; FAO, 2018; Ibrahim et al., 2016). Besides timber, forests have in recent years been increasingly recognized as a rich reservoir of many valuable biological resources, called non-timber forest products (NTFPs) (Ibrahim et al., 2016; Kusters et al., 2006). The term 'Non-Timber Forest Products' applies to any biological resources, other than timber and timber-related products, extracted from the wild for direct consumption or income generation on a small scale (Shackleton et al., 2011). Over the last two decades, NTFPs have been recognized and appreciated in both the research and policy sectors to promote forest conservation and community development, assuming that they can be used sustainably without harming other flora and fauna (Sharma et al., 2016).

Worldwide, an estimated 1.6 billion people, mostly in developing countries, depend on NTFPs as their primary sources of income, food, nutrition, and medicine (Khakhlary and Sharma, 2017; Bayesa and Bushara, 2022; Tambi and Kengah, 2018). In Africa, NTFPs are still substantial sources of livelihood sustenance (Tambi and Kengah, 2018). Many people living in or near forest reserves gather a wide range of commercially important forest products, including gums and resins, fruits, medicinal and aromatic plants, and bamboo. These products are critical to the existence of rural communities and account for a considerable portion of household revenue (Bayesa and Bushara, 2022; Tambi and Kengah, 2018). As for Ethiopia, most rural communities and a large proportion of urban households depend on NTFPs to meet some parts of their needs for nutrition, health, construction, energy, cultural activities, and income generation (Lemenih et al., 2003; Mamo et al., 2007; Mekonnen et al., 2013; Kidane and Kejela, 2021). For instance, over 80% of the population of Ethiopia depends on herbal medicines for their primary health care, while over 90% of the rural community depends on fuelwood (firewood and charcoal) for their energy demand (EFAP, 1994; Vivero, 2002).

Despite the significance of these products, nowadays, both biodiversity and natural forests are being lost at an alarming rate due to anthropogenic pressure, which poses a risk to the provision of ecosystem services and biological resources (Kidane and Kejela, 2021; Kidane et al., 2018a; Meinhold et al., 2022). In addition, unsustainable use of NTFPs may have an impact on the ecological organization, from individual organisms to the ecosystem level (Meinhold et al., 2022; Kusters et al., 2006; Tambi and Kengah, 2018; Peters, 1994; Ticktin, 2004; Gouwakinnou et al., 2019). To ensure the sustainability of forest resources and proper management of the natural forests, understanding the ecology and physiology of plant species as well as the plant-human relations is essential (Tambi and Kengah, 2018; Kidane et al., 2018a). Furthermore, understanding spatial distribution patterns, seasons of availability and regeneration status of NTFPs are important for creating, educating, and enforcing conservation regulations that facilitate development with minimum environmental impact (Meinhold et al., 2022; Ndah et al., 2013).

Due to its diverse ecosystems and rich biodiversity, Ethiopia is endowed with a rich flora of NTFPs. The benefits of these products have been enduring and playing great roles in the lives of people, particularly those of rural communities in the country (Mekonnen et al., 2013). However, there is a lack of adequate scientific investigation related to NTFPs, and very few studies have been conducted on the documentation and quantification of the diversity and other ecological aspects of these resources in the natural forests (Lemenih et al., 2003; Melese, 2016; Abdulla, 2013).

Sera Forest in Oromia Regional State is ecologically, socially, and economically very important for the inhabitants who are dependent on forest products to make their living. Local communities use this forest for different purposes both for timber and for NTFPs, such as animal fodder, generation of cash income, fuelwood, herbal medicine, farm implements, and many other NTFPs. However, there is a risk of overutilization of NTFPs, especially over-harvesting for firewood and selective cutting of trees for commercial use and construction purposes. The collection, use and commercialization of NTFPs need to be sustainable, as it is the main driver in the promotion of NTFPs for community development, poverty reduction, livelihood improvement and sustainable forest management (Mamo et al., 2007; Melese, 2016; Dessalegn and Tadesse, 2004; Asfaw and Etefa, 2017). Hence, a PFM program was introduced in the study area in 1997, jointly by the community and local government management bodies. It is still active and has the strategy to arrest forest degradation and to meet the livelihood needs of the local community. Except a pre-print note by Kidane and Balke (2020), there is, however, insufficient scientific documentation about these resources particularly on species-specific information on distribution and availability, their potential use, market frontiers and their conservation status. Therefore, the purpose of the present study is to investigate the diversity of NTFPs, plant species bearing them and their conservation status and sustainability for future generations in Sera Forest.

In this study, we asked: (i) What are the major types of NTFPs harvested in Sera Forest by the community having PFM program introduced? (ii) Which plant species are used as a source of NTFPs by the households living in and around the forest? (iii) Which ways of harvesting cause the major threats to the plant species in the forest? (iv) What should be the appropriate actions for sustainable use and conservation of plant species in the forest?

2. Materials and Methods

2.1. Description of the Study Area

This study was carried out in Sera Forest in Amigna District, East Arsi Zone of Oromia Regional State (Fig 1). It is located 142 km East of Addis Ababa and 80 km from Asella town. The forest lies within the range of latitudes $7^0$59’16.1’’ to $7^0$59’50.8’’ N and longitudes $39^0$22’45.50’’ to $39^0$23’15.8’’E.

Amigna district is characterized by rough topographic features. It has gorges, and plateaus. The altitudinal range of the district falls within 500 - 2,467m a.s.l. The altitudinal range of Sera is 1895 and 1978m a.s.l. Elele Chefa and Elele Achena kebeles are part of the study sites. Elele Chefa kebele is between 1845 and 1968 m a.s.l. and Elele Achena kebele is, between 1855 and 1948m a.s.l. Sera is on sloping land. The forest vegetation is on the north and northwest facing parts of the escarpment (ARDOAD, 2017). The climate of Amigna district is within the Weina Dega (middle land, 1,500-2,300m a.s.l.) and Kolla (lowland, 500-1,500m a.s.l.) agro-ecological zones of Ethiopia (Bekele-Tesemma et al., 1993). As most parts of the district are found in the low land, the mean annual temperature differs from 20^0C to 25^0C. It obtains high rainfall about 1,300mm between May and September; and low rainfall about 250mm from December to February (ARDOAD, 2017).

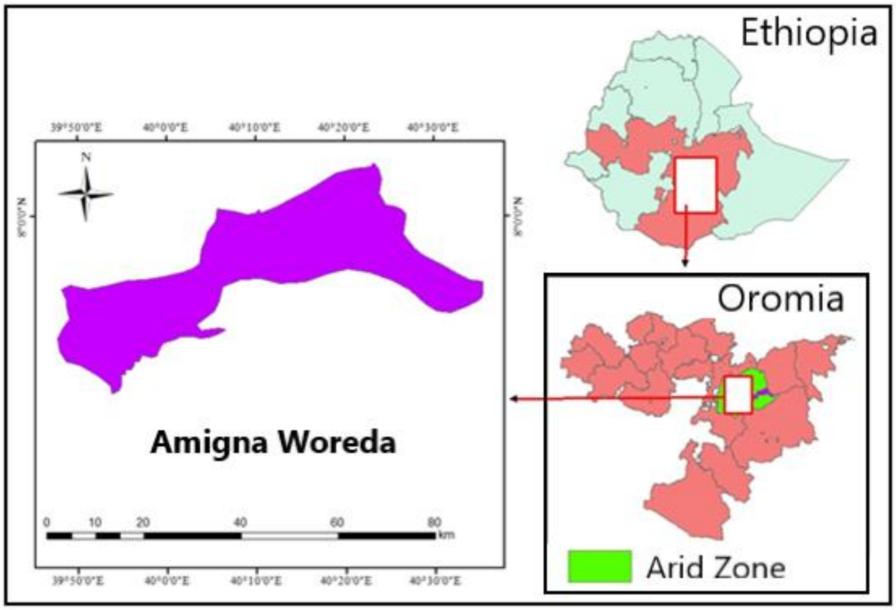

Figure 1. Map of the study area, Amigna Woreda (District).

Most of the land currently degraded in the district was probably once covered with forest (ARDOAD, 2017). Today, few remnants of big trees are observed in the farmlands and roadsides. For example, trees like *Ficus vasta*, *Albizia schimperiana*, *Cordia africana*, *Ficus sycomorus, Prunus africana, Croton macrostachyus, Olea europaea* ssp. *cuspidata* and *Ficus sur* are observed in the farmlands and on roadsides. The presence of these trees is a sign that the tree cover of the district was denser in the past (ARDOAD, 2017).

However, there are still some areas of woodlands and forests found beside Sera Forest, particularly Lotu (7 ha), Jidda (11 ha), Roka (10 ha), Gurati (15 ha), Hallo (5 ha) and Karraa (10 ha). They are separated by settlements and mainly restricted to slopes of escarpments (ARDOAD, 2017). This indicates that most of the vegetation of the woodlands and forests has been removed from areas that are suitable for agricultural expansion.

According to the data obtained from Amigna District Statistical Agency (ADSA, 2022), currently the total population of Amigna district is 107,834 of which 54,165 (50.23%) are men and 53,669 (49.77%) are women. Of the total population, 11,452 (10.62%) live in urban areas. Of these, 5,924 (51.73 %) are men and 5,528 (48.27%) are women. The remaining 96,382 (89.38%) people are rural of which 48,663 (50.49%) are men and 47,719 (49.51%) are women.

2.2. Research Design

2.2.1. Reconnaissance Survey and Site Selection

A reconnaissance survey of the study area was conducted during October 2018 to obtain baseline information. Sampling sites were identified to establish a household selection for data collection. Sera forest was selected due to its natural endowments that attract scientists and researchers. The study primarily focuses on the parts of Sera Forest, which are currently under the process of a Participatory Forest Management (PFM) program (ARDOAD, 2017).

Among the 16 kebeles in Amigna District the PFM scheme is being implemented in two kebeles (Elele Chefa and Elele Achena). There are five Forest User Groups (FUGs) formed in the two kebeles under the process of implementing PFM. Out of these, three FUGs were purposely selected for this study. These are Sera FUGs and Arbogne from Elele Chefa kebele, and Achena FUGs from Elele Achena kebele. The selection of these three FUGs was based on forest density and forest coverage in the area, the proximity of households to the forest, the distance they take from marketplaces and the accessibility and convenience of collecting data.

2.3. Ethnobotanical Data Collection

2.3.1. Sample Size Determination and Selection of Informants

Martin (1995) noted that the number of informants required for an ethnobotanical study depends on the size of the domain. Hence, the required representative sample size for collecting ethnobotanical data for this research was determined using Cochran's (1977) formula as follows:

$$\text{n} = \frac{N}{1 + N(e)^{2}}$$

Where, n = required sample size of the research,
N= total number of households in all three Forest User Groups,
e= maximum variability or margin of error 5% (0.05),
1= the probability of the event occurring.

The total number of members (households) in the three FUGs are, 425 (Arbogne =121, Sera =145, Achena =159). Accordingly, the total sample size required from all sample sites is 206 (Table 1). The sample size required for each FUG was calculated using its proportion of the number of households (HH):

$$\text{Informants from each FUGs} = \frac{Number\ of\ HH\ of\ the\ FUGs\ X\ Total\ number\ of\ informants}{\text{Total Number of HH}}$$

Table 1. Number of informants selected from the three Forest User Groups.

Kebele	***Forest User Groups***	***Total members***	***General informants***			***Key informants***		
			Male	***Female***	***Total***	***Male***	***Female***	***Total***
Elele Chefa	Arbogne	121	39	20	59	5	3	8
	Sera	145	45	25	70	6	2	8
Elele Achena	Achena	159	57	20	77	7	1	8
	Total	425	141	65	**206**	18	6	**24**

Informants for data collection of this study include men and women in different age groups (aged ≥20) from each household. Systematic sampling was used to identify respondents for interview. Informants were selected following Martin (1995). In addition to the 206 general informants, 24 key informants (8 from each FUG) were selected. These include knowledgeable and/or elderly residents, group leaders, plant collectors and traditional healers which were purposively selected by FUG leaders.

2.3.2. Ethnobotanical Data Collection Technique

2.3.2.1. Ethical Considerations

Ethical approvals were given by Mekelle University and Amigna district Administration offices, prior to the data collection. To develop a positive mindset between informants and the researcher, the objectives and significance of the study were introduced to the local officials and to the community. After they understood the objectives and value of the research, all data were collected through their consent. Thus, ethnobotanical data were collected based on a comprehensive participation, friendly interactions, and the willingness of informants.

2.3.2.2. Semi-structured Interviews

Semi-structured interviews as described by Martin (1995); Cotton (1996); and Cunningham (2001), were conducted. The schedule of the interviews was arranged beforehand, and adequate questions were prepared (see Appendix 1, Supplementary Material) and translated to the community's language (Afaan Oromo). The prepared questions were used to guide data collection, and other questions rose during the conversation. The interviews were conducted in the areas where the informants were most comfortable and during the time they wanted, in an informal and conversational way but carefully controlled. Each individual informant was interviewed directly by the researcher in a face-to-face session.

The main objective of the interviews was to determine the types of NTFPs utilized in the study area, their source of plant species, habits of harvesting, major threats, and conservation status. The informants were asked both about their general background and for ethnobotanical information according to predetermined questions and topics. Some key and volunteer informants were used to list the diversity of NTFPs in the study area before interviewing the general informants. This list includes types of NTFPs in local names, plant species used, part of plant used, threats on NTFPs producing plant species and their conservation practices.

The eight key informants from each FUG were interviewed to obtain relevant supportive data (Huntington, 2000) and for a listing exercise of each NTFP in the study area. The data obtained from general informants were confirmed by key informants using analytical tools of ethnobotany.

2.3.2.3. Group Discussion

Five focus group discussions consisting of six to eight individuals in each group were conducted in each FUG to confirm the data collected through the semi-structured interviews as recommended by Alexiades (1996). The discussion was focused on availability of the resource base of NTFPs, experience of local people with tree planting and cultivation, the main threats to the forest, constraints and opportunities to promotion and protection of NTFPs and the conservation status of NTFPs.

2.3.2.4. Guided Field-walk

Guided field walks, which include a combination of observations and interviews, were performed with one or two key informants through areas where the plants of interest are expected to be found. This also gave an opportunity to make notes on the list of plant species, habits, appearance, and status of NTFP bearing plants in the study area. Signs of harvesting or patterns of plant distribution and disturbance were also observed and discussed. During these guided field walks, recording, explaining, and collecting of plant type specimens were done at the spot. Key informants who helped during the guided field walks had a vital role in identifying the NTFP plants encountered in the field by providing its local (vernacular) name and use type.

2.3.2.5. Market Survey

A market survey was conducted in three local markets (Amigna, Chefa and Roka) near the study area. Two surveys for each marketplace were made. During the market survey, types of traded NTFPs with their source of plant species were recorded by interviewing traders.

2.3.3. Plant Specimen Collection and Identification

Whenever a new species for NTFP was encountered, specimens were placed in a reference collection. Voucher specimens were collected in all sites. Local names, if present, were also recorded. Specimens were identified both in the field and later at the National Herbarium of Ethiopia (ETH) following the Flora of Ethiopia and Eritrea (Edwards et al., 1995; Edwards et al., 1997; Edwards et al., 2000; Hedberg and Edwards, 1989; Hedberg and Edwards, 1995; Hedberg et al., 2003; Hedberg et al., 2004; Hedberg et al., 2006).

2.4. Data Analysis

2.4.1. Ethnobotanical Data Analysis

For statistical analysis SPSS version 20 was used. Both qualitative and quantitative analytical tools were employed following the methods of Martin (1995); and Cotton (1996). To gain credibility and agreement of the informants on the reported use of NTFP plants, analytical tools of ethnobotany were employed. These include preference ranking, pairwise comparison, triadic comparison, and informant consensus.

2.4.1.1. Preference Ranking

Preference ranking is the ranking or ordering of a set of objects to determine their order of importance across a community. Understanding preferences is important in choosing appropriate and effective interventions. In this study, preference ranking was done by key informants for the highly cited 11 NTFP categories, commercially important NTFPs, threats of the forest and for some highly cited plant species used for wild edible, toothbrush, and twinning items.

2.4.1.2. Paired Comparison

Paired comparison is used to compare entities in pairs to judge which of each pair is preferred. By randomizing the order of the pairs, the items are presented to the interviewee to choose the one, which he/she prefers. The numbers of pairs of objects to be compared were computed as:

$$\mathrm{NP} = \frac{n(n-1)}{2}$$

Where, NP- is the number of pairs of objects, and n stands for the number of items to be compared. In this study, pairwise comparison was used to compare seven species used for making ploughs, eight species used for making yokes and six species used to make ropes.

2.4.1.3. Triadic Comparison

Triadic comparison is another way to obtain overall similarity judgments to present items, three at a time, and ask informants to pick the one that is most important or different from the other two or which two go together. The total number of possible triads in such comparison is given by n! /3! (n - 3)! where n is the number of the items being compared (Martin, 1995). Then the overall ranking was made by adding the ranks given in each triad. This method was used to compare six species used for toothbrush.

2.4.1.4. Informant Consensus

Informant consensus means agreement among informants. In ethnobotany, informant consensus values give good indications about a particular species that serve for particular use categories and about specific plants used for several use categories. The plants with higher informant consensus need to be seriously considered for further studies, since they are species widely applied by many people and they have probably been used for a long time (Macia et al., 2005).

2.4.1.5. Informant Consensus Factor

The Informant Consensus Factor (ICF) is used to calculate the level of homogeneity among the information provided by different informants. It can be calculated by using the following formula (Trotter and Logan, 1986):

$$\text{ICF} = \frac{nur - nt}{nur - 1}$$

Where, nur = the number of use citations of a certain use category, and nt = number of species used for this category.

The results of ICF range from 0 to 1. A high value of ICF indicates agreement of selection of taxa between informants, whereas a low value indicates disagreement (Heinrich et al., 1998). In this study, ICF was used to identify the agreements among the informants on the reported groups of the types of NTFP categories and their source of plant species.

2.4.2. Diversity of NTFP Species

The Shannon–Wiener diversity index was used to determine the diversity, richness, evenness, and equitability within and among the NTFP species (Kent, 2012). The Shannon–Wiener diversity index was calculated as follows:

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

Where, H'= Shannon Diversity Index, S = the number of species, and Pi= number of individuals belonging to the 'i' species and ln = the natural log of the number.

Evenness or equitability is a measure of the homogeneity of abundances in a sample (Kent and Coker, 1992). It is obtained from the Shannon equitability index calculated as:

$$Equitability(J) = \frac{H'}{H'max} = \frac{H'}{\ln S}$$

Where, J= Equitability, H' = Shannon-Wiener diversity index, H' max= lnS (where S is the species richness and lnS is the natural logarithm of the species richness).

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Floristic Composition of the NTFPs in Sera Forest

The study has shown that Sera Forest is rich in NTFP plants of different growth forms (trees, shrubs, herbs and lianas, see Appendix 1, Supplementary Material). Out of the total NTFP species recorded, trees comprise 58% while shrubs, herbs and lianas constitute 22%, 12% and 9%, respectively (Fig 2).

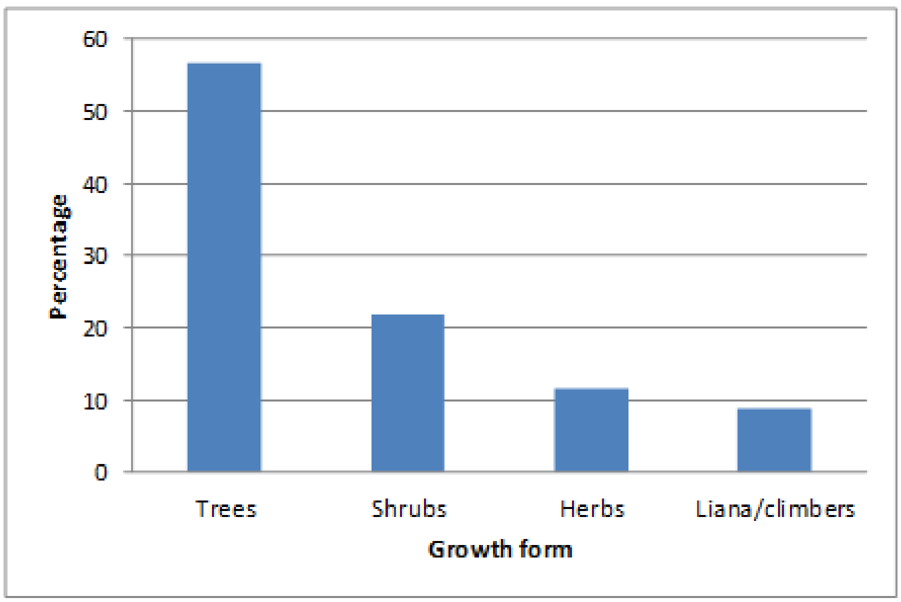

Figure 2. Growth form of plant species collected from the study area.

A total of 137 NTFP species from 49 families were recorded from the study area (Appendix 1). Fabaceae, Asteraceae and Euphorbiaceae were the three most dominant families represented by 20, 10 and 8 species, respectively. Eight of the species (5%) are endemic to Ethiopia (Table 2).

Table 2. Endemic plants of the study area and their conservation status with their use types.

No	***Species***	***Family***	***Habit***	***IUCN category***	***NTFP categories***
1	*Erythrina* brucei	Fabaceae	T	LC	MP, FW, HF
2	*Erythrina abyssinica*	Fabaceae	T	NT	MP, FW, HF
3	*Lippia adoensis*	Verbenaceae	S	LC	FS
4	*Maytenus addat*	Celastraceae	T	NT	CM,
5	*Millettia ferruginea*	Fabaceae	T	LC	MP, FW
6	*Rhus glutinosa*	Anacardiaceae	T	LC	FM, CM, FW
7	*Echinops kebericho*	Asteraceae	H	VU	MP, FS
8	*Acanthus sennii*	Acanthaceae	S		HF

Note: VU=Vulnerable; NT=Near Threatened; LC= Least Concern; S=shrub; H=herb; T=tree, C=climber; HF=Honeybee flora; FW=Fuel wood; MD=Medicinal plant; FS=Flavour and sanitation; CM=Construction material.

3.1.2. Ethnobotanical Investigation of NTFPs in Sera Forest

3.1.2.1. Demographic and Socio-economic Characteristics of Respondents

Information on the types of NTFPs extracted from the forest and their source of plant species were obtained from the household survey that involved 206 general and 24 key informants from three Forest User Groups (Table 1). Most of the respondents were from Achena, 85 (37%), followed by Sera, 78 (34%) and Arbogne, 67 (29%). More men were interviewed 159 (69%) compared to 71 (31%) women. Of the respondents, 151 (66%) were unable to read and write, 49 (21%) could read and write, while 17 (7%) had gone to primary school and 13 (6%) to high school. In addition, 75 (33%) of the respondents were between 20 and 40 years of age, 120 (52%) were between 41 and 60 years, 25 (11%) were between 61 and 80 years and 10 (4%) were above 81 years of age. Two hundred eleven (92%) of the respondents were farmers. However, people that attained relatively higher education level had other substantial sources of income from non-farm small businesses.

3.1.2.2. Types of NTFP Categories Recorded

Eleven major categories of NTFPs were documented. These are: (i) medicinal plants, (ii) food plants, (iii) animal fodder, (iv) construction materials, (v) farm implements, (vi) household tools and utensils, (vii) firewood and charcoal, (viii) honey production, (ix) twinning items (for making ropes) (x) smoke and flavoring wood, and toothbrush.

3.1.2.3. Informant Consensus Factor (ICF) of the Major NTFP Categories

The informant consensus analysis shows fuel wood to be cited by the highest number of informants followed by farm implements and construction materials (Table 3). ICF values were computed for the eleven NTFP categories. In the three study sites combined, the highest ICF value was recorded for Twinning plants followed by honey production and Household tools and utensils (Table 3).

Table 3. Informant Consensus Factor values of 11 major categories of NTFPs.

NTFP Categories	***Number of taxa (nt)***	***Number of use report (nur)***	***Consensus factor***	***Rank***
Twinning plants	5	122	0.97	1
Honey Production	5	129	0.96	2
Household tools and utensils	8	130	0.95	3
Smoke and Flavor	6	99	0.94	4
Toothbrush	7	90	0.93	5
Animal Fodder	16	190	0.92	6
Farm Implements	18	211	0.92	6
Charcoal and Firewood	22	217	0.89	8
Food Plants	23	125	0.82	9
Construction plants	38	201	0.81	10
Medicinal Plants	53	186	0.72	11

3.1.2.4. Diversity of Plant Species Used for NTFPs

Of the eleven major NTFP categories mentioned by the informants, most NTFP plant species fell into the categories of medicinal (53 species) plants followed by plants for construction (Table 4). The highest Shannon's diversity index (3.07) was seen for medicinal plants and the highest species evenness (0.94) for toothbrush plants (Table 4).

3.1.2.4.1. Plants Used for Medicinal Purpose

53 plant species belonging to 34 families were recorded as having medicinal uses (Appendix 1). The highest number were recorded within the family of Fabaceae. *Buddleja polystachya* and *Combretum paniculatum* are the species with the highest relative abundance (Table 5).

3.1.2.4.2. Plants Used for Food

A total of 23 wild edible plant species belonging to 20 families were identified for their food value (Appendix 1 and Table 6). Shrubs was the dominant growth form, followed by trees.

Vangueria apiculata was the most preferred with a high commercial value followed by *Mimusops kummel* and *Oncoba spinosa* (Table 6).

Table 4. Species richness, diversity, and evenness of species of each NTFP category.

NTFP Categories	***Species Richness***	***Shannon Diversity***	***Evenness***
Medicinal Plants	53	3.073	0.77
Food Plants	23	2.461	0.79
Construction plants	38	2.749	0.76
Animal Fodder	16	1.518	0.55
Charcoal and Firewood	22	2.251	0.72
Honey Production	5	1.476	0.92
Farm Implements	18	2.195	0.76
Toothbrush	7	1.835	0.94
Smoke and Flavor	6	0.683	0.38
Household tools and utensils	8	0.843	0.41
Twinning plants	5	1.468	0.91

Table 5. Diversity, relative abundance, and frequency of plant species used for medicine.

Botanical name	***Informants (%)***	***Frequency (%)***	***Relative abundance (%)***
Aeschnomene elaphroxylon	35	10	1.49
Aloe macrocarpa	33	6	1.15
Buddleja polystachya	49	46	37.11
Calpurnia aurea	94	22	1.03
Canthium pseudosetiflorum	65	14	1.72
Capparis tomentosa	79	6	1.83
Carissa spinarum	82	6	0.92
Caucanthus auriculatus	55	8	1.37
Combretum paniculatum	25	38	30.36
Cordia monoica	42	16	1.15
Croton macrostachyus	64	8	1.15
Cyphostemma adenocaule	63	16	2.75
Dalbergia lactea	78	8	1.72
Dichrostachys cinerea	84	8	1.83
Echinops kebericho	72	14	1.60
Ehretia cymosa	97	6	1.72
Erythrina abyssinica.	88	6	0.92
Grewia ferruginea	62	8	1.60

Table 6. Preference ranking of wild edible fruits based on their taste quality as agreed by respondents.

Edible plants	***Key informants (R1−R7)***							***Total***	***Rank***
	R1	***R2***	***R3***	***R4***	***R5***	***R6***	***R7***		
Vangueria apiculata	6	5	6	3	6	5	5	36	1
Mimusops kummel	5	5	6	5	5	4	5	35	2
Oncoba spinosa	5	6	5	4	5	4	5	34	3
Ziziphus mucronata	5	6	5	6	4	4	3	33	4
Balanites aegyptiaca	3	4	5	4	4	6	4	30	5
Ximenia americana	4	3	4	5	3	4	5	28	6
Dovyalis abyssinica	2	3	2	3	4	1	2	17	7
Cordia africana	1	2	1	2	1	2	3	12	8
Carissa spinarum	1	2	1	2	1	1	2	10	9

3.1.2.4.3. Plants Used for Animal Fodder

Sixteen plant species belonging to twelve families were reported to be used for animal feed. *Ficus mucuso, Erythrina brucei* and *Ehretia cymosa* had the highest informant citation. Two species (*Buddleja polystachya* and *Rhus glutinosa*) were the most abundant species and the most frequently occurring in the study area (Appendix 1). Trees were the dominant source of forage (71%) followed by shrubs (29%).

3.1.2.4.4. Plants Used for Construction Purpose

A total of 38 plant species were reported for their use as construction material (Appendix 1). Among these, 18 species were reported for their use in house construction and other utilization categories (fences, shade, and beehives), 3 species for only beehive making and 16 species for fences only. *Olea europaea* ssp. *cuspidata, Acacia etbaica, Rhus glutinosa*, *Acacia sieberiana*, *Balanites aegyptiaca*, *Bridelia micrantha*, *Dombeya torrida*, *Grewia mollis* and *Hagenia abyssinica* were the most important species used for one or more construction types. *Jasminium abyssinicum*, *Clematis simensis*, and *Myrsine africana* were the most preferable plant species used for beehive making. Stem/trunk and branch parts of these plants were mentioned for their role in these construction materials. *Maytenus addat, M. arbutifolia, Ziziphus mucronata* and *Ximenia americana* were the most cited plant species used for fence construction.

Informants mentioned diverse uses of construction items obtained from plants, like construction of houses, animal barns, temporal shades around farmland, fences around resident and farming sites.

3.1.2.4.5. Plants Used for Farm Implements

Various types of traditional farm tools are used. Hoes, spades, and axes are used for land clearing. For tillage and land turn over, ploughs called Moofara are used, a wooden structure that extends from the yoke to the ground. Its basic components are a shoe, a share, a body, a handle, and a beam. A tool called Wanjoo is a wooden beam that is fastened over the necks of two oxen. It is held on the animals' necks by an oxbow and secured by a rope to a beam of implements like the plough. Spade, pickaxe, and hoe are also used. Small spades and pickaxes are used for crop husbandry. Further, a sickle is used during harvesting, 'Maashii' for threshing, 'Laamedaa' for winnowing and 'Gooraraa' for cereal storage (Gootaraa). These are all made from plants and used in the study area (Appendix 1).

Eighteen plant species were mentioned as used for making different types of farm implements. *Olea europaea* ssp *cuspidata* (for plough), *Grewia mollis* (for cereal storage), *Prunus africana*, *Rhus glutinosa*, *Hagenia abyssinica*, *Schefflera abysinica* and *Ekebergia capensis*, were the most important plant species used for one or more sub-categories of this purpose. Paired comparisons of seven highly cited plants used to make ploughs were done by seven key informants selected from each site. The result showed that *O. europaea* was the most important plant species followed by *E. capensis* and *Allophylus abyssinicus* (Table 7).

Table 7. Pairwise comparison of seven plant species used for making ploughs (**Moofara**).

Plants used for making ploughs	***Key informants (R1−R7)***							***Total***	***Rank***
	R1	***R2***	***R3***	***R4***	***R5***	***R6***	***R7***		
Olea europaea ssp. *cuspidata*	6	6	5	6	5	6	6	40	1
Ekebergia capensis	4	5	4	3	5	6	4	31	2
Allophylus abyssinicus	5	6	4	3	6	2	3	29	3
Prunus africana	6	4	6	3	6	1	4	28	4
Grewia mollis	5	3	5	4	2	3	4	26	5
Balanites aegyptiaca	5	4	2	5	3	2	1	23	6
Rhus glutinosa	4	3	2	4	2	1	0	16	7

Preference ranking of four highly cited plant species used for making 'Laameedaa' (the tool used for winnowing crops from debris) showed that *H. abyssinica* is the most preferred, having a high commercial value, followed by *S. abysinica* and *E. capensis* (Table 8).

Table 8. Preference ranking of four plant species used for making '**Laamedaa**'.

Plants used for making Laamedaa	***Key informants (R1−R7)***							***Total***	***Rank***
	R1	***R2***	***R3***	***R4***	***R5***	***R6***	***R7***		
Hagenia abyssinica	5	6	5	6	6	5	4	37	1
Schefflera abysinica	5	5	5	4	5	5	4	33	2
Ekebergia capensis	4	5	4	3	5	6	4	31	3
Prunus africana	6	4	6	3	6	1	4	28	4

3.1.2.4.6. Plants Used for Household Tools and Utensils

Eight plant species (6% of all NTFP species) belonging to 5 families were recorded as being used to make different household tools and utensils (Appendix 1 and Table 12). Among these *Hagenia abyssinica*, *Ficus vasta*, *Ficus sycomorus*, *Celtis africana*, *Erythrina brucei*, *Cordia africana* and *Erythrina abyssinica* were common ones. A Shannon diversity index of 0.84 has been recorded for species providing household tools and utensils (Table 4). Rural communities living in and around Sera Forest use woody plants for household utensils, furniture, and tools for various services, including chopsticks, bowls, and various types of spoons, 'Rakaboo' (wooden tray used for carrying coffee cups), mortars and pestles.

Preference ranking of five highly cited plants used to make household tools and utensils were done by seven key informants selected from each site. *Hagenia abyssinica* is the most important of the species followed by *Celtis africana* and *Cordia africana* (Table 9).

Table 9. Preference ranking of five plant species used for making household tools and utensils.

Plants used for making mortar and pestle	***Key informants (R1−R7)***							***Total***	***Rank***
	R1	***R2***	***R3***	***R4***	***R5***	***R6***	***R7***		
Hagenia abyssinica	5	6	4	5	6	5	3	34	1
Celtis africana	4	5	4	3	5	6	4	31	2
Cordia africana	5	4	4	5	3	6	5	30	3
Ficus vasta	6	4	6	3	6	1	4	28	4
Erythrina abyssinica.	4	3	2	4	2	1	0	16	5

3.1.2.4.7. Plants Used for Firewood and Charcoal Making

Fuel wood is the most important energy source and income generation for both rural and urban households in the study area. All woody species were used for firewood and charcoal, and 22 species were recorded. The choice depends on availability, drying time and value in the market, and therefore some species were preferred. Four of the species were mentioned as used both for firewood and charcoal, 15 for firewood only and three species for charcoal making only (Appendix 1 and Table 12).

3.1.2.4.8. Forage Plants for Honeybees

Honey production is the second most important NTFP in the study area. Besides beekeeping, honey hunting in hollow trees is a common practice. Of the many flowering plants that exist in the forest and surrounding areas, five plant species were found as the most valued. These are *Erythrina abyssinica*, *Erythrina brucei*, *Ekebergia capensis*, *Croton macrostachyus* and *Hagenia abyssinica.* Four species were cited by more than 50% of the informants and the diversity, abundance, and frequency of five species that occurred in the study area are shown in Table 10.

Table 10. Relative abundance and frequency of plant species used as forage plants for honeybees.

Species	***Informant (%)***	***Frequency (%)***	***Relative abundance (%)***
Erythrina abyssinica.	85	6	0.92
Erythrina brucei	78	8	1.72
Croton macrostachyus	52	4	0.23
Hagenia abyssinica	41	8	1.03
Ekebergia capensis	62	6	1.37

3.1.2.4.9. Plants Used for Twinning

Twinning materials are items for ropes or strings, which are extracted from the bark of plant species, mainly climbers (vine stems) and lianas. Some lianas/climbers (*Clematis simensis*, *Jasminum abyssinicum*, *Pavonia urens*) are used in place of nails in house construction, animal barns and fences. These species have also commercial importance. Other species such as *Acacia sieberiana*, *Dombeya torrida*, *Girardinia bullosa*, *Gnidia glauca*, *Agave sisalana* and *Pavonia uren*s, are used to make ropes or strings that are used for many purposes, like to tie firewood for market, to make farm tools and to tie cattle in place.

3.1.2.4.10. Plants Used for Smoke and Flavoring

Six plants are used for fumigating and sanitation of milk vessels, beehives and containers for local drinks. *Calpurnia aurea*, *Olea europaea* ssp. *cuspidata* and *Ximenia americana* were the most cited of these.

3.1.2.4.11. Plants Used as Toothbrush

Brushwood used as toothbrush is collected and traded by children in local markets. Six species (*Calpurnia aurea*, *Grewia mollis*, *Olea europaea* ssp. *cuspidata*, *Osyris quadripartita*, *Ficus palmata* and *Dodonaea angustifolia*) were identified for this use. A triadic comparison of four highly cited plant species done by seven key informants showed that *Olea europaea* ssp. *cuspidata* was the most preferred species followed by *Grewia mollis* (Table 11).

Table 11. Triadic comparison on four plant species used for toothbrush.

Plant used for making toothbrush	***Key informants (R1−R7)***							***Total***	***Rank***
	R1	***R2***	***R3***	***R4***	***R5***	***R6***	***R7***		
Olea europaea ssp. *cuspidata*	5	6	6	5	5	4	5	33	1
Grewia mollis	5	6	4	5	6	3	3	32	2
Calpurnia aurea	6	4	6	3	6	2	4	29	3
Ficus palmata	4	3	2	4	2	1	0	16	4

3.1.2.5. Plant Species having Multiple Functions

Twenty six plant species were found to have a multipurpose role (more than two NTFPs) by the community (Table 12).

Table 12. Plant species having multipurpose function in the study area.

S. No.	***Plant Species***	***Number of Uses***
1	*Hagenia abyssinica*	6
2	*Olea europaea* ssp. *cuspidata*	5
3	*Grewia mollis*	5
4	*Croton macrostachyus*	5
5	*Ximenia americana*	5
6	*Carissa spinarum*	4
7	*Ziziphus mucronata*	3
8	*Balanites aegyptiaca*	3
9	*Withania sominifera*	2
10	*Syzygium guineense*	2
11	*Sterculia stenocarpa*	2
12	*Rhus natalensis*	2
13	*Rhus glutinosa*	2

14	*Prunus africana*	2
15	*Oncoba spinosa*	2
16	*Mimusops kummel*	2
17	*Erythrina abyssinica*	2
18	*Erythrina brucei*	2
19	*Ehretia cymosa*	2
20	*Dovyalis abyssinica*	2
21	*Calpurnia aurea*	2
22	*Buddleja polystachya*	2
23	*Allophylus abyssinicus*	2
24	*Acacia sieberiana*	2
25	*Acacia persiciflora*	2
26	*Acacia etbaica*	2

3.1.2.6. Threats and Conservation Status of Sera Forest

All informants distinguished one or more threats of the source of NTFP plant species and of the overall vegetation of the forest. Among nine major threats identified, the highest threat was charcoal making followed by farm expansion and collection of construction material (Table 13).

Table 13. Threats to the vegetation of Sera Forest. Figures are number of general informants mentioning a threat.

Threats	***Study sites***			***Total number of informants***	***Rank***
	Sera	***Chefa***	***Achena***		
Charcoal making	71	69	74	214	1
Farm expansion	75	65	52	192	2
Construction materials	63	58	68	189	3
Firewood collection	59	63	59	181	4
Illegal cutting of tree for timber	52	61	45	158	5
Natural Fire	53	30	40	123	6
Over-stocking	42	38	39	119	7
Drought	29	43	37	109	8
Smoke and flavoring wood	35	25	41	101	9

In addition, ranking of five highly cited threats of the vegetation of the area were also undertaken by eight key informants to confirm and find out the most serious threats of NTFP bearing plants, based on their degree of destructiveness (Table 14). Farm expansion was considered the most serious threat followed by charcoal making and illegal timber extraction.

Table 14. Priority ranking of threats to NTFP bearing plants in the study area (1 = least destructive and 6 = most destructive) based on information from key informants.

Threats	***Key informants (R1−R8)***								***Total***	***Rank***
	R1	***R2***	***R3***	***R4***	***R5***	***R6***	***R7***	***R8***		
Farm expansion	5	6	5	4	6	6	4	5	41	1
Charcoal making	5	6	5	2	6	5	4	6	39	2
Illegal timber extraction	4	6	6	4	3	2	5	6	36	3
Construction materials	4	3	4	5	6	4	3	4	33	4
Over harvesting NTFPs	6	4	6	5	4	3	2	1	31	5

The local communities perform various participatory traditional conservation activities to lessen the above-mentioned major threats. These forest protection and management practices include, e.g., regulations of grazing and extraction of forest products, forest surveillance/patrolling (both day and night), clearance and maintenance of firebreaks, selective preservation of tree species and rearing of plants in nurseries, focused on the restoration of some indigenous woody species. The approach of participatory forest management in the study area is a reflection to the failure of the conventional command and control system by forest guards and other staff. Now, the local communities themselves watch the forest considering that the forest resources are sources of their livelihood. Although there are some few individuals within the society who fail to respect their responsibilities (being involved in illegal cutting and resource overuse), all protection and conservation activities involve rotation among member households.

3.2. Discussion

3.2.1. Floristic Composition of the NTFPs in Sera Forest

Studies of human-plant relations are essential for sustainable use of plant products and to combat the current issues of climate change and biodiversity loss (Kidane et al., 2018a; Kassa, 2017). The current study is a contribution in that field. Eleven categories of NTFPs with a total of 137 plant species were identified. A similar Ethiopian study by Fetene et al. (2010), reported 59 plant species bearing nine different types of NTFPs. Solomon et al. (2014) identified eleven categories of NTFPs in the forest of Dawro; and Reshad et al. (2017) nine different types of NTFPs from 98 plant species from Jello-Muktar Forest. Compared to these, Sera Forest has a high diversity of NTFPs.

We have shown that Sera Forest is rich in plant species compared to similar forests in Ethiopia. Although we have recorded species for NTFPs only, their number is higher than recorded in floristic investigations in Jibat Forest in West Shewa Zone (131 species) (Bekele, 1993); Menagesha Suba forest in West Shewa zone (135 species) (Belachew, 2010) and Komto forest in East Wollega Zone (103 species) (Gurmessa et al., 2012). Fabaceae is the most common family in our study, followed by Asteraceae. A dominance of Fabaceae was also reported from similar Ethiopian forests, such as Dirki and Jato forest (Tadesse, 2015) and Berehet forest (North Shewa Zone) (Alemayehu et al. 2015). The importance of Asteraceae and Fabaceae in the flora might be due to their having well-organized pollination and successful seed dispersal mechanisms that might have adapted them to a wide range of ecological conditions in the past (Kelbessa and Soromessa, 2008). However, the variation in landscape and environmental conditions like temperature and amount of rainfall could be the reasons of variation in dominance positions of plant taxa.

In our study, eight species are endemic to Ethiopia. Following the IUCN categories, *Echinops kebericho* is vulnerable (UV). Of the others, four are of least concern (LC) and two are near threatened (NT). The number of endemic species reported in the current study is somewhat lower than reported from other related forests where full inventories have been performed, e.g., 13 endemic species in Dirki and Jato forest (Tadesse, 2015) and 10 species from Sese Forest (Belachew, 2010). The differences may be the consequence of the sampling effort. In general, high conservation priority should be given to the study area to save the diverse plant richness and endemism.

3.2.2. Types of NTFP Categories and Diversity of their Source Plant Species

Eleven major forest products were collected in the study area which is on the same level as was found in other Ethiopian studies (Beyene et al., 2017; Solomon et al., 2014). Nevertheless, it has been suggested (Sultan, 2009), that there is a pronounced variation in the extent to which forest products are used from area to area and even between households within a community. Therefore, oversimplifications must be avoided concerning use, understanding and value addition of NTFPs. This includes benefits and management of individual species (Solomon et al., 2014; Balama et al., 2016). Such differences reveal the level of awareness of the importance of the NTFPs for rural livelihoods (Solomon et al., 2014; Beyene et al., 2017; Sultan, 2009; Balama et al., 2016; Chou, 2018). The high H' and E values of the NTFP yielding species indicate their abundance and good distribution in Sera Forest.

The Informant consensus factor (ICF) is highest for plants used for twinning and lowest for medicinal plants. This is because the plant species used for twinning are known by many informants, whereas the knowledge of medicinal plants is restricted to fewer persons (Kidane et al., 2018b).

The number of plant species used for medicinal purpose is high, which shows that traditional medicinal plants are important for the local people (Tambi and Kengah, 2018; Balama et al., 2016; Canales et al., 2005; Kidane et al., 2018b). Fuel wood (firewood and charcoal) is the most important source of household energy supply and the main source of income, both in the rural and urban areas. Almost all informants said that in one way or the other they were involved in harvesting and trading firewood collected from the forest.

Three of the 22 species collected for firewood are particularly important. These are *Allophylus abyssinicus, Maytenus arbutifolia* and *Olea europaea* ssp. *cuspidata*. The latter is particularly harvested for commercial purpose to generate income. People also use different plant species for making agricultural implements. These can be classified as tillage and land preparation tools, like ploughs (Moofara), yokes (Wanjoo), spades, pickaxes and hoes), intercultural operation tools, like spades, harrows and hoes, and harvest and post-harvest tools.

Sites more exposed to sun light, lower altitudinal ranges, soils with sufficient moisture contents and less accessible sites can support relatively more biodiversity than other sites (Bekele, 1993). Grazing and other anthropogenic impact also affect the distribution of plant species (Tambi and Kengah, 2018; Kidane et al., 2018a; Bekele, 1993). We have seen that anthropogenic impact has affected the natural regeneration in Sera Forest. The widespread impact on forests which have been cleared since agriculture began (De Souza et al., 2003) can be seen also in our area. Small and medium sized trees and shrubs have been cut for charcoal production and fuel wood, and farmland has been expanded. Thus, the forest is under serious pressure. This is widespread in Sera Forest at all altitudes.

Foraging is another problem identified in the area, because cattle intrude into the forest. Consequently, the vegetation of Sera Forest has been more affected particularly from the east, south and west facing sides, as the vegetation is being rapidly changing into grazing land through continuous deforestation. The necessity for arable land, fuel wood and grazing areas are the foremost causes of forest degradation, commonly leading to loss of forest cover and biodiversity (Soromessa and Kelbessa, 2014).

Thus, there are many threats to the forest but the most severe impact on the flora is people involved in the regular harvesting of charcoal wood for the market. Therefore, the sustainability of NTFPs depends on the rate of harvesting relative to regrowth and regeneration as well as the stage, timing, and method of harvesting (Peters et al., 1989; de Silva and Atal, 1995).

3.2.3. Threats and Conservation Status of Sera Forest

Interviews and group discussions revealed that Sera Forest has a long history of disturbance and conservation practices. The participatory forest management plan (PFMP) has been going on, since 1997 with the purpose both to arrest forest degradation and to meet the livelihood needs of the local community. According to the formalized forest management agreements between local communities, nobody is allowed to cut a single tree without the consent of the kebele administration and forest cooperative leaders. One has to bring his/her case (the house being burnt down, burial or wedding ceremonies etc.) to the administration and get it approved for the access of limited timber extraction. All members of the Forest User Groups are tasked with keeping the forest from illegal cutting every day in turn. The role of the kebele administration is to enforce the rules and regulations agreed and accepted by the community if they fail to perform their duties and collect NTFPs illegally. However, if there are too many people in relation to the resource, its use will not be sustainable, unless people are forced to use the resource less than their actual needs. As it was described by Tewari (2012); NTFPs can play a bigger role for local communities by mitigating the effects of hunger and malnutrition and engendering rural development, but an integrated policy framework to develop the NTFP sector for encouragement of the rural development objective is vital.

Sustainable extraction of NTFPs requires planning, monitoring and proper management practices. Unless harvesting is controlled, the products are being depleted at an alarming rate and forest dependent communities continue to lose them, either through overexploitation or habitat destruction (Duchesne et al., 2001). This shows that sustainable harvesting is not only essential for conservation of the plant species, but also for the livelihoods of many rural people (Ticktin, 2004).

According to Karki (2001), resource management is a political subject because it involves exercise of power and control over users of resources, and this raises issues of administration and decision making. Therefore, the PFM approach in the study area needs to have strong evaluation and monitoring mechanisms to assess why the agreement reached is not effective. Moreover, developing a sense of ownership, responsibility, and integration of the traditional forest management practices with modern conservation approaches is required. Encouraging the community to plant a variety of trees (fast-growing eucalyptus alongside slower-growing and higher-value fruit plants), on fields previously producing crops can lessen the pressure to the remnant forest while providing a livelihood option.

4. CONCLUSION AND RECOMMENDATIONS

Sera forest is rich in NTFP-bearing plant species and the local communities have a rich source of indigenous knowledge in regulation of grazing and extraction of forest products, forest patrolling, firebreak clearance and maintenance and selective preservation of tree species, which has helped them to use plant products from the forest up to now. The forest has a significant socio-economic importance for the inhabitants living in and around it. It gives both commodities and income.

However, there is also pressure and overutilization, which makes measures of effective management and protection of the forest necessary. It is therefore important to raise awareness within the local community about forest conservation and wise utilization by intensive education and capacity building on how to use the commodities less than their actual needs besides avoiding illegal cutting. This can be done only in combination with alternative sources, particularly for firewood and charcoal. Woodlots for this purpose could be an alternative.

The ongoing deterioration of the forest shows that the present PFM management needs to be implemented effectively via strong evaluation and monitoring mechanisms with setting of harvesting quantities and regulating the types of collections. Moreover, developing a sense of ownership, responsibility and integrating their traditional forest management practices with modern conservation approaches is required. Conservation priority should be set to endangered multipurpose plant species (such as *Olea europaea* ssp. *cuspidata, Cordia africana* and *Hagenia abyssinica*) to reduce the risk of their extinction.

5. CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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Appendix 1. List of plant species collected from Sera Forest (Key: T= Tree; S=Shrub; C= Climber; L=Liana; H=Herb).

No	***Scientific name***	***Family***	***Local Name (Afaan Oromo)***	***Habit***	***Code/ Collection number***
1	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	Laaftoo	T	D012
2	*Acacia albida* Del.	Fabaceae	Garbii	T	D074
3	*Acacia brevispica* Harms	Fabaceae	Hammareessa	S	D093
4	*Acacia etbaica* Schweinf.	Fabaceae	Doddota	T	D009
5	*Acacia nilotica* (L.) Willd. ex Del.	Fabaceae	Burquqqee	T	D096
6	*Acacia persiciflora* Pax	Fabaceae	Laaftoo	T	D076
7	*Acacia sieberiana* DC.	Fabaceae	Xaddecha	T	D122
8	*Acacia seyal* Del.	Fabaceae	Waaccuu	T	D110
9	*Acanthus polystachyus* Delile	Acanthaceae	Sokorruu adii	S	D083
10	*Acanthus sennii* Chiov.	Acanthaceae	shokoruu	S	D080
11	*Acokanthera schimperi* (A.DC.) Schweinf.	Apocynaceae	Qaraaru	T	D134
12	*Aeschynomene elaphroxylon* Guill	Fabaceae	Qanqalcha	S	D077
13	*Agave sisalana* Perro ex Eng.	Agavaceae	Algee/Qaacca	S	D090
14	*Albizia schimperiana* Oliv.	Fabaceae	Imalaa	T	D136
15	*Allophylus abyssinicus* (Hochst.) Radlk	Sapindaceae	Sarara	T	D091
16	*Aloe macrocarpa* Tod.	Aloaceae	Hargisa	S	D086
17	*Andropogon abyssinicus* Fresen.	Poaceae	Baallammii	H	D047
18	*Apodytes dimidiata* E. Mey. ex Am.	Icacinaceae	Qumbaala	T	D087
19	*Asparagus africanus* Lam.	Asparagaceae	Sariitii	S	D112
20	*Balanites aegyptiaca* (L.) Del.	Balanitaceae	Deemmoo	T	D018
21	*Bidens biternata* (Lour.) Merr. &Sherff	Asteraceae	Cogoogitii	H	D104
22	*Bridelia micrantha* (Hochst.) Baill.	Euphorbiaceae	Agiraabaa	T	D106
23	*Buddleja polystachya* Fresen	Loganiaceae	Qawwisa	T	D019
24	*Calpurnia aurea* (Ait.)Benth.	Fabaceae	Ceekaa	S	D003
25	*Canthium pseudoseti* florum Bridson	Rubiaceae	Landhana	S	D062
26	*Capparis tomentosa* Lam	Capparidaceae	Gumaroo	S	D119
27	*Carissa spinarum* L.	Apocynaceae	Agamsa	S	D050
28	*Caucanthus auriculatus (*Radlk.) Nie Denzu	Malpighiaceae	Qaxxisaa	L/C	D067
29	*Celtis africana* Burm.f.	Ulmaceae	Mataqomaa	T	D052
30	*Cissampelos pareira* L.	Menispermaceae	Hidda kalalaa	L/C	D092
31	*Clausena anisata* (Willd). Benth.	Rutaceae	Ulmaayii	S	D121
32	*Clematis hirsuta* Perr. and Guill	Ranunculaceae	Hidda Fiitii	L	D057
33	*Coffea arabica* L.	Rubiaceae	Buna Bosona	T	D027
34	*Combretum molle* R. Br. ex G.Don	Combretaceae	Rukeessa	T	D049

35	*Combretum paniculatum* Vent.	Combretaceae	Manjoorrii	S	D095
36	*Cordia africana* Lam.	Boraginaceae	waddesaa	T	D044
37	*Cordia monoica* Roxb.	Boraginaceae	Mandheeraa	T	D117
38	*Croton macrostachyus* Del.	Euphorbiaceae	Bakkanisa	T	D029
39	*Cynodon dactylon* (L.) Pers.	Poaceae	Coqorsa	H	D128
40	*Cynodon nlemfuensis* Vanderyst	Poaceae	Waratii	H	D138
41	*Cynoglossum geometricum* Bak.	Boraginaceae	Maxxaannee	H	D089
42	*Cyphostemma adenocaule* (Steud. ex A.Rich) Desc.	Vitaceae	Hidda bofaa	L	D094
43	*Dalbergia lactea* Vatke	Fabaceae	Sarxee	T	D051
44	*Dichrostachys cinerea* (L) Wight & Arn.	Fabaceae	Jirimee	S	D006
45	*Dicranopteris linearis* (Burm.f.) Underw.	Gleicheniaceae	Kaaroollee	H	D055
46	*Dodonaea angustifolia* L.f.	Sapindaceae	Ittacha	S	D088
47	*Dombeya torrida* (G.F.Gmel.) P. Bamps	Sterculiaceae	Daannisaa	T	D114
48	*Dovyalis abyssinica* (A. Rich.) Warb.	Flacourtiaceae	Koshoomii	T	D010
49	*Dovyalis verrucosa* (Hochst.) Warb.	Flacourtiaceae	Liiqiimmee	T	D131
50	*Echinops kebericho* Mesfin	Asteraceae	Qarabichoo	H	D075
51	*Echinops longisetus* A. Rich.	Asteraceae	Qoraattii harree	S	D069
52	*Ehretia cymosa* Thonn.	Boraginaceae	Ulaagaa	T	D004
53	*Ekebergia capensis* Sparrm.	Meliaceae	Somboo	T	D099
54	*Erythrina brucei* Schweinf.	Fabaceae	Waleenssuu	T	D005
55	*Erythrina abyssinica.* Lam. ex DC	Fabaceae		S	D020
56	*Euclea divinorum* Hiern	Ebenaceae	Mi’eessa	S	D016
57	*Euphorbia tirucalli* L.	Euphorbiaceae	Ananno\Qincib	S	D026
58	*Ficus mucuso* Ficalho.	Moraceae	Qilinxoo	T	D126
59	*Ficus palmata* Forssk.	Moraceae	Luugoo	S	D120
60	*Ficus sur* Forssk.	Moraceae	Habruu	T	D011
61	*Ficus sycomorus* L.	Moraceae	Odaa	T	D001
62	*Ficus thonningii* Blume	Moraceae	Dambii	T	D042
63	*Ficus vasta* Forssk.	Moraceae	Qilxuu	T	D033
64	*Girardinia bullosa* (Steudel) Wedd.	Urticaceae	Doobbii	H	D101
65	*Gnidia glauca* (Fresen.) Gilg	Thymelaeaceae	Qaqaroo	S	D071
66	*Grewia ferruginea* Hochst. ex A. Rich.	Tiliaceae	Dhoqonuu	T	D123
67	*Grewia mollis* Juss.	Tiliaceae	Arooressa	T	D028
68	*Grewia villosa* Willd.	Tiliaceae	Ogobdii	T	D063
69	*Hagenia abyssinica* (Bruce) J.F. Gmel.	Rosaceae	Heexoo	T	D097
70	*Haplocarpha schimperi* Beav.	Asteraceae	Naciilloo	S	D107
71	*Harmsia sidoides* K.Schum.	Sterculiaceae	Qaxxee	S	D098

72	*Hyparrhenia anthistirioides* (A.Rich.) Andersson ex Stapf	Poaceae	Sanbaleeta	H	D132
73	*Jasminum grandiflorum* L.	Oleaceae	Xambelel	L	D130
74	*Jatropha curcas* L.	Euphorbiaceae	Dhaabbata buluukii	S	D031
75	*Kalanchoe marmorata* Bak.	Crassulaceae	Bosoqqee	H	D108
76	*Lannea rivae* (Chiov.) Sacleux	Anacardiaceae	Handaraka	T	D135
77	*Lippia adoensis* Hochst. ex Walp.	Verbenaceae	Kusaahee	S	D037
78	*Maesa lanceolata* Forssk.	Myrsinaceae	Abbayyii	T	D034
79	*Maytenus addat* (Loes.) Sebsebe	Celastraceae	Kombolbite	T	D048
80	*Maytenus arbutifolia* (A.Rich.) Wilczek	Celastraceae	Kombolcha	T	D059
81	*Medicago polymorpha* L.	Fabaceae	Siddisa	H	D081
82	*Millettia ferruginea* (Hochst.) Bak.	Fabaceae	Birbirraa	T	D140
83	*Mimosa pigra* L.	Fabaceae	Arangamaa	S	D035
84	*Mimusops kummel* A. DC.	Sapotaceae	Olaatii	T	D024
85	*Myrsine africana* L.	Myrsinaceae	Qacama	S	D046
86	*Nuxia congesta* R.Br. ex Fresen.	Loganiaceae	Qawwisa	T	D038
87	*Ocimum lamiifolium* Hochst. ex. Benth.	Lamiaceae	Ancabbii diimaa	S	D116
88	*Ocimum urticifolium* Roth.	Lamiaceae	Ancabbii adii	S	D043
89	*Olea europaea* L. *subsp. cuspidata* (Wall. ex G. Don) Cif.	Oleaceae	Ejeersa	T	D017
90	*Oncoba spinosa* Forssk.	Salicaceae	Aakuku	T	D014
91	*Osyris quadripartita* Decne.	Santalaceae	Waatoo	T	D118
92	*Otostegia integrifolia* Benth.	Lamiaceae	Xunjiitii	S	D082
93	*Panicum monticola* Hook.f.	Poaceae	Marga gogorrii	H	D045
94	*Pappea capensis* Eckl. and Zeyh.	Sapindaceae	Biiqqaa	T	D022
95	*Pavonia urens* Cav	Malvaceae	Hincinnii	S	D072
96	*Phragmites karka* (Retz.) Steud.	Poaceae	Qashaa	H	D133
97	*Phyllanthus ovalifolius* Forssk.	Euphorbiaceae	Qacamoo	T	D073
98	*Phytolacca dodecandra* L'Herit.	Phytolaccaceae	Handoodee	S	D068
99	*Plantago lanceolata* L.	Plantaginaceae	Qorxxobbii	H	D102
100	*Premna schimperi* Engl.	Verbenaceae	Urgeessaa	S	D023
101	*Prunus africana* (Hook.f.) Kalkm.	Rosaceae	Hoomii	T	D111
102	*Pterolobium stellatum* (Forssk.) Brenan	Fabaceae	Kontir	S	D084
103	*Rhamnus staddo* A.Rich.	Rhamnaceae	Qadiidaa	T	D046
104	*Rhoicissus revoilii* Planch.	Rhamnaceae	Indirifaa	L/C	D137
105	*Rhus glutinosa* A. Rich.	Anacardiaceae	Xaaxessaa	T	D025
106	*Rhus natalensis* Krauss	Anacardiaceae	Daboobessaa	T	D008
107	*Rhynchosia minima* (L.) DC.	Fabaceae	abdulsalim	H	D015
108	*Salix mucronata* Thunb.	Salicaceae	Alaltuu	T	D065
109	*Schefflera abysinica* (Hochst. ex A.	Araliaceae	Affarttuu	T	D127

	Rich.) Harms				
110	*Scolopia theifolia* Gilg	Flacourtiaceae	Gaallitee	T	D139
111	*Scutia myrtina* (Burm. f.) Kurz	Rhamnaceae	Kombolcha adii	S	D058
112	*Senna petersiana* (Bolle) Lock	Fabaceae	Gaafatoo	T	D036
113	*Sida rhombifolia* L.	Malvaceae	Karabaa	S	D085
113	*Solanum aculeatissimum* Jacq.	Solanaceae	Hiiddii Waraabeessa	S	D056
115	*Solanum anguivi* Lam.	Solanaceae	Hiddii saree	S	D124
116	*Solanum incanum* L.	Solanaceae	Hiiddi	H	D125
117	*Solanum nigrum* L.	Solanaceae	Awixii	S	D100
118	*Sphaeranthus suaveolens* (Forssk.) DC.	Asteraceae	Bokkolluu	H	D061
119	*Sterculia stenocarpa* H. Winkler	Sterculiacea	Qaqarrii	T	D053
120	*Stereospermum kunthianum* Cham.	Bignoniaceae	Botoroo	T	D039
121	*Syzygium guineense* (Willd.) DC.	Myrtaceae	Baddeesaa	T	D002
122	*Tamarindus indica* L.	Fabaceae	Rooqaa	T	D078
123	*Teclea nobilis* Del.	Rutaceae	Hadheessa	T	D105
124	*Terminalia brownii* Fresen	Combretaceae	Bir'essaa	T	D030
125	*Terminalia macroptera* Guill. & Perr.	Combretaceae	Dabaqqaa	T	D040
126	*Terminalia schimperiana* Hochst.	Combretaceae	Gaarrii	T	D066
127	*Thalictrum rhynchocarpum* Dill. & A.Rich.	Ranunculaceae	Sira bizuu	H	D054
128	*Tragia ashiae* M.Gilbert	Euphorbiaceae	Gurgubbee	H	D070
129	*Urera hypselodendron* (A.Rich.) Wedd.	Urticaceae	Laanqisaa	L	D041
130	*Urtica simensis* Steudel	Urticaceae	Samma	H	D113
131	*Vangueria apiculata* K. Schum.	Rubiaceae	Buruurii	S	D060
132	*Vernonia hymenolepis* A. Rich.	Asteraceae	Sooyyoma	S	D079
133	*Vernonia myriantha* Hook.f.	Asteraceae	Reejjii	T	D129
134	*Withania somnifera* L.	Solanaceae	Gizaawaa	S	D021
135	*Ximenia americana* L.	Olacaceae	Hudhaa	T	D007
136	*Zanthoxylum chalybeum* Engl.	Rutaceae	Gaddaa	S	D103
137	*Ziziphus mucronata* Willd.	Rhamnaceae	Qurquraa	T	D013