



WOODY SPECIES DIVERSITY, REGENERATION STATUS AND SOCIO-
ECONOMIC VALUE UNDER NATURAL FOREST AND ADJACENT SEMI-
COFFEE FOREST: IN THE CASE OF KEBENA FOREST, KERSSA
DISTRICT, JIMMA ZONE, SOUTH WEST ETHIOPIA

MSC THESIS

By:

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JIMMA, ETHIOPIA

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DEDICATION

I dedicate this thesis to my beloved wife Lubaba Hussein, my mother Nure Regasa, as well as my daughter Sinan, and my son Nabeki Alemu for their encouragement and support throughout my study.

STATEMENTS OF THE AUTHOR

First, I declare that this thesis is my work and that all sources of the materials used for this thesis properly acknowledged. I, Alemu Serbesa Jebesa, hereby declare that the thesis entitled “Woody Species Diversity, Regeneration Status and Socio-Economic Value Under Natural Forest and Adjacent Semi-coffee Forest, Kerssa District, Jimma zone, South western Ethiopia, submitted to the Department of Natural Resource College of Agriculture and Veterinary Medicine, Jimma University, in fulfillment of the requirements for the Degree of Master Science in Forest and Nature Management. It deposited at the University Library to be made available to borrowers under the rules of the library. I seriously declare that this thesis has not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate,

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BIOGRAPHICAL SKETCH

The author, Alemu Serbesa was born on May 06, 1991 at place called Gute Qannawe Telgo lema kebele, Ameya woreda, southwest shoa zone, Oromia, Ethiopia. He attended his elementary education school (grade1-8(1999-2006) at Sekela elementary school and Secondary and preparatory school (grade 9-12 (2007-2010) in Gindo secondary and preparatory school at Ameya woreda. Then he joined the Haramaya University in 2011 academic year and graduated with BSc degree in Forest Resource Management in July 06, 2013.

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ABBREVIATIONS AND ACRONYMS

BA	Basal Areas
DBH	Diameter at breast height
EARO	Ethiopian Agricultural Research Organization
FAO	Food and agricultural organization
FGD	Focus group discussion
GTZ	The Deutsche Gesellschaft für Technische Zusammenarbeit
HA	Hectare
HH	Household
HHU	Household untesil
IVI	Importance value index
JFM	Joint Forest Management
NF	Natural Forest
NFPAs	National Forest Priority Areas
NFSDP	National Forest Sector Development Program
NGOs	Non-governmental organizations
NGPME	Natural Gum Processing and Marketing Enterprise
NTFPs	Non-Timber Forest Product
OFWLE	Oromia Forest and Wild Life Enterprise
PRA	participatory Rural Appraisal
SCF	Semi-coffee forest
SFC	Semi forest coffee
SFM	Sustainable Forest Management
THPs	Traditional Health Practitioners

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ABSTRACT

The southwest Ethiopian Afromontane moist forests are home to a variety of plant species and known as one of the world's biodiversity hotspots. They are also the origin and domestication centers for Arabica coffee. The main objective of this study was to investigate woody species composition, diversity, regeneration status and socio-economic value of woody species under natural forest and adjacent semi-coffee forest. This study conducted at Kebena Natural forest, which is found in Jimma zone, Oromia regional state, and shared by four woredas (Kerssa, Limu Kosa, Limu Seka, and Manna). Both vegetation and socioeconomic data collected in April 2023. Systematic sampling method has applied to collect vegetation data. The forests divided into natural forest and semi-coffee forest. Eight (four each) transect lines and a total of 60 plots (30 plots in NF and 30plots SCF) with an area of 20x20 m at a distance of 300 m between transect and 100m within the plots were established to collect the vegetation data. Within the main plot, subplots of 10x10 and 5x5 m, were nested for saplings and seedlings assessment, respectively. Based on the collected data, heterogeneity of the entire species were determined using Shannon-Weiner diversity and Evenness indices. The current situation about population status of NTFP woody species investigated by constructing population structure of the whole vegetation in general, and NTFP bearing species in particular. The results illustrate that 75 woody species representing 48 families were identified. Sixty-nine (69) woody species from natural forest and 55 from semi-coffee forest. The two forest shares high woody species or they had similar woody species composition the only significant variation between two forests was seen in density of growth stage (seedling, and sapling, stage. This study concluded: natural forests exhibited higher diversity and regeneration capacity, semi-coffee forests showed alterations in population structure and species composition influenced by coffee management practices. Natural forests displayed a more vigorous regeneration capacity with higher densities of seedlings and saplings compared to semi-coffee forests. The government and the concerned body should have to proposed a strategy to aware the local community, and encourage the adoption of sustainable management practices in semi-coffee forests to mitigate the negative impacts on woody species regeneration and population structure.

Key words: Natural forest, NTFP, semi-coffee forest, species composition, woody species

1. INTRODUCTION

1.1. Back Ground of the Study

The Afromontane moist forests in southwest Ethiopia are home to a variety of plant species and are acknowledged as one of the hotspots for biodiversity (Anthony *et al.*, 2002). They are also the origin and domestication centers of Coffee arabica (Tadesse *et al.*, 2014). However, due to the intensification of coffee management, these forests are constantly changing (Schmitt *et al.*, 2010; Tadesse *et al.*, 2014) and have now been transformed into coffee agroforests that are mostly managed by smallholder farmers (Aerts *et al.*, 2011). This shift has resulted in a 34% decrease in woody forest species in southwestern Ethiopia over the past four decades, negatively affecting biodiversity and forest structure (Tadesse *et al.*, 2014; Beyene, 2022).

Different coffee production systems, ranging from forest coffee to plantation coffee, contribute to this transformation, with semi-forest coffee being particularly prevalent in disturbed areas (Kufa, 2012). A "semi-coffee forest" refers to a carefully managed agroforestry system where coffee plants are cultivated within a partially forested environment. In this system, coffee cultivation is integrated into existing forested areas, allowing coffee plants to thrive under the canopy of taller trees. The term "semi" implies that while the area retains characteristics of a forest ecosystem, it may not exhibit the full density or biodiversity of a natural forest.

Kebena forest has been piloted under a participatory forest management approach for the last five years and has potential for adjacent semi-coffee forests. Participatory forest management is the approach to manage the remaining forests of Ethiopia. However, from time to time, forests that communities regularly use are declining through different anthropogenic activities, including agricultural expansion, overexploitation, human encroachments, settlements, and the expansion of large commercial farms in forest areas (especially through the semi-forest coffee and plantation coffee systems) (EPA, 2003; MELCA Mahiber, 2008; Fekedu, 2019). According to Gole *et al.* (2002), the deforestation rate in the southwest Ethiopian coffee-growing regions is 10,000 hectares per year.

Large forest areas in Ethiopia are found in the major coffee-growing areas, including the Kebena forest in southern Ethiopia (Gole & Senbeta, 2008). These forest areas have already been globally recognized as hotspot areas for biodiversity conservation (Mittermeier *et al.*, 2005) because of the challenging anthropogenic threats to plant and animal species and their biodiversity composition. According to Valencia (2015), coffee agroforestry may be particularly significant for conserving trees of conservation concern and late-successional stage. The original habitat of forest coffee has been promoted as a means for preserving biodiversity in the tropics (Ambinakudige & Sathish, 2009). Indigenous shade trees for coffee production are very common features in the coffee production systems of Afromontane rainforests (Gole & Senbeta, 2008). Recent studies on some coffee forests of Ethiopia also showed that coffee forests are rich in plant species diversity (Gole, 2003; Schmitt & Grote, 2006; Senbeta, 2006; Gole *et al.*, 2008).

In semi-forest and sub-forest coffee systems, farmers traditionally manage their farms by removing all competing vegetation, including canopy tree seedlings and saplings, on an annual basis to boost coffee yield (Hundera, 2013). The current report revealed that increased demands for traditional coffee management to produce coffee products through traditional methods, such as situational-based thinning and regular slashing of tree seedlings and saplings, have resulted in a constant decline in forest biodiversity and native forest composition, affecting quality, structure, and the regeneration potential of native flora.

There are many studies focusing on the Afromontane forest in southwest Ethiopia (Aerts *et al.*, 2011; Hundera *et al.*, 2013; Senbeta, Denich, 2006). However, literature that bring into attention the comparative analysis of woody species diversity, regeneration status and socioeconomic value of natural forest and adjacent coffee forest are less studied. The way forest resources are used under semi-forest coffee affects woody species conservation. Hence, understanding the woody species diversity and socioeconomic benefits provides insights into resource use and conservation (Gomez *et al.*, 2010, cited by Yassin *et al.*, 2018).

My study aims to providing a holistic understanding of these aspects within the Kebena forest context.

1.2. Statement of the Problem

The Afromontane moist forests in southwest Ethiopia are renowned for their rich biodiversity and are recognized as biodiversity hotspots (Anthony *et al.*, 2002). These forests also hold

significance as the birthplace and primary domestication centers of Arabica coffee (Tadesse *et al.*, 2014). Arabica coffee is typically cultivated beneath a dense canopy of indigenous trees, a practice known as semi-forest coffee (SFC), often in patches scattered across an open agricultural landscape (Kumsa *et al.*, 2016). Despite escalating deforestation trends in Ethiopia, these moist forests remain vital natural assets, particularly for the sizable local population reliant on forest resources (Stellmacher, 2008).

The ecological and economic importance of these remaining Afromontane forests has earned significant attention. However, the intensification of coffee management has led to ongoing transformations, turning these forests into predominantly smallholder-managed coffee agroforests (Aerts *et al.*, 2011; Schmitt *et al.*, 2010; Tadesse *et al.*, 2014). Some argue this transition aids in forest preservation by facilitating regeneration (Gordon *et al.*, 2007; Gole *et al.*, 2008; Didita *et al.*, 2010), and many conservation organizations predict coffee agroforestry as a viable strategy among those proposed to reduce pressure on the remaining natural forest by serving as a buffer zone (Yasin *et al.*, 2018).

While others attribute significant forest cover loss to coffee production expansion, leading to biodiversity decline (Ambinakudige & Sathish, 2009). Coffee agroforestry is a means of exploiting natural forests to derive more benefits. On the other hand, coffee intensification results in changes in the woody species composition and regeneration status.

The Kebena forest exemplifies this trend, where semi-forest coffee cultivation displaces natural forest cover. Although previous studies have explored ecological differences between natural forests and coffee agroforestry systems in southwestern Ethiopia (Senbeta & Denich, 2006; Wiersum *et al.*, 2008; Aerts *et al.*, 2011; Hundera *et al.*, 2013), a comprehensive assessment of woody species diversity, regeneration dynamics, and non-timber forest product potentials is lacking. Therefore, the aims of this study is to fill this gap by providing insights into woody species usage, changes due to overexploitation, and the potential of non-timber forest products (NTFPs), which are essential for designing sustainable conservation approaches. Through statistical analysis, we delineate differences in forest composition, regeneration dynamics, and non-timber forest product potentials between semi-forest coffee areas and adjacent natural forests, shedding light on the ecological and socio-economic

implications of coffee agroforestry expansion for conservation and sustainable forest management.

1.3. Research Questions

- What is the species richness, diversity and how does the vegetation composition of woody species differ between natural forest and semi-coffee forest ecosystems?
- Are there differences in recruitment rates, seedling density, and sapling distribution between the two forest types?
- What are the categories and potential of Non-Timber Forest Products (NTFPs) and how do local communities utilize forest products, and what are the primary purposes for their use, and are there any disparities in the natural forest and semi-coffee forest?

1.4. Objective

1.4.1. General objective

The main objective of this study was to investigate the woody species diversity, regeneration status, and utilization patterns within the natural forest and adjacent coffee forest ecosystems of the Kebana Forest, Kersa District, Jimma Zone, and Southwestern Ethiopia

1.4.2. Specific objectives

- To quantify woody species diversity and composition within natural forest and adjacent semi-coffee forest in study area;
- To evaluate the regeneration status of woody species in both natural forest and adjacent semi-coffee forest ecosystems;
- To assess woody species used for NTFPs collection potential and access to forest products in natural forest and semi-coffee forest;

1.5. Significance of the Study

This study could provide four major benefits:

Understanding woody species diversity and vegetation composition:

Assessing the woody species diversity and vegetation composition is crucial for evaluating the ecological health and resilience of forest ecosystems. Quantifying these parameters in both natural forest and semi-coffee forest areas offers insights into the impacts of land use change, such as coffee cultivation, on biodiversity conservation and ecosystem functioning.

Assessing regeneration status of woody species:

Evaluating the regeneration status of woody species is essential for predicting future forest dynamics and ecosystem sustainability. Understanding how regeneration processes differ between natural forest and coffee forest ecosystems can inform forest management practices aimed at promoting natural regeneration and enhancing forest resilience in the face of environmental changes.

Non-Timber Forest Products (NTFPs):

NTFPs play a significant role in the livelihoods of local communities and contribute to the socio-economic value of forest ecosystems. Comparing NTFP-producing woody species categories and their potential between natural forest and semi-coffee forest environments helps identify valuable resources and potential management strategies for sustainable NTFP harvesting and economic development.

Local community access and utilization of forest products:

Understanding how local communities access and utilize forest products is crucial for promoting sustainable resource management and ensuring equitable distribution of benefits from forest resources. Evaluating access and use patterns in semi-coffee forest and natural forest environments can inform policies and interventions aimed at improving livelihoods, conserving biodiversity, and mitigating conflicts over resource access and ownership.

2. LITERATURE REVIEWS

2.1. Biodiversity Conservation

Biodiversity refers to the total number, variety, and variability of living organisms and the ecological complexes in which they occur (Rosenzweig, 1995). Floristic biodiversity specifically pertains to the number, variety, and variability of flora. Additionally, biodiversity encompasses human cultural diversity, which can be affected by the same drivers as biodiversity and, in turn, impacts the diversity of genes, other species, and ecosystems (Buscher & Whande, 2007). The distribution and quantity of species and ecosystems are expected to shift significantly, leading to the disappearance or degradation of biodiversity-rich areas, particularly in the tropics (Leadley, 2010).

The ability of forest ecosystems to adapt and recover from natural and human-induced disturbances is diminished due to the loss of forest biodiversity. Societal changes, particularly those associated with increasing wealth and consumption, further intensify pressures on forests (Haines-Young, 2009). Forest biodiversity loss is most severe in biodiversity-rich natural forests in developing countries, where deforestation and forest degradation are highest (Pereira *et al.*, 2010).

Ethiopia faces rapid deforestation and resource degradation. Forest cover decreased from 15.11 million hectares in 1990 to 12.2 million hectares in 2010, with 2.65% of the forest being deforested. As a result, approximately 700,000 hectares of forest are destroyed annually due to deforestation and degradation (Moges *et al.*, 2010). This decline is partly due to logging activities and habitat conversion for agricultural expansion, which accounts for up to 40% of forest losses (Winberg, 2010). Despite the decline in forest resources, the population heavily depends on wood (Duguma *et al.*, 2009).

Clearing natural vegetation to meet the demands of an increasing human population continues, driven by the need for agricultural land, firewood, and charcoal (Soromessa *et al.*, 2004). Most of the remaining natural high forests in Ethiopia are located in the southwest, which was relatively remote and inaccessible until recently. The three regions with the highest forest cover Oromia National Regional State, SNNPR, and Gambela have seen approximately 1.24 million hectares of natural high forests cleared for agricultural expansion between 1990

and 2014. This equates to a loss of one-third of these regions' high forest resources since 1990 (Bekele *et al.*, 2015).

Integrating local land use with biodiversity conservation through community-based forest management and environmentally friendly agricultural practices is crucial (Scherr & McNeely, 2005). Common insights and principles can improve forest biodiversity conservation across various landscapes and land uses (Lindenmayer & Hunter, 2010). These include understanding landscape mosaics and forest remnants, enhancing connectivity across landscape gradients, recognizing species' variable responses to disturbances, and acknowledging the roles of various forms of planted forests in biodiversity conservation. Improved methods for conceptualizing, organizing, and overseeing land use change have been implemented (Pfund, 2010).

Focusing on individual species and specific land uses helps recognize interdependencies between ecosystems and human populations (Bond & Parr, 2010). Conservation approaches build alliances between ecologically sustainable agriculture and existing conservation efforts to manage human-modified landscapes, enhancing biodiversity conservation and promoting sustainable livelihoods (Harvey *et al.*, 2008; Chazdon *et al.*, 2009). The extent of natural forest maintained in human-modified landscapes primarily determines species richness (Gardner *et al.*, 2010). Agricultural biodiversity includes all biological variety components related to food and agriculture, such as fish, crops, trees, livestock, and all interacting species like pollinators, symbionts, pests, parasites, predators, and competitors (Atta-Krah *et al.*, 2004).

Agroforestry systems, by incorporating additional species such as trees and shrubs into agriculture, contribute to agricultural biodiversity and provide a refuge for forest-dwelling organisms. Traditional coffee production systems are one example of such agroecosystems. Numerous investigations over the past decades, particularly in Central and South America (e.g., Méndez, 2004; Jha & Vandermeer, 2010; Méndez *et al.*, 2010; De Souza *et al.*, 2012), have demonstrated the biodiversity conservation potential of coffee agroecosystems.

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2.2. Coffee Cultivation System in Ethiopia

Coffee cultivation systems around the world fall along a continuum, ranging from nearly wild conditions to modern, highly managed systems. These systems are categorized as follows:

Wild (Forest) Coffee System: Coffee grows in a forest ecosystem with minimal or no management.

Traditional System: Characterized by high shade cover (60-90%), low coffee density (1,000-2,000 plants/ha), and low levels of management.

Modern System: Features high-yielding varieties with dense planting (3,000-10,000 plants/ha), chemical inputs, mechanization, and low levels of shade (0-50%) (Perfecto et al., 1996).

In Ethiopia, there are four major coffee production systems:

Plantation/Modern Coffee (PC):

Accounts for 10% of the nation's total coffee production. Dominant in southwestern Ethiopia. Involves large-scale plantations managed by private farmers (investors) or the state. High-intensity management practices such as weeding, pruning, fertilization, and thinning.

Garden Coffee (GC):

For 35% of the nation's total coffee production. Predominantly found in the southern, southeastern, and eastern parts of the country. Coffee is grown with other crops, especially horticultural crops like enset, fruits, and spices. Managed in areas surrounding the farmer's home.

Semi-Forest Coffee (SFC):

Accounts for 35% of the nation's total coffee production. Considered part of the forest coffee ecosystems, occupying 33% of the land designated for coffee (Senbeta, 2006). Evolved from natural forest coffee by thinning out small trees and shrubs in the lower story and large trees in the upper story. Management includes thinning of shade tree canopies and removal of competing plants. Referred to as SFC-plantation or semi-plantation coffee (SPC) by various researchers (Gole, 2003; Hundera *et al.*, 2013a).

Forest Coffee (FC):

Accounts for 15% of the nation's total coffee production. Coffee berries are harvested from naturally growing (wild) coffee in the natural forest with no management. Considered part of the forest coffee ecosystems along with SFC.

The intensity of management varies significantly across these systems. FC involves little to no interventions, while PC uses improved varieties, chemical inputs, and extensive management practices. Understanding these systems is crucial for devising strategies to balance coffee production with biodiversity conservation and sustainable land use in Ethiopia.

2.3. Categories and Uses of Non-Timber Forest Products

Forests contribute significantly to rural life by providing food, fuel, medicine, construction materials, and household items, as well as many intangible benefits like cultural symbols and ritual artifacts (Falconer, 1995, Nzinzi, 2016). The degree to which forest products are used varies greatly from region to region and even between households within a community. This variation makes it challenging to make broad statements about how non-timber forest products (NTFPs) are used. The variability highlights the crucial role NTFPs play in rural incomes, as people typically exploit forest resources when they cannot find them on adjacent fallow lands or when they are gathering for trade and better supplies are not accessible in the forests. Understanding the NTFP market requires classifying these products into related categories (Nzinzi, 2016). NTFPs can be divided based on various criteria, such as intended use (for example, food, fuel, medicine, household utensils, or farm implements), level of use (self-supporting or commercial), harvested plant parts (leaf, fruit, stem, roots), and trophy from wild animals (Nzinzi, 2016). This classification helps in better understanding and managing the market for NTFPs, ensuring sustainable use and effectively supporting rural economies.

2.3.2. Food products

According to numerous studies, many food items are removed from the forest each year and consumed by individuals or the family, particularly during the dry season to protect the family from harsh weather conditions. Wild fruits and berries, plants, essential oils, honey, nuts, seeds, spices, coffee, tea, insects, edible tubers and roots, and saps are some of the food items on this list. Many people's everyday diets include a significant amount of wild forest plants, according to (Shillington, 2002).

For instance, about 1,500 species of wild plants are gathered for consumption in central and West Africa. Among the non-timber forest products that are rich in vitamins and other essential nutrients for survival are oiled seeds, leaves, and fruit. Falconer (1992) cite in (Nzinzi, 2016) observed that although a wide range of goods are collected from forests and fallow lands, the forests frequently furnish tubers, mushrooms, and snails. Forest foods continue to play an important role in the diet of many rural households.

2.3.3. Medicinal value

This includes seeds, bark, resin, and medicinal plants (Andel, 2006). The vast majority of urban and rural residents receive their medications from forests, and a variety of people consistently rate medicines as one of the most valuable forest products. According to Falconer (1992), all people use plant medicines, and the vast majority of them (80%) depend primarily on wild plants for their medicinal needs. Plant medicines are frequently used, particularly as first aid, even in urban households. The majority of healing practices and beliefs use plants, despite the many distinct varieties. Common plant remedies are recognized and used by the majority of people, not just specialized healers.

In this regard, women are crucial because they typically provide first aid to their children. Common medicines are passed down through families, and as the environment changes, so does this knowledge. Since ancient times, many woodland plants have been used for their medicinal properties. For instance, health care is primarily a forest-based utility in Sub-Saharan Africa. According to Barfoot (2006), numerous studies have issued warnings against harvesting non-timber forest products, particularly medicinal plants. It has been noted that more medicinal plants are harvested than any other type of natural resource. For instance, there are about 24,000 natural species in China, 16 of which are used medicinally in more than 10,000 cases. Additionally, 50,000 plant types are thought to be used medicinally globally.

2.3.4. Fuel (Energy supply)

Andel (2006) mentioned lighting resins, petroleum substitutes, and fuel wood (firewood, charcoal) as forms of fuel. The sole source of energy for all rural households is fuel wood. The majority of fuel wood has gathered from fields, bushland, and forests. In none of the study communities, there is a shortage of fuel wood. Despite the fact that in some instances

where the fuel wood is used for commercial purposes, such as in markets or the preparation of cooked foods for sale, fuel wood collection may be challenging and there may not be enough easily available supplies(Falconer, 1992).

2.3.5. Animal Fodder

Even though the livestock are frequently left to roam free for part of the day, the majority of the households still gather fodder for them (Falconer, 1992). Through the provision of fodder trees and fodder shrubs, forests play a major part in the feeding of domestic and wild creatures. Since the number of livestock in most tropical nations grew proportionally to the growth in the human population in recent years, the significance of fodder trees has come to the attention of the larger scientific community. Then, it is believed that fodder plants are crucial parts of animal feed, especially as sources of proteins and as a supplement to feed during dry seasons(FAO, 1992)

2.3.6. Honey product

As ancient as human history it is beekeeping(Farm Africa, 2008). Beekeeping is a long-standing custom in Africa that is still carried out by the larger rural population. For instance, studies in Ethiopia indicated that the country's climate is suitable for a prolonged flowering season, which encourages farmers to engage in beekeeping activities (EFAP, 1994 cite in Nzinzi, 2016)).

Ethiopia has a long history of creating significant amounts of honey and beeswax, which primarily consumed locally. The estimated 43,000 tons of yearly production of honey almost exactly matched by the annual consumption. Ethiopia is one of the top ten nations in the world for producing honey and beeswax, according to (Ayalew and Gezahegn, 1991), and it is the top producer of honey in Africa. Additionally, beekeeping has a major role in the development and conservation of forests, according to Nzinzi, (2016).

This is because beekeepers preserve the forest or large tree fragments for hanging beehives, and plant blooming for a long time, so they can regularly collect honey.

2.3.7. Construction materials

These include forest products like palm leaves or grass for roof thatch, bamboo, wood (sticks and poles) (Andel, 2006). Although it is possible to buy building supplies like cement and

aluminum roofing sheets, most rural households in the study area cannot afford to do, so and instead depend on the forest for their building supplies. According to (Falconer, 1992), most country homes are made of mud and wattle, with raphia (leaf petioles) or bamboo used to create a lattice and sapling-sized trees used as standing supports. Even within a single community, a wide range of various materials are used, even though certain species are sought after for particular purposes.

2.3.8. Household utensils and agricultural equipment

Forest products like fibers, baskets, furniture, bows and arrows, dye, paint, varnish, and glue are included in this(Andel, 2006). NTFP frequently appears in material culture as a supplier of marketing, agricultural, and household equipment. Mortars, furniture, and sleeping mats, wood for hoe and other tool handles, agricultural tools, poles for crop storage containers and crop dryers, canes for baskets, crop drying mats, fish traps, and other fishing equipment are additional necessary domestic items. Every household uses items made from NTFPs in their daily lives and the majority of items are made rather than purchased in the home(Falconer, 1992)

2.4. Diversity Indices

The result of species richness and evenness is species diversity. Different metrics can used to measure diversity. A community's species variety quantified mathematically using a diversity index (Frosini, 2006).

Richness and evenness are the two primary metrics used to assess diversity. The difference in the number of species in two or more communities must taken into account for a diversity index to be sensitive to both of these factors (Negash *et al.*, 2013). Species richness is a measure of the variety of species at a given site and can expressed in a mathematical index to compare diversity between sites (Frosini, 2006).

A community's species diversity directly related to a richness measure. The number of species found in a community with at least one individual known as its species richness (Dinkisa, 2011).

The second factor, evenness, gauges the relative abundance of various species that make up the region's richness (Dinkisa, 2011). A species' frequencies or proportions determine an

evenness index, which, according to Frosini (2006), rises when the proportions tend to be equal or perfectly homogeneous and decreases when one species tends to dominate the others (Frosini, 2006). Richness has a precise bearing on how evenness is to be interpreted (Dinkisa, 2011).

The species diversity indicator (Frosini, 2006) provided information about species rarity and frequency. Additionally, diversity indices reveal more about the makeup of communities than just species variety and relative species abundances (Woldu, 2012). This kind of quantitative measurement of diversity is a crucial instrument for comprehending community structure. Additionally, historical significance has been attached to measuring diversity because of the clear declines in habitat diversity (Frosini, 2006). Shannon-Wiener index and Sorenson's index of similarity were two of the diversity indices most frequently used among numerous species (Mueller-Dombois and Ellenberg, 1974).

2.4.1. Shannon- Wiener index of diversity

The most useful diversity measure is the Shannon- Wiener index (Grieg-Smith, 1983). We'll use a metric called the Shannon-Wiener diversity index to extract data from field sample data. It blends the species richness and species evenness, two quantifiable measures. The Shannon Diversity Index (H') was calculated using the following formula.

$$H' = -\sum_{i=1}^S P_i \ln P_i \quad (\text{Krebs, 1989})$$

Where H' = Shannon- Wiener index of Diversity, S = total number of species; P_i = is the proportion of each species (individuals) or the abundance of the i th species expressed as proportion of total cover; and $\ln$ = log base n Shannon- Wiener diversity index is a representative of diverse communities (Grieg-Smith, 1983; Kent and Coker, 1992; Frosini, 2006).

Shannon's Equitability or Evenness (E) is given by $E = H'/\ln S$ (Kent and Coker, 1992) Where E = Shannon's Equitability or Evenness, H' = Shannon- Wiener index of Diversity, S = total number of species; and $\ln$ = log base n .

E has a value between 0 and 1, where 1 represents perfect evenness. An even distribution of the species would result in a high E value. As a result, the E value enables us to determine how a species' abundance is spread throughout the community's species (Mosleh, 2017).

2.4.2. Measurement of similarity and dissimilarity

The degree to which the species composition of quadrats is alike is a Similarity indices measure; whereas dissimilarity coefficient assesses which two quadrats differ in composition (Dinkisa, 2011). Sorenson is the most common binary similarity coefficients because it depend on presence or absence data. The coefficient of Sorenson differs from the other measurements since it gives more weight to species that are present in both quadrats and less weight to species that are present in only one quadrant. Sorenson's Coefficient is expressed as $S_s = 2a / (2a + b + c)$ (Kent and Coker, 1992 Where S_s = similarity, a =number of species with common to both quadrats; b = number of species unique to quadrat 1; and c = number of species unique to quadrat 2, to give percentage similarity index multiply mostly the coefficient by 100.

2.5. Species Importance Value Index (SIV) and Dominance

The species dominance of the woody were described and compared using the Importance Value (I.V.) metric developed by Cottam and Curtis in 1956. To comparing the ecological significance of different species, the importance value (IV) of a forest is helpful (Hambrech, 1989)

The important value index (IVI) enables species comparison within a specific forest type and illustrates the sociological makeup of an entire population within a given community. It is the total of a species' dominance, occurrence, and abundance relative to other species that are present in the same area (Kent and Coker, 1992). This makes it a useful index for ranking species for management and conservation strategies and summarizing vegetative characteristics (Bayisa *et al*, 2020)

The species' great dominance and density, which may be related to the low demand for timber from the local population, are the main causes of their high IVI value (Gebrehiwot, 2014).

SIV-lower species require greater conservation efforts than SIV-higher species, which require monitoring and management (Kent and Coker, 1992). However, this can only indicate something if and only if the species being compared has the same kind of habit. Typically, a higher percentage of a forest's IVI value contributed by the abundant, frequent, and dominant species (Simon Shibru and Girma Balcha, 2004).

2.6. Abundance and Frequency

The quantity of plants per square meter is abundance. The number of distinct species of plants in specific area must be counted in order to calculate plant abundance. It can be used to display ranges and spatial distribution over time. The percentage of plots where a species occurs is its frequency. It is a measurement of the amount of a particular species in a particular area. It provides information on species distribution and serves as an important ecological metric. In other words, it provides an idea of the homogeneity of the stand being evaluated (Kent and Coker, 1992)

2.7. Regeneration Status of the Forest

The potential regenerative state of individual species within a forest stand in space and time determines the future composition of the forest (Henle *et al.*, 2004). The population structure, characterized by the presence of sufficient population of seedlings, saplings and matured indicates successful regeneration of forest species (Tesfaye *et al.*, 2017). In plants, the colonization of forest gaps, new habitats and the maintenance of diversity and evolutionary potentials achieved mostly through regeneration. It is therefore surprising that despite more than a century of interest by foresters, very little detailed information is available on the regeneration and the dynamics of regeneration stages (Molla, 2016). However, any effective conservation and restoration plan must comprehend spontaneous renewal. Production, grazing, germination, dispersal, establishment of new individuals (recruitment), and development to mature (reproductive) trees are all included in regeneration (Pausas, 1997). Regeneration status of the forest analyzed by comparing seedling and saplings with mature trees (Dhaulkhandi *et al.*, 2008; Tiwari *et al.*, 2011).

3. MATERIALS AND METHODS

3.1. Location of Study Area

The study conducted at Kebena Natural forest, which found in Jimma Zone, Oromia National Regional State, and shared by four woredas (Kerssa, Limu Kosa, Limu Seka, and Manna). Which is located about 323 km Southwest of Finfinnee and about 22km East of Jimma town. Geographically Kebena Forest is located at latitude of $7^{\circ} 43' - 8^{\circ} 00'$ North latitude and $36^{\circ} 56' - 37^{\circ} 14'$ East longitudes with an altitude range between 1200 and 3020 m a sl. (Limu Kosa Agricultural Development Office, 2013). Kebena forest is one of the moist mountain forest ecosystem found in southwestern Ethiopia. The forest area administered under the Oromia forest and Wildlife enterprise Jimma branch Babia Fola district. According to the (OFWE, 2010) the total area of Kebena forest was more than 25,000 in ha.

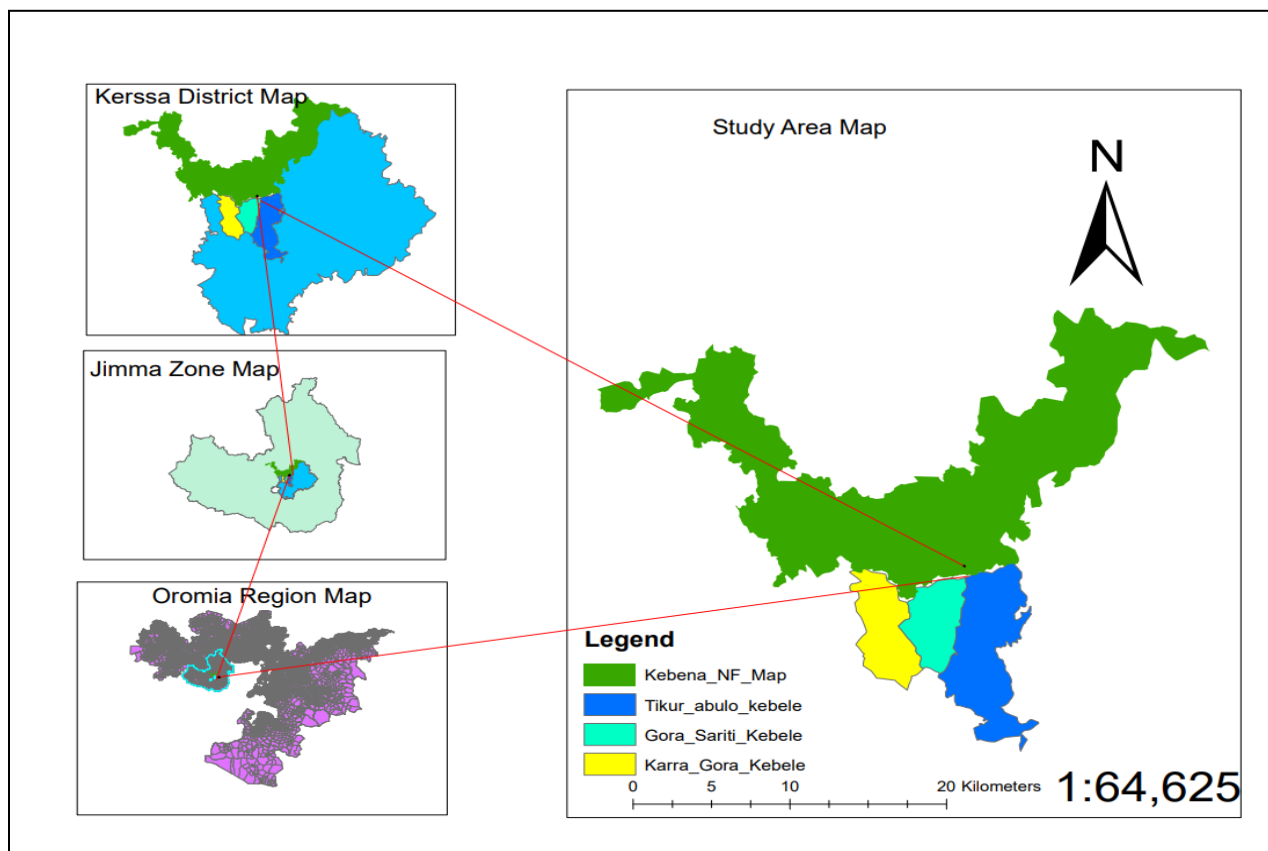


Figure 1: Map of Study area

3.1.1. Demographic and socio-economic characteristics

The total population of Kerssa district was 234,886 [2022 – *Projection*] of which 118,101 (50.3%) males and 116,785 (49.7%) female. Forest demarcation statistics (2014) from the Jimma branch office of Oromia Forest and Wildlife Enterprise indicate that the concession area of the study area is assessed to be 3735.27ha total, of which 555.27ha is planted forest and the rest of it is natural forest.

3.1.2. Soil Types

The present land configuration of the district is the result of tertiary volcanic (Acidic volcanic & Basaltic flow). The largest part of the district areas belong part of western highland and associated low land (Tariku, 2017).

3.1.3. Topographical and climate

Geographical it found between 7°43'-80 00' North latitudes and 36°56'-370 14' East longitudes. The altitude of the area ranges between 1600 -2400 meters above sea level. The annual rainfall of the area ranges between 1000-1800 mm. The rainfall of the district is weakly bi-modal with spring a small rainy season during the months of April and May while summer along rainy season during the months of June, July and August(Tariku, 2017)

3.1.4. Vegetation

Vegetation coverage area of the district was consists 65.1% cultivation, 30.5% forest, 2% woodland, and 2.4% grassland. The largest dense forest does ideal for the harvesting the natural coffee (Tariku, 2017).

3.2. Methods

3.2.1. Reconnaissance Survey

In February 2023, a reconnaissance survey was conducted in Kersa District, is one of the 22 districts of Jimma zone, to gather baseline information and understand vegetation distribution in both natural forest and semi-coffee forest areas. Following the guidance of Schulz *et al.* (2009), it was deemed critical to understand the extent of vegetation and determine the appropriate number of plots to be set up per hectare before data collection. As a result, the

number of plots, transect lines per site, and the direction of transect lines were determined for both natural forest and semi-coffee forest sites.

Accurately delineating the boundaries of the study site is essential for precise measurements and efficient work. During the reconnaissance survey, the researcher familiarized themselves with the local plant species and compiled a checklist of these species. This preparatory phase not only facilitated the identification of key vegetation types but also ensured that the subsequent data collection process would be well-informed and systematic

3.2.2. Site selection

Kebana natural forest, Kerssa District was purposefully selected from the four (Manna, Limu Kosa, Limu Seka and Kerssa), since Kebana forest shared boundaries with these all woredas. Due to its strategic location and based on others criteria, including the presence of natural forest adjacent to semi-coffee forest areas, accessibility via road networks, and the extensive boundary sharing between many kebele (sub-districts) of the district and Kebana natural forest.

Within Kersa District, three kebele were purposively selected for the study: Karra Gora, Gora Sariti, and Tikur Abulo. These kebele were chosen because they comprise users of both Kebana natural forest and adjacent semi-coffee forest areas. This selection allows for a comprehensive understanding of the dynamics between natural forest utilization and semi-coffee forest management practices within the study area.

3.2.3. Sampling Design and Techniques

In the study area encompassing the three kebele (Karra Gora, Gora Sariti, and Tikur Abulo), the forest was stratified into two based on forest management practices, natural forest and semi-coffee forest. To systematically assess vegetation characteristics, a systematic transect sampling technique was employed in both semi-coffee forest and natural forest areas.

Sixty plots were established across both natural forest and semi-coffee forest, with 30 plots allocated to each Natural forest and Semi-coffee forest sites. Following the methodology outlined by Kent and Coker (1992), each plot was set at a size of 20 m x 20 m, with a distance of 100 m between consecutive plots.

At the Karra Gora site, two transect lines were established for each natural forest and semi-coffee forest. Along the first transect line, eight plots were laid out, while seven plots were established along the second transect line, which was set 300 m apart from the first. The positioning of the first transect line was determined randomly on one side of the forest with the assistance of a compass, and the second transect line was set parallel to the first.

On the other hand, at the Gora Sariti and Tikur Abulo sites, a single transect line was laid out for each natural forest and semi-coffee forest. Ten main plots were designated along the transect line at Gora Sariti, while five main plots were established at Tikur Abulo, depending on the vegetation status.

All transect lines were positioned along the elevation gradient of the forest to encompass different species found along the gradient. Each plot covered an area of 400m² and was spaced along the transect lines. This plot size was chosen to ensure comparability with previous research studies that employed 400 m² plot sizes for floristic studies (e.g., Mulugeta Lemenih *et al.*, 2004; Feyera Senbeta *et al.*, 2007).

Within each main plot, subplots of 10m x 10m and 5m x 5m were nested for assessing saplings and seedlings respectively (Figure 1). To mitigate edge effects, all sample plots were positioned at least 50 meters away from any internal roads or forest margins (Senbeta, and Teketay, 2001). This approach aimed to ensure the representativeness and accuracy of the collected data in capturing the true vegetation composition and structure within the study area

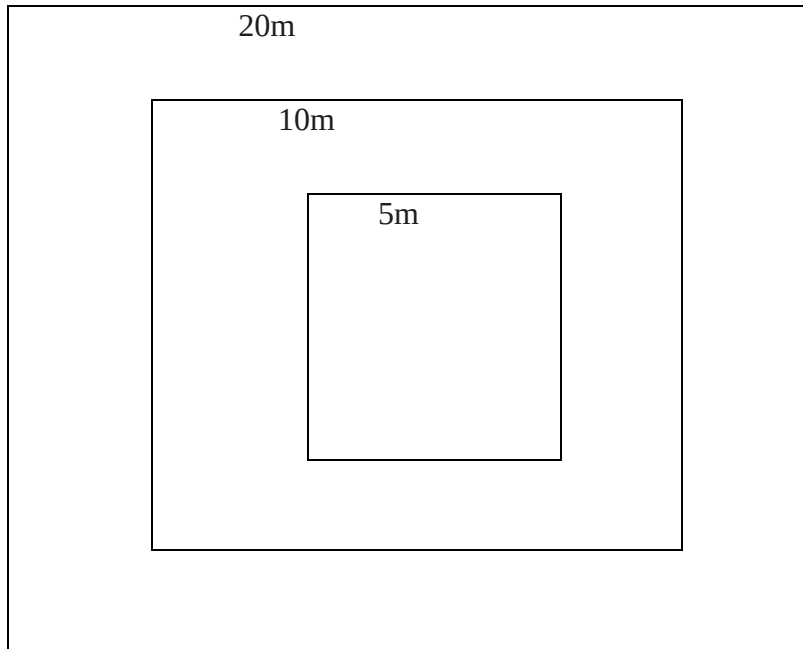


Figure 2: Sample plot design

3.2.4. Vegetation Data Collection

Woody species were surveyed, and their diameter at breast height (DBH) was measured for trees and shrubs with a height of ≥ 2 m and DBH ≥ 10 cm. Height was measured using a hypsometer, while DBH was measured using a diameter tape. In each plot, all naturally regenerated woody species were identified, with seedlings (≤ 50 cm in height, < 10 cm DBH) and saplings (> 50 cm - 2 m in height, < 10 cm DBH) counted in plots of 5 m x 5 m and 10 m x 10 m, respectively (Kelbessa and Soromessa, 2008; Yasin *et al.*, 2018; Abdo *et al.*, 2020).

As per Bhishma *et al.* (2011), trees and shrubs bordering the quadrat were classified as included if more than 50% of their basal area was inside the quadrat and excluded if more than 50% was outside. Trees overhanging into the quadrat were excluded, but trees with their trunks inside the sampling quadrat and branches outside were included.

During vegetation data collection, parameters such as dominance, frequency, abundance, diversity, importance value index (IVI), and population structure or regeneration status of all encountered woody species were considered.

Local names of woody species (in Afan Oromo) and their local uses were recorded following consultations with knowledgeable members of the local community in the field. Plant

documentation followed the nomenclature of plant species as published in the Flora of Ethiopia and Eritrea (Edwards *et al.*, 2000; Hedberg *et al.*, 2006) and Useful Trees and Shrubs for Ethiopia (Bekele, 2007).

3.2.5. Questioner survey

The selection of household heads was carried out using a systematic random sampling technique, resulting in a total sample size of 128 household heads for this study. The determination of this sample size was based on a formula outlined by Barlett *et al.* (2001) and was decided proportionally to the total kebele population size for this study.

Table 1: Sample size determination of households

Name of kebele	Total household	Sample size
Kara gora	960	52
Gora sariti	682	37
Tikur abulo	724	39
Total	2366	128

Socioeconomic information was gathered from all households comprising the total sample size. Structured and semi-structured questionnaires were prepared and administered in each selected kebele to collect data. The questionnaire comprised two parts: the first part focused on background information of the respondents, while the second part delved into detailed questions about the socioeconomic influences related to key Non-Timber Forest Products (NTFPs) producing Woody species in the study area. These questions were directly presented to each sample respondent through face-to-face interviews. Information regarding landholding size, family size, age of the respondent, education, number of livestock owned, and the benefits of woody species and NTFPs were gathered.

3.3. Vegetation Data Analysis

Woody species diversity index, Sorensen's similarity index and Important Value Index were used to analyze. The indexes were calculated using the formula following Magurran (2004). All individuals of species registered in all the sample quadrates used in the analysis of diversity, frequency, density, dominance and regeneration status. The Diameter at Breast

Height (DBH), basal area, tree density, frequency and important value index were used for description of vegetation structure.

Comparisons of diversity, species richness, mean uniformity and density in the two forest areas were analyzed using one-way ANOVA. An analysis of variance (ANOVA) was performed using the values for diversity, species richness, mean evenness and density to determine whether there was a significant difference in mean woody species between natural forest and semi coffee forest.

The potential status of NTFPs woody species categories diversity, density, important value index and basal area between the natural forest and semi coffee forests were hypothesized by t.test.

3.3.1. Woody species diversity indices

Woody species diversity was analyzed using Shannon diversity index (H') and Shannon equitability/evenness index (E). These diversity indices provided important information about rarity and commonness of species in a community

The Shannon-Weiner diversity index (H') was calculated using the following equation

$$H' = - \sum_{i=1}^s P_i (\ln(P_i))$$

Where, H' = Shannon diversity index, s = the number of species, P_i = the proportion of individuals of the ith species expressed as a proportion of total cover in the sample, and ln = the natural logarithm.

Species richness was determined by adding up the number of species of woody plants that were found in the sample plot.

Shannon evenness (E): Evenness was calculated to compare the observed distribution with the maximum possible even distribution of the number of species in the studied forest (Pielou, 1975) or it is the distribution of individuals among the species in a studied forest. Evenness is maximums when all the species have same or nearly equal number of individuals

This is how Shannon's Evenness or Equitability Index is determined:

$$J = H' / H_{max}; = H' / \ln(S)$$

Where: J = Evenness; H' = Shannon-Wiener Diversity Index; Hmax = ln(S); S = total number of species in the sample.

The value of evenness index falls between 0 and 1.

Similarity and dissimilarity analysis

The degree to which the species composition of several systems is similar is gauged using similarity indices. There are many methods for determining how similar or distinct vegetation samples or plots are. Because it provides greater weight to species that are common in the samples than to those that only appear in each sample, the Sorensen similarity coefficient was used to examine the similarity in the species composition across the agro-ecology and between research sites (Kent, 2011). The following equation was used to calculate the Sorensen coefficient of similarity (S s):

$$Ss = \frac{2a}{2a+b+c} * 100$$

Where Ss= Sorensen similarity coefficient

a = number of species common to both site

b = number of species in site one

c = number of species in site two

3.3.2. Regenerations status data analysis

Height class vs. density for each height class used to determine the population structure and regeneration status, In other words, by comparing the number of each individual seedling, sapling, and mature tree or shrub (Gebrehiwot and Hundera, (2014). Regeneration status assigned:

Good", if the number of seedling > sapling > mature strata; „Fair“, if the number of seedling > sapling < mature strata; „Poor“, if the number of mature > sapling> seedling strata; „None“, if a species is absent, both in sapling and seedling stages, but present as mature; and New“, if a species has no mature, but only sapling and/ or seedling stages.

To compare the status of the two-forest type's R. version 4.1.3 used in determining standard error of the mean. Then density, population structure, of trees and shrubs plotted for both types of forest using Microsoft excel.

3.3.3. Woody species producing NTFP statistical data analysis

In this study, the collecting data from woody species inventory and household questionnaires were be coded, computerized and analyzed using the Microsoft Excel and R. version 20 for different statistical purpose. T-test used to compare, NTFP bearing woody species categories composition differences in the natural forest and semi-forest coffee

3.4. Household survey data analysis

The data collected through questionnaire interview coded, cleaned and analyzed by means of Microsoft Excel 2010. Additionally the Data was analyzed and summarized using percentages and descriptive statistical, for investigation the NTFP contribution to local community of woody species diversity. Family size, wealth status, educational level, land holding size and income, Population growth, Agricultural land expansion, Fuel wood, Charcoal production, are the socioeconomic variable at the two forest area.

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4. RESULTS AND DISCUSSION

4.1. Woody Species Composition in Natural Forest and Semi Coffee Forest

The species accumulation curve used to calculate the total sample size needed to evaluate woody species. As seen by Figure 3, the natural forest coffee plots levels out at the 26th and semi-forest coffee plot levels out at the 24th. This suggests that there were enough samples collected overall for both NF and SFC in this investigation.

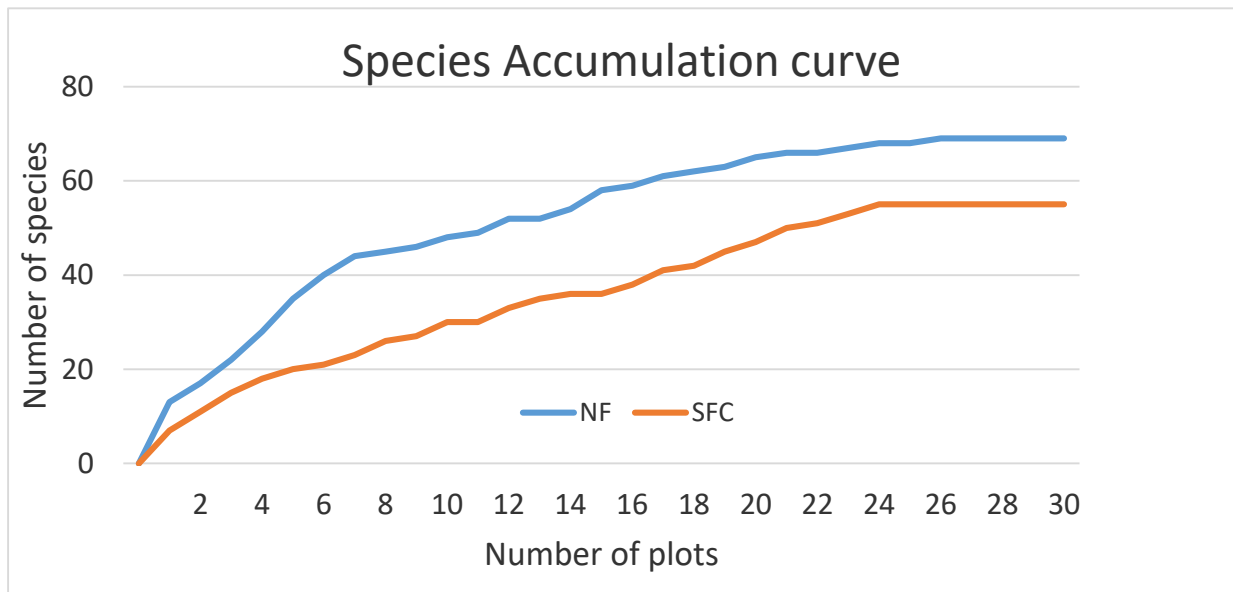


Figure 3: Species accumulation curve of natural forest (NF) and semi- coffee forest (SCF)

There are 75 known woody species, belong to 45 families and 65 genera. Within this diversity, the natural forest hosts 69 species across 62 genera and 44 families, while the semi-forest coffee environment supports 55 species covering 48 genera and 35 families (see Appendices 2 and 3). Despite the greater number of woody species in the natural forest, the statistical analysis did not reveal a significant difference ($p > 0.05$). This finding resonates with previous research by Molla and Asfaw (2014) and Fekadu *et al.*, (2019), which observed similar trends in woody species diversity between natural forests and coffee agroforestry systems. In the natural forest, dominant families include Fabaceae, Oleaceae, and Celastraceae, each represented by four species (17.4%), followed by Araliaceae and Rubiaceae, with three species each (8.7%). These dominant families collectively account for 26% of the total woody species in the natural forest. Twelve families, Rosacea,

Euphorbiaceae, Sapotaceae, Acanthaceae, Asteraceae, Ebanaceae, Flacourtiaceae, myrsinaceae, Solanaceae, were represented by two species each, these families covered 35% of the total woody species of the natural forest, and whereas, 27 families were represented by one species each, and they consist 39% of the total woody species in the natural forest. In the semi-forest coffee, dominant families are Celastraceae and Fabaceae, each with four species, followed by Rubiaceae and Oleaceae, each with three species. Together, these four dominant families comprise 25.4% of the total woody species. Additionally, 10 families are represented by two species each, covering 36.4% of the total woody species, while the remaining 21 families are represented by one species each, accounting for 38.2% of the total woody species in the semi-coffee forest.

Family, Fabaceae, Celastraceae, Oleaceae, and Rubiaceae were dominant families in both Natural forest and semi forest coffee. This is in line with previous study in which *Fabaceae* and *Asteraceae* have been reported as dominant families in the Afromontane Flora of Ethiopia (Negusse, 2006); Getachew *et al.*, 2008). The dominance of Fabaceae and Asteraceae could be attributed to their efficient and successful dispersal mechanisms and adaptation to a wide range of ecological conditions (Ensermu Kelbessa and Teshome Soromessa, 2008). Fabaceae is the largest family in the Flora of Ethiopia and Eritrea. They were better for coffee shade, these common dominant families for coffee in natural and semi-forest environments became dominant in coffee forests. Fekadu *et al.* (2019) in the Belete Gera forest and Burik (2015) in the Gera forest who reported these family members, and verify this conclusion.

The Sorensen's floristic similarity index indicates a high degree of commonality (0.790) in woody species between the natural forest and coffee forest, Forty-nine woody species were common to both natural forest and semi forest coffee (Appendix Table 4). This implies that more woody species commonality between the two-forest communities. Sørensen (1948) revealed that Sørensen's similarity index of 0 indicates there is no species similarity between the communities and a value of 1 indicates exactly the similar species are found in both communities. This index underscores that the woody species in the semi-forest coffee have been established from the natural forest through intensified management practices, retaining remnants of the past forest.

Notably, from the total recorded tree species, 20 (29%) are unique to the natural forests, while 6 (10.9%) are unique to the coffee forest ecosystem. This suggests that intensive coffee management compared to the natural forest influences woody species composition in semi-coffee forestry systems. The finding of this study also agrees with the findings of (Kewessa *et al.*, 2019; Hylander; Sileshi 2009) and contradicts with the finding of (Mendez *et al.*, 2007).

In both the semi-coffee forest and natural forest, trees, shrubs, and lianas are present. In the natural forest, trees account for 57% of woody species, shrubs for 35%, and lianas for 8%, while in the semi-coffee forest, trees constitute 62.3%, shrubs 33.33%, and lianas 4.37% (see Figure 4). The increase in tree species proportions and decrease in shrubs and lianas in semi-forest coffee are attributed to the removal of undergrowth during coffee management practices to optimize coffee production. This trend aligns with findings by (Yassin *et al.*, 2018; Hundera *et al.*, 2013; Fekadu *et al.*, 2019), indicating a decrease in shrubs and lianas due to coffee management techniques discouraging undergrowth and leading to a decrease in woody species in semi-forest areas.

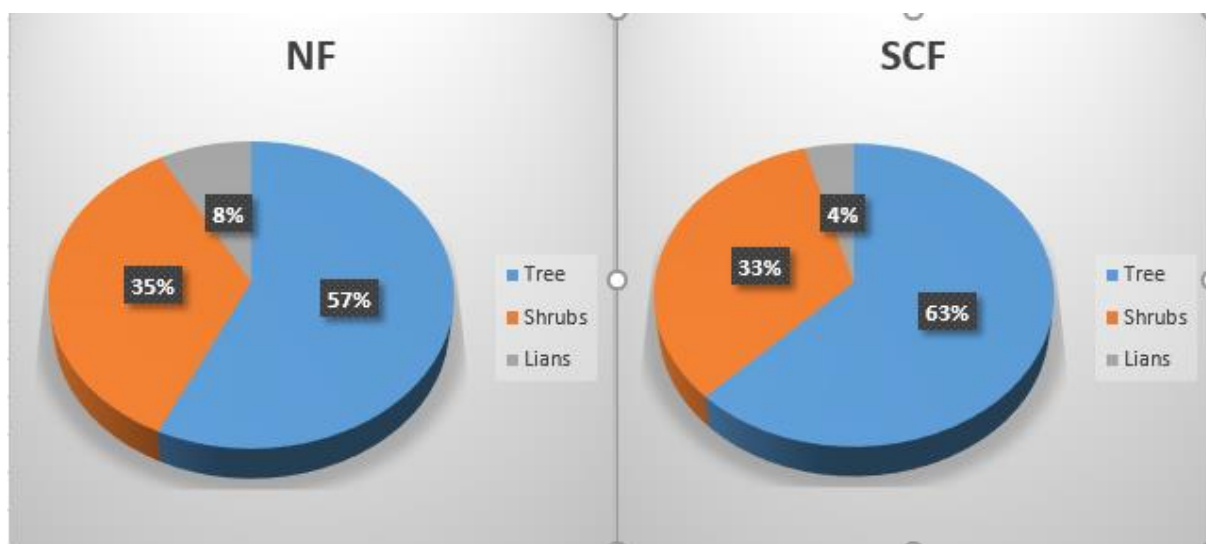


Figure 4: Woody species life form proportion in Natural forest and semi-coffee forest

4.1.1. Woody species diversity in natural forest and semi-coffee forest

The Shannon's diversity index of woody species was calculated for both the natural forest ($H' = 3.79$) and semi-coffee forest ($H' = 2.55$), with corresponding Shannon evenness indices of 0.89 and 0.69, respectively. The H' of this forest is within the value of Shannon diversity index for most vegetation's, which usually falls between 1.5 and 3.5 (Magurran, 1988), and

suggests that this forest is of good diversity. The species evenness value ranges between 0 and 1. When it is 0, the area is dominated by single species and when it is 1, the species are evenly distributed in the area. The analysis result also indicated that the average evenness value for natural forest is 0.89; showing more evenly distributed of individuals of most woody species in the sampled plots whereas semi coffee forest is 0.69: shows less evenly woody species distribution when compared to natural forest. However, despite these differences, the variance in Shannon diversity of woody species between the natural forest and semi-coffee forest was not statistically significant ($p > 0.05$), as indicated in Table 2. Despite the lack of statistical significance in the difference in Shannon diversity between natural forest and semi-forest coffee, these findings underscore the importance of maintaining biodiversity in both ecosystems. Further research and conservation efforts are warranted to better understand and preserve the ecological integrity of these environments.

This finding is similar to that of Belete Gera Forest in Southwestern Ethiopia. Yassin *et al.* (2018) reported Shannon diversity indices for natural forest and coffee agroforestry as $H' = 3.79$ and $H' = 2.82$, respectively. The species evenness for the natural forest and coffee agroforests was 0.95 and 0.81, respectively. Similarly, Abdo *et al.* (2020) reported Shannon diversity indices of $H' = 3.15$ for the natural forest and $H' = 2.32$ for the coffee agroforest in Manna District, Southwestern Ethiopia. The Shannon evenness values for the coffee agroforests and natural forests were 0.72 and 0.92, respectively.

Table 2: Diversity of woody species in Natural forest and Semi-coffee forest

Forest site	species Richness	Shannon index	
		Shannon diversity	Shannon evenness
Natural Forest	69	3.79	0.89
Semi-coffee forest	55	2.55	0.69
p-value	0.184	0.350	0.235

4.1.2. Density and frequency of woody species in natural forest and semi forest coffee

The total density of woody species in the natural forest was observed to be 4919 individuals per hectare, whereas in the semi-coffee forest, it was significantly lower at 1262 individuals per hectare, with a statistical significance at $p=0.05$. This difference may be attributed to the removal of certain species during coffee management practices.

Among the most densely populated species in the natural forest were *Dracaena afromontane* (51 individuals/ha), *Croton macrostachyus* (30 individuals/ha), *Teclea nobilis* (28 individuals/ha), and *Albizia grandibracteata* (24 individuals/ha). *Albizia grandibracteata* is a deciduous tree with a rounded or flat crown; it can grow 6 - 30 meters tall. The tree is harvested from the wild for local use as a medicine and source of wood. It is cultivated as an ornamental and shade tree, and to improve the soil (Plant Resource of Tropical Africa and Useful Tropical plants). In contrast, in the semi-coffee forest, *Coffee arabica* had the highest density (248 individuals/ha), followed by *Albizia grandibracteata* (39 individuals/ha), *Albizia gummifera* (23 individuals/ha), *Allophylus abyssinicus* (17.5 individuals/ha), and *Anogeissus leiocarpus* (14 individuals/ha) in descending order.

This disparity in density indicates that the natural forest harbors a higher density of woody species both in total density and per individual density compared to the semi-coffee forest. This finding aligns with the results presented by Beyene (2022), who reported average densities of 689 individuals per hectare in naturally occurring forests and 401 individuals per hectare in traditionally managed coffee agroforestry systems.

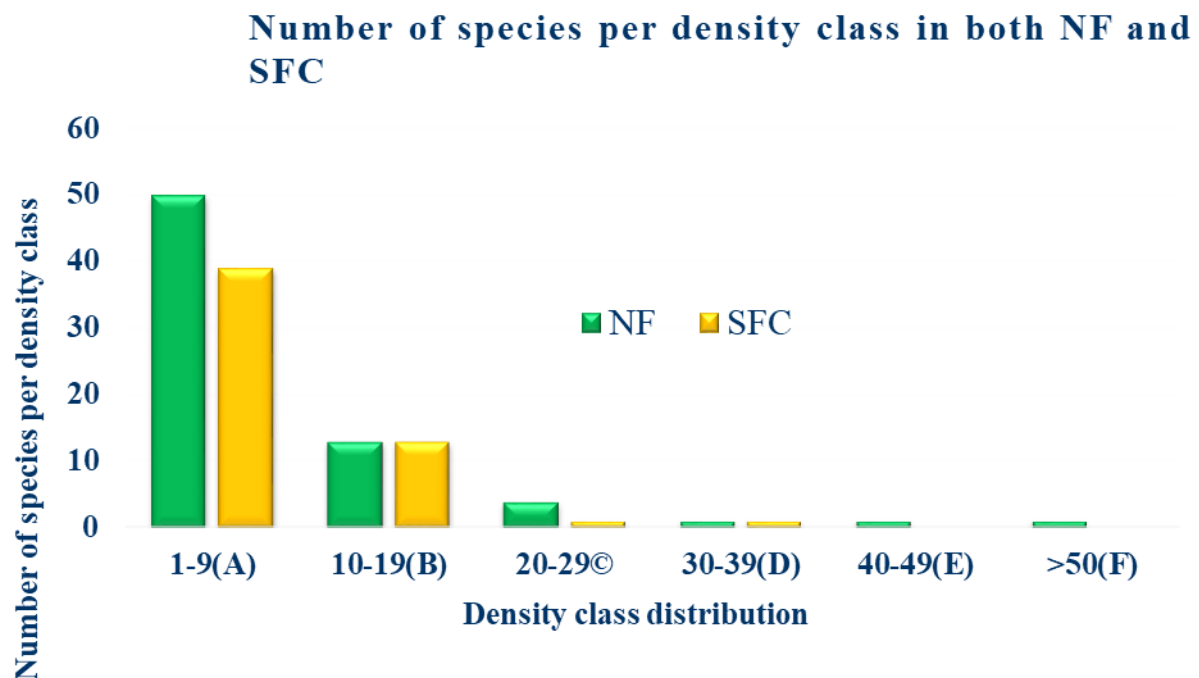


Figure 5: Density Class Distribution of species in Natural forest and Semi-coffee forest

The result of the study showed that the variation of the species frequency ranges between 3.3 – 80% in natural forest and in semi forest coffee (Figure 6). The species frequency classes were A (3-20%), B (21-40%), C (41-60%), D (61-80%), in Natural forest and Semi forest coffee. *Croton macrostachyus*, *Teclea nobilis* and *Dracaena afromontana* were species only found in the fourth class D (61-80%) it counts 4.4% of the total species, however in semi-forest coffee, 10 species. *Albizia grandibracteata*, *Albizia gummifera*, *Allophylus abyssinicus*, *Allophylus abyssinicus*, *Anogeissus leiocarpus*, *Apodytes dimidiata*, *Asplenium protensum* Schard., *Bersama abyssinica* *Caparis tomentosa*, and *Clausenia anisata* species recorded in fourth class (61-80% (D)), it accounts 18.5% of the total species. Most species recorded in the first class (A), which accounts 69.3% and 44.4% of the total species in natural forest and semi forest coffee respectively (Figure 6).

In natural forests, there appears to be greater homogeneity in species distribution compared to semi-forest coffee plantations. This difference could indeed be attributed to the specific management practices employed in coffee cultivation. In semi-coffee forest plantations, there's a higher frequency of certain species found in the fourth class (D) compared to natural forests. This difference might be a result of intentional management decisions made by coffee owners or local communities to favor specific shade tree species that benefit coffee cultivation. These shade trees could be selected based on their ability to provide suitable microclimatic conditions, improve soil fertility, or offer other ecosystem services that support coffee growth.

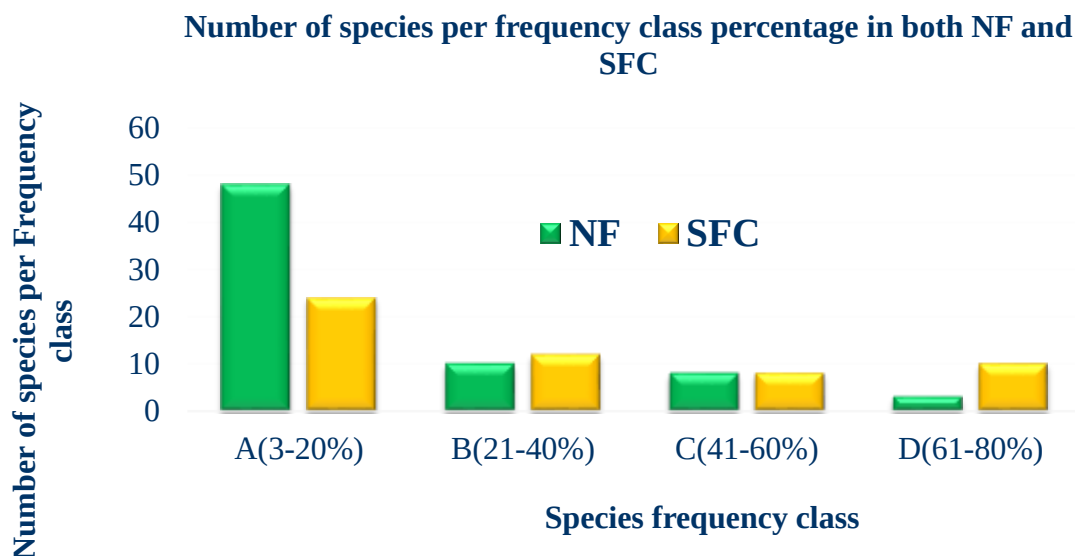


Figure 6: Frequency class distribution of species in Natural forest and Semi-coffee forest

4.1.3. Important value index

The Importance Value Index (IVI) serves as a comprehensive measure summarizing the dominance, abundance, and frequency of species within ecosystems. In this study, the IVI values for all woody species in both the natural forest and semi-coffee forest are listed in Appendices 5 and 6. Additionally, the ten leading dominant and ecologically significant woody species in each forest type are presented in ascending order in Table 3.

In the natural forest, the species with the highest IVI values were *Croton macrostachyus* (25%), *Pouteria adolfi-friederici* (17%), and *Dracaena afromontana* (15%), among others. On the other hand, in the semi-coffee forest, the highest IVIs were recorded for *Pouteria adolfi-friederici* (34.59%), *Croton macrostachyus* (25.501%), and *Maytenus undata* (17.73%), followed by other species. The IVI serves as an indicator of the overall importance of a species within a particular area, providing insights into its ecological success (Worku *et al.*, 2012)

Table 3: Important value Index in Natural forest and Semi-coffee forest

Natural forest		Semi-coffee forest	
Botanical name	IVI	Botanical name	IVI

<i>Croton macrostachyus</i>	24.676	<i>Pouteria adolfi-friederici</i>	34.588
<i>Pouteria adolfi-friederici</i>	17.114	<i>Croton macrostachyus</i>	25.501
<i>Dracaena Afromontane</i>	15.284	<i>Maytenus undata</i>	17.733
<i>Ficus sur</i>	13.428	<i>Ficus sur</i>	17.623
<i>Teclea nobilis</i>	12.261	<i>Syzygium guineense</i>	16.512
<i>Polyscias fulva</i>	12.156	<i>Albizia grandibracteata</i>	16.225
<i>Albizia grandibracteata</i>	12.127	<i>Apodytes dimidiata</i>	14.354
<i>Prunus africana</i>	10.027	<i>Polyscias fulva</i>	13.274
<i>Schefflera abyssinica</i>	9.778	<i>Albizia gummifera</i>	12.048
<i>Albizia gummifera</i>	9.748	<i>Olea hochstetteri</i>	10.747

4.1.4. Population structure of natural forest and semi-coffee forest

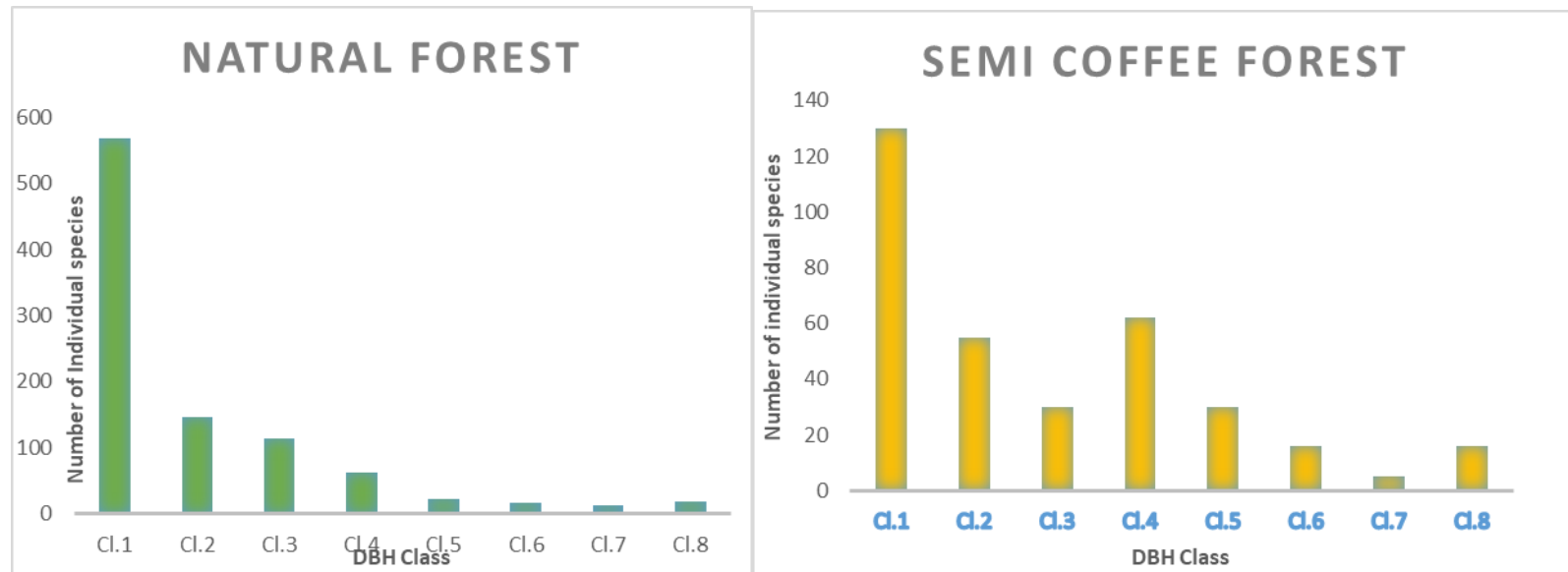
The distribution of individuals across different diameter at breast height (DBH) size classes exhibited distinct patterns in natural forests and semi-coffee forest systems. In the natural forest, the distribution displayed an inverted **J** shape, with a majority of individuals concentrated in the lower diameter size class (see Figure 7); Small sized woody species predominate in the natural forest. This indicates Kebana natural forest has been exposed to high rate of deforestation through selective cutting of large sized individuals and it is in the stage of secondary regeneration whereas in the semi-coffee forest system, the distribution was irregular (see Figure 8). This irregularity may be attributed to coffee management practices, including the removal of certain lower woody species and selective management of specific coffee shade tree species

Specifically, 59.1% of individuals in the natural forest and 37.8% in the semi-coffee forest were concentrated in the lower diameter size class, while only 1.9% and 4.7%, respectively, were found in the higher diameter size class (> 70 cm). The low number of woody species in higher diameter classes might be due to selective use of the mature trees in the higher DBH class for different purposes like house construction, and timber. This pattern aligns with findings from Beyene (2022), indicating a higher percentage of individuals in DBH classes greater than 60 cm in traditionally managed coffee agroforestry systems compared to natural forests. Overall, the diameter class distribution exhibited an inverted J-shape in the natural forest. Indicating a higher concentration of species in lower diameter classes, gradually decreasing towards higher classes, while in the semi-coffee forest, the shape was irregular.

The higher DBH species in both forest were recorded by *Apodytes dimidiata* (173cm), *Pouteria adolfi-friederici* (155cm), *Prunus africana* (110cm), and *Schefflera abyssinica* (142cm) in semi coffee forest, and *Apodytes dimidiata* (158 cm), *Pouteria adolfi-friederici* (110 cm), *Prunus africana* (105 cm), and *Schefflera abyssinica* (146 cm) in natural forest exhibited varying patterns in DBH measurements between the two forest types (see Figure 9). For instance, *Apodytes dimidiata* showed a higher density in lower DBH classes in the natural forest but was only found in higher DBH classes in the semi-coffee forest (see Figure 9a), suggesting disturbance by coffee management practices. Similarly, *Schefflera abyssinica* exhibited different distribution patterns between the two forest types (see Figure 9b), indicating a specific impact of coffee management practices.

Prunus africana displayed high density in lower DBH classes in the natural forest, while in the semi-coffee forest, it was predominantly found in the highest DBH class (see Figure 9c), likely due to selective cutting practices. *Pouteria adolfi-friederici* exhibited a contrasting pattern between the two forest types, with a higher density in lower classes in the natural forest and higher classes in the semi-coffee forest (see Figure 9d), possibly due to selective cutting for timber and construction purposes in the natural forest.

Overall, the observed differences in DBH class distributions highlight the significant impact of coffee management activities on woody species regeneration, emphasizing the need for sustainable management practices to maintain biodiversity and ecosystem health in forest ecosystems.

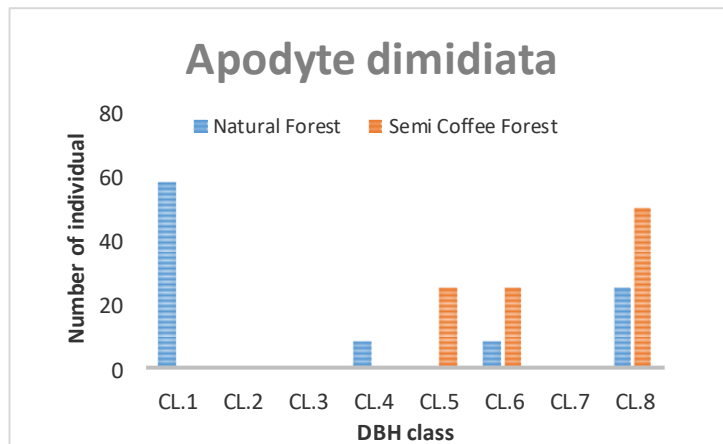


(a)

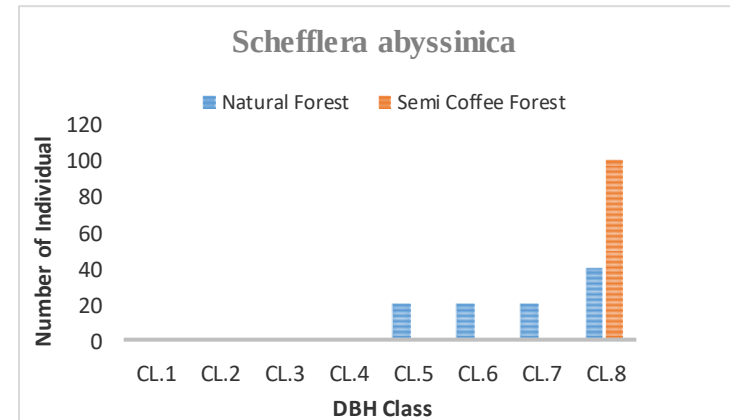
(b)

Figure 7: DBH Class Distribution in both Natural forest and semi- coffee forest

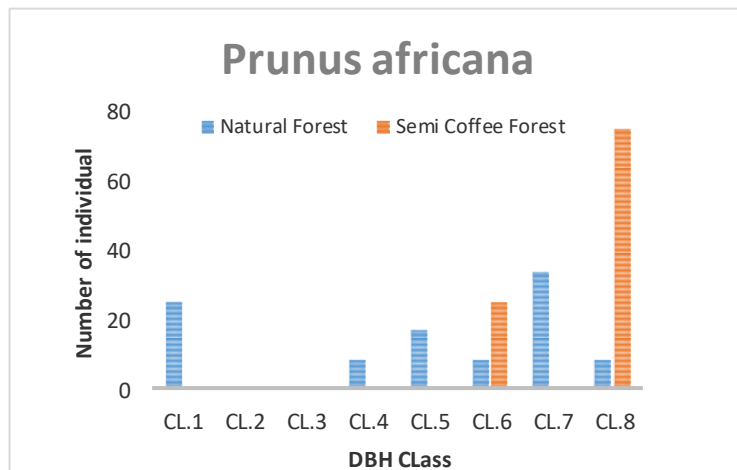
Note: <10cm=Class1, 10-20cm=Class2, 21-30cm=Class3, 31-40cm=Class4, 41-50cm=Class5, 51-60cm= Class6, >70cm= Class7



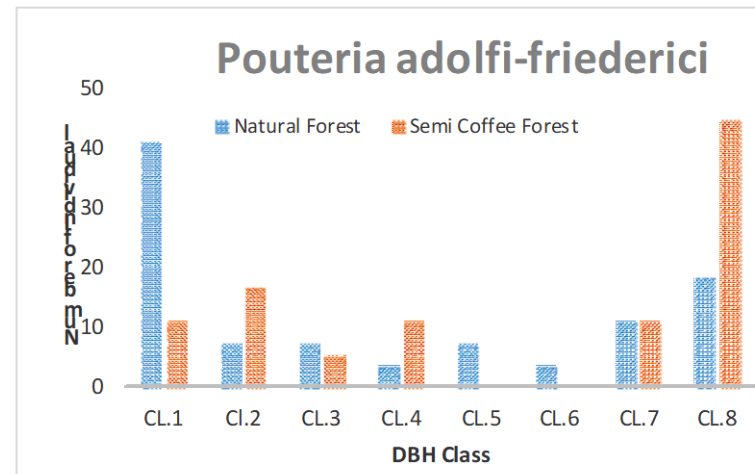
a)



b)



c)



d)

Figure 8: DBH Class Distributions of highest DBH species in Both Natural forest and Semi-coffee forest

Note: CL.1=<10cm, CL.2=10-20cm, CL.3=21-30cm, CL.4=31-40cm, CL.5=41-50cm, CL.6=51-60cm, CL.7=61-70cm, CL.8=>7

4.2. Regeneration Status

The research conducted an analysis of the densities of seedlings, saplings, and mature plant species in both natural forests and semi-coffee forests. In natural forests, the mean density of seedlings, saplings, and mature trees was enumerated as 3627, 707, and 585 per hectare, respectively. It showed that natural forest in study area experienced good regeneration as the number of seedling >sapling >matured woody plant species. On the other hand, in semi-coffee forests, these densities were observed as 453, 257, and 552 per hectare, respectively and it is fair regeneration status, (seedling >sapling< mature tree) (Table 4). The findings revealed that compared to semi-coffee forests, natural forests exhibited significantly higher numbers of seedlings and saplings, whereas the variation in mature tree density was not statistically significant (Table 4). This suggests that woody species in semi-coffee forests have a lower rate of regeneration compared to those in natural forests, indicating an impact of coffee management practices on species density and regeneration. This study supported by (Tefesa, 2020), he reported undisturbed natural forest has good regeneration status while coffee forest has confirm fair regeneration status, for study conducted at Saki forest in Ilu Aba bor Hurumu District

During the assessment, observations revealed a lack of regeneration (in seedling and sapling stages) for certain woody species such as *Cordia africana*, *Podocarpus falcatus*, *Schefflera abyssica* and *Hagenia abyssinica* in both forest types, indicated potential human disturbances in the forests. The transformation of natural forests into semi-coffee forests was associated with a decline in woody species regeneration. This finding aligns with previous studies by (Tadesse *et al.* 2014; Fekadu *et al.*, 2019), which highlighted the preference of smallholder farmers for natural forest fragments due to their higher recruitment and regeneration rates compared to semi-coffee forests. Moreover, it was noted that in coffee management practices, small shrubs and the herbaceous layer are regularly cleared to reduce competition for coffee shrubs and enhance coffee production, thus limiting woody species regeneration.

Interestingly, woody species were only found in the mature stage in semi-coffee forests, with no regeneration observed in the form of seedlings and saplings, unlike in natural forests where woody species were present in all growth stages, except few species. This phenomenon may be attributed to the management practices employed in semi-coffee forests. On the other hand, selective cutting of some woody species in natural forests has contributed to loss higher DBH

class and it seems that semi-coffee forests may serving as a seed source for presence of low DBH class or regeneration in natural forest, e.g. *Syzygium guineense*.

Table 4: Comparison of Seedling, Sapling and Tree Density of Woody Species in Natural Forest and Semi-coffee Forest

Growth stage	Natural forest	Semi forest coffee	P-Value
	Density per ha.	Density per ha.	
Seedling	3627	453	0.000 ***
Sapling	707	257	0.000 ***
Tree(matured)	585	552	0.55

Note: '***': indicated that highly significant

4.3. Potential of Woody Species used for NTFPs Categories and Access to forest products

4.3.1. Woody species uses diversity (NTFPs categories)

The research delved into the utilization of Non-Timber Forest Products (NTFPs) derived from woody species, encompassing various categories like animal feed, medicine, food, honey, and material sources. Among the 75 woody species identified, 62 were recognized as suppliers of NTFPs, with 49 (69.0%) in semi-coffee forest areas and 60 (84.5%) in natural forests (Appendix Table 7).

Remarkably, 87.3% of woody species in Kabana's natural forest contributed to the provision of NTFPs across different uses. Further analysis revealed differences in NTFP categories between natural forests and semi-coffee forest areas, with ten categories identified in semi-forest coffee and nine in natural forests environments (Figure 9).

The study highlights that the higher potential of natural forests in harboring diverse woody species capable of providing NTFPs compared to semi-forest coffee areas, despite the latter encompassing nine out of the ten NTFP categories identified. This disparity may stem from the fact that NTFP categories can involve multiple woody species or presence of multipurpose woody species. Additionally, bamboo species were noted in Kebena's natural forest during inventory activities.

Despite both sites recording NTFP categories, the proportion of each species varied. Except for coffee plants and coffee shade tree, all NTFP categories exhibited higher proportions in natural forests compared to semi-forest coffee areas (Figure 9). This discrepancy suggests that the removal of significant NTFP-producing woody species, such as shrubs, from the forest ecosystem negatively affects the composition of species contributing to NTFP availability, highlighting the adverse effects of semi-forest coffee expansion on NTFP diversity and distribution.

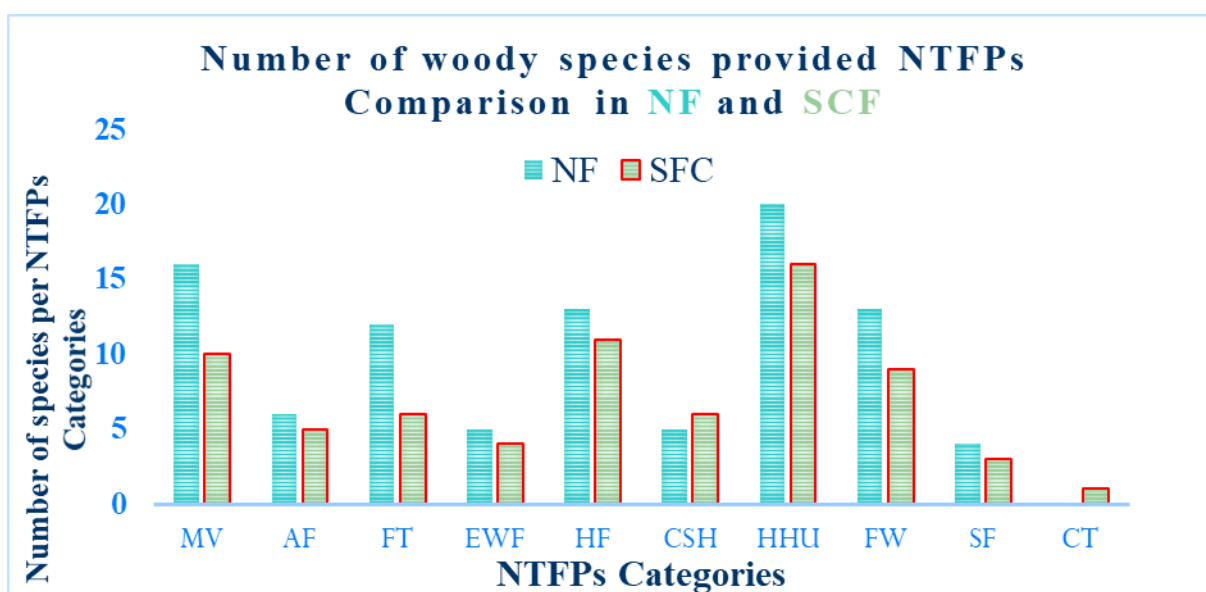


Figure 9: Number of woody species used for NTFPs categories in both Natural forest and Semi-coffee forest

Note: MV= medicinal value, AF= Animal fodder, FT =Farm tool, EWF= Edible wild fruit, HF =Honeybee flora, CSHT= Coffee shade tree, HHU= Household utensil, FW= Fuel wood, SF= Smoking and Flavoring, CT=Coffee tree

1. Woody species used as medicine

In Kebena Natural Forests, 16 woody species within the sample plots and 1 outside were identified for their medicinal properties, whereas adjacent semi-coffee forest areas contained only 10 woody species with medicinal significance (Appendix Table 8). When comparing the important value index (IVI), basal area, density, frequency, and species diversity of these medicinal woody species between the two forest sites, no significant difference was observed

($p > 0.05$)(Table 5). However, natural forests exhibited greater mean values across all categories except for basal area, suggesting that human disturbances in semi-forest coffee areas make natural forests habitats that are more suitable.

The presence of larger woody species for shade in both semi-forest coffee and natural forests, coupled with selective felling of mature trees for various purposes, may explain the differences in basal area. Belay *et al.* (2018), who noted a greater basal area in the coffee-based forest portion compared to non-coffee forests, reported similar findings. In coffee-based forests, fewer seedlings were reported, indicating a practice of preserving certain trees for coffee shade while harvesting others for fuelwood as they mature or even at a younger age.

2. Woody species used as animal fodder

Six woody species identified as animal fodder were observed in the natural forest, with *Cordia africana* notably absent in the semi-coffee forest areas. Although there were no statistically significant differences ($p > 0.05$) (Table 5). This result is similar with Belete Gera forest reported by Fekadu *et al.*(2019),who reported five woody species used as animal fodder source. Non-Timber Forest Products (NTFPs) from natural forests exhibited higher mean values in species diversity, density, frequency, basal area, and important value index (IVI) compared to those from semi-coffee forest areas. Notably, animal fodder species in natural forests showed higher basal areas. With the possible exception of *Ficus sur*, all fodder-producing species had small diameters at breast height (DBH), and *Ficus sur* was limited in semi-coffee forest environments.

Among these species, *Dracaena afromontane* emerged as the most significant for animal fodder in the study area, particularly frequented in natural forests.

3. Woody species use for farm tools

Farm implements such as ploughshares, yokes, and processing materials like "*Gindo*" and "*Qenber*" are derived from Non-Timber Forest Products (NTFPs) and are vital resources for the farming community, particularly in areas where subsistence agriculture is the primary economic activity. During the study, it was observed that only six out of twelve woody species utilized for these purposes were reported in the semi-coffee forest (Appendix Table 8).

Among them, *Olea hochstetteri* stood out as the most significant for producing ploughshares and was extensively utilized in natural forests. These materials were primarily sourced from the stems of the identified species. Analysis revealed no significant difference ($p>0.05$) between natural forests and semi-forest coffee areas in terms of *Clematis simenis Fresen*, *Dombeya torrida*, *Ehretia cymosa*, *Olea capensis*, *Olea hochstetteri*, and *Teclea nobilis* concerning species diversity, density, frequency, basal area, and important value index (Table 5).

4. Woody species used as source of food or edible fruit

The research findings indicate a disparity in the presence of woody species within the study area compared to other categories of Non-Timber Forest Products (NTFPs). Specifically, only a limited number of woody species are observed, with five of them falling under the classification of NTFPs utilized for edible wild fruit (see appendix table 8). Particularly, all these species are reported within natural forests, with four of them found in semi-coffee forests.

Examining (Table 5) reveals a noteworthy trend: while basal area exhibits an inverse correlation with mean species diversity, density, frequency, and Important Value Index (IVI) in natural forests in contrast to semi-coffee forests, these variations do not achieve statistical significance ($p>0.05$). This suggests that although the relative composition of NTFP species bearing edible fruits remains consistent, the observed discrepancy in value might stem from the elimination of certain species during coffee management practices.

5. Woody species use for honeybee flora

The study site revealed thirteen woody species serving as honeybee flora, as outlined in (Appendix Table 8). Notably, only two of these species, *Hagenia abyssinica* and *Pycnostachys meyeri*, were absent in semi-forest coffee habitats.

Among the identified species, including *Anogeissus leiocarpus*, *Apodytes dimidiata*, *Croton macrostachyus*, *Dracaena afromontana*, *Polyscias fulva*, *Prunus africana*, *Psychotria orophila*, *Rhus glutinosa*, *Schefflera abyssinica*, *Syzygium guineense*, and *Vernonia amygdalina*, their species diversity, density, frequency, basal area, and Important Value Index

(IVI) mean values were observed across both forest sites, as detailed in (Table 5). However, these observations did not yield statistically significant differences ($p > 0.05$).

Although Table 5 indicates that natural forests consistently exhibited higher mean values across all factors compared to semi-coffee forests, these disparities were not statistically significant. Hence, while the composition of honeybee flora may vary between the two forest sites concerning the proportion of woody species, these distinctions do not hold statistical significance.

6. Woody species use for coffee shade

According to the findings listed in (Appendix Table 8), six species were identified as preferred choices for coffee shade within the study area. Notably, all of these species were encountered in semi-coffee forests, whereas in natural forests, the species *Allophylus abyssinicus* was notably absent. It is speculated that the limited canopy cover and shading attributes of these species may account for their unanimous selection by respondents for coffee shade purposes.

Among the identified species, *Croton macrostachyus*, *Polyscias fulva*, *Millettia ferruginea*, and *Albizia gummifera* were observed in both natural and semi-coffee forests. Their respective frequencies were noted as 70% and 56%, 60% and 46%, and 34% and 27% in each habitat. However, *Allophylus abyssinicus* was exclusively found in semi-coffee forests, suggesting its deliberate cultivation by farmers due to its shade preference. Notably, all these species exhibited high mean values of Important Value Index (IVI), basal area, diversity, density, and frequency in natural forests.

Table 5 indicates that the mean differences in the composition of these NTFP species were not statistically significant ($p > 0.05$), thereby supporting the null hypothesis. This suggests that despite variations in species presence and habitat preference, the overall composition of these species remains consistent across forest types within the study area.

7. Household utensils and construction material

Among the species identified, 21 are recognized for their household utility. Among them, 15 species were encountered in both semi-forest coffee and natural forests, while five were exclusive to natural forests and one to coffee forests, as detailed in Appendix Table 8. These

species serve essential roles in household furniture construction and building materials for fences and houses, crucial for the daily survival of users.

The comparison of Important Value Index (IVI), density, basal area, and diversity frequency of these woody species bearing NTFPs was conducted between the two sites using the t-test. The results failed to reach significance ($p > 0.05$), aligning with the null hypothesis. However, it's value noting that the mean values were consistently higher in natural forests compared to semi-coffee forest, as illustrated in (Table 5). This suggests that while the presence of these species remains consistent across habitats, their abundance and diversity tend to be greater in natural forest environments.

8. Fuelwood

Presently, about 13 woody species serve as sources of fuelwood within the community, as outlined in (Appendix Table 8). Interestingly, only nine of these species were identified in coffee semi-forest habitats, with the remaining species reported exclusively in natural forests. The examination of Important Value Index (IVI), diversity, density, frequency, and basal area of NTFP woody species generated mean values that were not significantly impacted ($p > 0.05$), supporting the null hypothesis, as depicted in (Table 5). However, it's notable that in natural forests, the mean values of density, frequency, and basal area of these NTFP woody species surpass those observed in semi-forest coffee habitats. Conversely, semi-forest coffee habitats exhibit greater mean diversity and Important Value Index (IVI) of these species compared to natural forest coffee environments, as indicated in (Table 5). This phenomenon might be attributed to the protective measures undertaken by farmers to safeguard these woody species within semi-forest coffee habitats.

9. Smoking wood and flavoring woody species

Certain woody species also yield valuable compounds utilized for local drink preparation, milk vessel cleanliness, and fumigation, as detailed in (Appendix Table 8). However, compared to other NTFPs types, the presence of such NTFPs was notably limited. Specifically, only four woody plants were identified, among which the first species, *Ekerbergia carpens*, holds significance for smoking hives to attract honeybees, despite its absence in semi- coffee forest habitats.

In contrast to its predominant use for milk containers, the bark of *Ekerbergia carpensis* serves the purpose of smoking beehives, while its leaves and stems contribute to teeth cleaning practices. Another species, *Vernonia amygdalina*, is smoked and utilized in the preparation of local beverages and milk containers.

Upon calculating the mean difference in diversity, density, frequency, basal area, and Important Value Index for the three species discovered in both sites, it was established that no significant difference existed ($p>0.05$), thereby supporting the null hypothesis, as delineated in (Table 5)

Table 5: Hypothesized mean Diversity, Density, Frequency, IVI, and BA tested of NTFP bearing woody species in Natural forest and Semi-coffee forest at 95% confidence level.

NTFP Types		variables					
	Test	Site	Diversity	Density	Frequency	IVI	BA
<i>medicinal</i>		NF	0.07	10.104	25	5.275	0.633
		SCF	0.093	10	21	7.612	0.58
	T.test		0.791	0.023	0.515	0.776	0.100
	P.value		0.444	0.982	0.612	0.45	0.922
	Sign.		ns	ns	ns	ns	Ns
<i>Animal fodder</i>	Test	Site	Diversity	Density	Frequency	IVI	BA
		NF	0.075	13.19	24.44	5.75	0.6
		SCF	0.098	8.67	22	7.22	0.55
	T.test		0.637	0.559	0.182	0.367	0.074
	P.value		0.544	0.597	0.859	0.722	0.943
<i>Farm tools</i>	Test	Site	Diversity	Density	Frequency	IVI	BA
		NF	0.05	6.88	19.72	3.66	0.38
		SCF	0.057	4.44	11.67	4.47	0.52
	T.test		0.323	0.813	1.216	0.467	0.475
	P.value		0.752	0.428	0.242	0.65	0.652
<i>Edible fruit</i> <i>wild</i>	Test	Site	Diversity	Density	Frequency	IVI	BA
		NF	0.056	7.166	22.666	5.688	1.088
		SCF	0.043	2.708	10.833	4.033	1.095
	T.test		0.644	1.49	1.396	0.573	0.012
	P.value		0.543	0.196	0.212	0.585	0.99
	Sign.		ns	ns	ns	ns	ns

	Test	Site	Diversity	Density	Frequency	IVI	BA
<i>Honeybee flora</i>		NF	0.068	10.769	25.898	7.435	1.42
		SCF	0.055	4.392	12.422	4.306	0.441
	T.test		0.594	1.479	1.679	1.164	1.743
	P.value		0.559	0.159	0.109	0.257	0.098
	Sign.		ns	ns	ns	ns	ns
	Test	Site	Diversity	Density	Frequency	IVI	BA
<i>Coffee shade tree</i>		NF	0.119	19.167	50	13.535	2.538
		SCF	0.129	15.278	31.667	15.471	2.153
	T.test		0.249	0.565	1.519	0.317	0.275
	P.value		0.812	0.587	0.163	0.761	0.79
	Sign.		ns	ns	ns	ns	ns
	Test	Site	Diversity	Density	Frequency	IVI	BA
<i>Household utensil</i>		NF	0.07	10.38	29	7.05	1.21
		SCF	0.1	9.84	24.79	9.92	1.2
	T.test		1.384	0.157	0.611	0.999	0.021
	P.value		0.178	0.876	0.545	0.328	0.983
	Sign.		ns	ns	ns	ns	ns
	Test	Site	Diversity	Density	Frequency	IVI	BA
<i>Fuelwood</i>		NF	0.078	11.59	28.89	6.76	1
		SCF	0.1	10.08	25.33	9.11	0.89
	T.test		1.077	0.445	0.447	0.762	0.194
	P.value		0.297	0.661	0.659	0.456	0.848
	Sign.		ns	ns	ns	ns	ns
	test	Site	Diversity	Density	Frequency	IVI	BA
<i>Smoking and flavoring</i>		NF	0.05	7.083	21.67	3.44	0.22
		SCF	0.084	6.944	15.56	4.89	0.17
	T.test		1.179	0.033	0.622	0.885	0.296
	P.value		0.292	0.975	0.579	0.425	0.781
	Sign.		ns	ns	ns	ns	ns

Note: ns= not significant, NF =Natural forest, SCF= Semi-coffee forest, IVI=Important value index, BA =Basal area, and NTFP=Non-timber forest product, Sign. =Significance

4.3.2. Access to forest products in Natural forest and Semi-coffee forest

The study area's households mostly rely on non-timber and timber forest products for their livelihood. Nonetheless, the majority of the items derived from this forest are a variety of forest products that are gathered by households for both domestic usage and commercial purposes. The primary forest products that households report include medicinal plants, firewood, honey, lumber for construction, and charcoal. In the case of a natural forest, households are dependent on timber and non-timber forest products.

The land property size of households in the sample is one of the restrictive issues for better management of the prevailing natural forests and for extra planting of trees as buffer zones to decrease pressure on the natural forest. The survey result indicated that there is variation in land holding sizes among the various households and the land holding sizes can generally be classified in to three different classes as: < 1 ha, 1.01-2.0 ha, and >2.ha (Table 2). According to (Table 2), 26% of household respondents have less than one-hectare farmland. Whereas, 39% of household respondents have 1 to 2 hectare and 35 % household respondent have greater than two-hectare farmland. In this study, larger farm land holder household is significantly decreased the level of dependency on forest product extraction in addition, can get dead branches or wood from their own farms for their fuel wood and lumber needs. This result is similar with Abdo *et al.* (2020), he reported, that landholding size was impacts forest product extraction and dependency negatively. Most households look forward to harvesting forest products from their owned land and a significant increase in their cash income from coffee agroforestry.

Table 6: Household land size of respondents at the studied area

land size in (ha)	Frequency	%age
<1.0	33	26
1.0-2.0	50	39
>2	45	35
Total	128	100%

Of the household respondents, 67.3% stated that they have unrestricted access to timber in the natural forest area. Whereas roughly 32.7% of household respondents said that there are

restrictions on access to and usage of timber in natural forests. Conversely, in the semi-coffee coffee, the majority of respondents (93%) state that they have no access to timber for use (Figure 10), seven (7%) of the respondents said that they have access to use some NTFPs after coffee had harvested.

According to some respondents, access to the natural forest was restricted once it was put under PFM management, and only group members were permitted to enter under the new system. No one is allowed to visit or use the timber in a semi-forest because it is owned and controlled by the owner; in a natural forest, however, timber products are accessible to all.

This study result is similar with Kuleni *et al.*, (2019), access to use NTFPs was severely restricted in semi-forest coffee; according to 87.7% of household respondents, their property prevented anyone from using NTFPs. Of the household respondents, 12.3% claimed to be able to obtain NTFPs from semi-forest coffee.

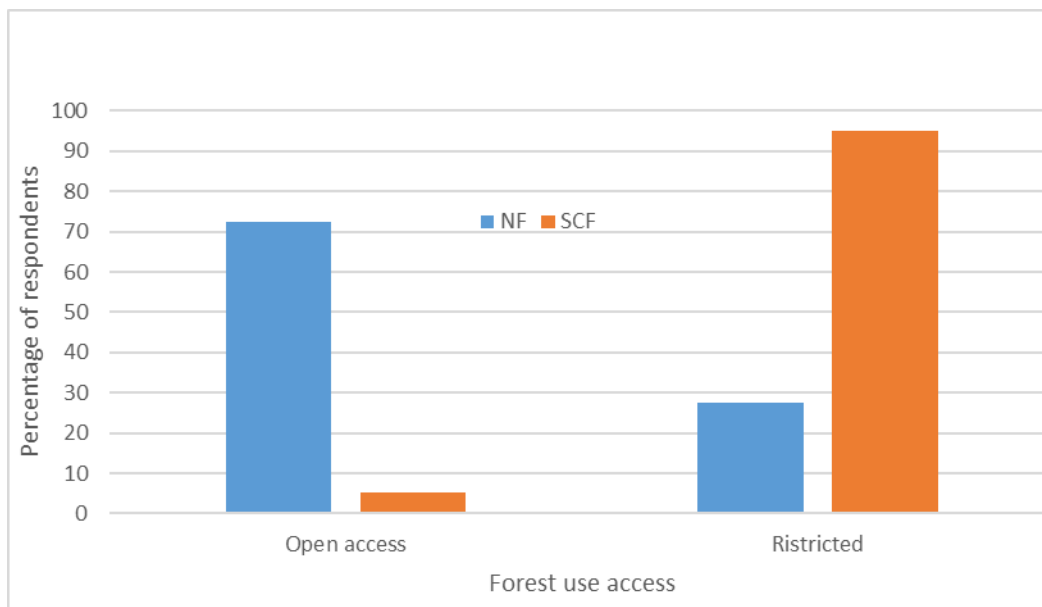


Figure 10: Access use of NTFP from Natura forest (NF) and Semi- coffee forest (SCF)

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The research compared the diversity, population structure, regeneration capacity, and availability of Non-Timber Forest Products (NTFPs) between natural forests and semi-coffee forest ecosystems. Except in regeneration, there were a similar number of woody species identified in both ecosystems. Natural forests showed marginally higher diversity and evenness, however, this difference was not statistically significant. The floristic similarity index indicated substantial overlap in species composition between natural forests and semi-coffee forests, with 49 common species suggesting potential species exchange. Population structure analysis revealed differences in tree distribution, with natural forests exhibiting a more stable structure compared to semi-coffee forests, influenced by selective management practices in coffee areas.

Furthermore, natural forests displayed a more vigorous regeneration capacity with higher densities of seedlings and saplings compared to semi-coffee forests. The establishment of semi-coffee forests negatively impacted woody species regeneration, attributed to human disturbances and coffee management practices. Additionally, natural forests were found to harbor a greater diversity of NTFP-producing species compared to semi-coffee forests, impacting habitat quality and species diversity in coffee areas. Access to timber and NTFPs varied between the two ecosystems, with natural forests generally allowing broader access, while semi-coffee forests imposed restrictions, affecting local livelihoods.

Overall, while natural forests exhibited higher diversity and regeneration capacity, semi-coffee forests showed alterations in population structure and species composition influenced by coffee management practices, impacting both ecological dynamics and local livelihoods.

5.2. Recommendation

Based on the research findings, it is imperative that all stakeholders collaborate to maintain and enhance the ecological health of forest ecosystems while simultaneously supporting the sustainable livelihoods of local communities. This can be achieved through the implementation of the following recommendations.

Conservation Efforts: All stakeholders those have an interest on this forest and adjacent coffee should have to give prioritize conservation efforts to protect the higher diversity and regeneration capacity observed in natural forests ecosystem.

Sustainable Management Practices: government and coffee owners should have to Encourage the adoption of sustainable management practices in semi-coffee forests to mitigate the negative impacts on woody species regeneration and population structure. This could involve promoting agroforestry techniques that integrate coffee cultivation with native tree species to enhance biodiversity and ecosystem services.

Awareness should be generated among the local communities: Any organization or person or researcher who wants to save natural resource and do with local community should have to adopt the strategy for the sustainable use of important species, such as *Cordia africana*, and *Ekerbergia capensis*, who is rarely present in the study area and those woody species mostly used their timber products (*Syzygium guineense*) and those does not have regeneration like *Cordia africana* and *Podocarpus falcatus*

Community Engagement and Livelihood Support: Work closely with local communities to develop alternative livelihood strategies that are compatible with conservation goals. Provide training and support for sustainable harvesting of NTFPs in natural forests, while also exploring income-generating opportunities within semi-coffee forest landscapes. This could be by the Oromia forest and wild life enterprise Jimma branch and any organization that interested to work on this area.

Policy and Governance: Ensure that land-use planning and management regulations consider the ecological value of natural forests and the potential impacts of land-use changes, such as the conversion of natural forests to coffee plantations.

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7. APPENDIX

Appendix Table 1: Botanical Name and their family of woody species recorded in Natural forest

No.	Scientific Name	Family Name	Local .Name	Gro For
1	<i>Albizia grandibracteata</i> (Taub.)	<i>Fabaceae</i>	Alale	T
2	<i>Albizia gummifera</i> (J.F. Gmel.) C.A. Sm.	<i>Fabaceae</i>	Ambabesa	T
3	<i>Allophylus abyssinicus</i> (Hochst.) Radlk	<i>Sapindaceae</i>	Se'o	T
4	<i>Anogeissus leiocarpus</i> (DC.) Guill. & Perr.	<i>Combretaceae</i>	Qeyo	T
5	<i>Apodytes dimidiata</i> E. Mey. ex Arn.	<i>Icacinaceae</i>	Wandabiyo	T
6	<i>Asparagus racemosus</i> Willd.	<i>Asparagaceae</i>	Sariitii	S
7	<i>Asplenium protensum</i> Schard.	<i>Aspleniaceae</i>	Qawo	T
8	<i>Bersama abyssinica</i> Fresen.	<i>Melanthaceae</i>	Lolchisa	S
9	<i>Calpurnia aurea</i> (Aiton) Benth.	<i>Fabaceae</i>	Ceeke	S
10	<i>Caparis tomentosa</i> Lam.	<i>Capparidaceae</i>	Harangama	L
11	<i>Celtis africana</i> Burm. f.	<i>Ulmaceae</i>	maxoqoma	T
12	<i>Clausenia anisata</i> (Willd.) Hook.f. ex Benth.	<i>Rutaceae</i>	Ulmayi	S
13	<i>Clematis longicauda</i> Steud. ex A. Rich.	<i>Ranunculaceae</i>	Hida gagura	L
14	<i>Clematis simenis</i> Fresen	<i>Ranunculaceae</i>	Hida gaale	L
15	<i>Cordia africana</i> Lam.	<i>Boraginaceae</i>	Wadesa	T
16	<i>Croton macrostachyus</i> Hochst. ex Delile	<i>Euphorbiaceae</i>	Makanisa	T
17	<i>Culcasia falcifolia</i> Engl.	<i>Araceae</i>	omoroko	S
18	<i>Diospyros abssinica</i> (Hiern) F. White	<i>Ebenaceae</i>	Loko	T
19	<i>Discopodium penninervum</i> Hochst	<i>Solanaceae</i>	Qomonyo	T
20	<i>Dombeya torrida</i> (J.F. Gmel.) Bamps	<i>Sterculiaceae</i>	Danisa	T
21	<i>Dovyalis verrucosa</i> (Hochst.) Warb.	<i>Flacourtiaceae</i>	Wantafulas	T
22	<i>Dracaena afromontana</i> Mildbr.	<i>Dracaenaceae</i>	Alge	S
23	<i>Ehretia cymosa</i> Thonn.	<i>Boraginaceae</i>	ulaga	S
24	<i>Ekerbergia carpens</i> is Sparrm.	<i>Meliaceae</i>	Sombo	T
25	<i>Embelia schimperi</i> Vatke	<i>Myrsinaceae</i>	Hanqu	L
26	<i>Euclea schimperi</i> (A. DC.) Dandy	<i>Ebenaceae</i>	Mi'esa	S
27	<i>Ficus sur</i> Forssk.	<i>Moraceae</i>	Harbu	T
28	<i>Galinieria saxifraga</i>	<i>Rubiaceae</i>	Simararu	T
29	<i>Gouania longispicta</i> Engl.	<i>Rhamnaceae</i>	Homachesa	L
30	<i>Hagenia Abyssinica</i> (Bruce) J.F. Gmel.	<i>Rosaceae</i>	Hexo	T
31	<i>Hippocrata africana</i> wild	<i>Celastraceae</i>	Hidagalle	L
32	<i>Hypoestes forskaolii</i> (Vahl) R. Br.	<i>Apocynaceae</i>	Yebo	L
33	<i>Ilex mitis</i> (L.) Radlk.	<i>Aquifoliaceae</i>	Huto/qQetto	T

34	<i>Jasminum abyssinicum</i> Hochst. ex DC.	<i>Oleaceae</i>	Ichime	L
35	<i>Juniperus procera</i> Hochst.ex A.Engl.	<i>Cuppressaceae</i>	Gatira Habasha	T
36	<i>Justicia schimperiana</i> (Hochst. ex Nees) T. Anders.	<i>Acanthaceae</i>	Dhumuga	S
37	<i>Maesa lanceolata</i> Forssk.	<i>Myrsinaceae</i>	Abayi	T
38	<i>Maytenus</i> sp.	<i>Celastraceae</i>	Xumame	S
39	<i>Maytenus undata</i>	<i>Celastraceae</i>	Kombolcha	S
40	<i>Maytenus undata</i> (Thunb.) Blackelock	<i>Celastraceae</i>	Karro	S
41	<i>Millettia ferruginea</i> (Hochst.) Baker	<i>Fabaceae</i>	Askira	T
42	<i>Mimusopis kummel</i> A. DC	<i>Sapotaceae</i>	Mixo	T
43	<i>Monotheций glandulosum</i> Hochst.	<i>Acanthaceae</i>	Xobbe	S
44	<i>Olea capensis</i> L.	<i>Oleaceae</i>	Gaja	T
45	<i>Olea hochstetteri</i> Baker	<i>Oleaceae</i>	Gagama	T
46	<i>Olea welwitschii</i> (Knobl.) Gilg & Schellenb.	<i>Oleaceae</i>	Baya	T
47	<i>Olinia rochetiana</i> A.Juss.	<i>Oliniaceae</i>	Noole	T
48	<i>Oncoba spinosa</i> Forssk.	<i>Flacourtiaceae</i>	Akuku	T
49	<i>Pavetta oliveriana</i> Hiern	<i>Rubiaceae</i>	Buna qamale	S
50	<i>Piper capense</i> L.f.	<i>Piperaceae</i>	Togoo	S
51	<i>Podocarpus falcatus</i> (Thunb.) R. Br. ex Mirb.	<i>Podocarpaceae</i>	Birbirs	T
52	<i>Polyscias fulva</i> (Hiern) Harms	<i>Araliaceae</i>	Kariyo	T
53	<i>Polyscias fulva</i> (Hiern) Harms	<i>Araliaceae</i>	Birango jaldesa	S
54	<i>Pouteria adolfi-friederici</i> (Engl.) A. Meeuse	<i>Sapotaceae</i>	qararo	T
55	<i>Prunus africana</i> (Hook.f.) Kalkman	<i>Rosaceae</i>	Omoo/Homi	T
56	<i>Psychotria orophila</i> Petit	<i>Rubiaceae</i>	Xumame	T
57	<i>Pycnostachys meyeri</i> Gurke.	<i>Lamiaceae</i>	Xirooftu	T
58	<i>Rhoicissus tridentata</i> (L.F.)	<i>Vitaceae</i>	Laaluu	L
59	<i>Rhus glutinosa</i> Hochst. ex A.Rich.	<i>Anacardiaceae</i>	xaxesa	T
61	<i>Ricinus communis</i> L	<i>Euphorbiaceae</i>	qobbo	S
62	<i>Schefflera abyssini</i> (Hochst. ex A. Rich.) Harms	<i>Araliaceae</i>	Butto/Gatama	T
63	<i>Solanum tarderemotum</i> Bitter	<i>Solanaceae</i>	Beco	S
64	<i>Stephania abyssinica</i> (Dillon & A. Rich.) Walp.	<i>Menispermaceae</i>	Kabola	S
65	<i>Syzygium guineense</i> (Willd.) DC	<i>Myrtaceae</i>	Badesa	T
66	<i>Teclea nobilis</i> Del.	<i>Rutaceae</i>	Hadhesa	T
67	<i>Tectaria gemmifera</i> (Fée) Alston	<i>Tectariaceae</i>	Gixoo	S
68	<i>Vernonia amygdalina</i> Delile	<i>Asteraceae</i>	Eebicha	S
69	<i>Vernonia auriculifera</i> Hiern	<i>Asteraceae</i>	Reeji	T

Appendix Table 2: Botanical name and family of woody species recorded in Semi-coffee forest

Scientific Name	Family Name	Local.Name	Growth Form
<i>Albizia grandibracteata</i> (Taub.)	<i>Fabaceae</i>	Alale	T
<i>Albizia gummifera</i> (J.F. Gmel.) C.A. Sm.	<i>Fabaceae</i>	Ambabesa	T
<i>Allophylus abyssinicus</i> (Hochst.) Radlk	<i>Sapindaceae</i>	Se'o	T
<i>Anogeissus leiocarpus</i> (DC.) Guill. & Perr.	<i>Combretaceae</i>	Qeyo	T
<i>Apodytes dimidiata</i> E. Mey. ex Arn.	<i>Icacinaceae</i>	Wandabiyo	T
<i>Asplenium protensum</i> Schard.	<i>Aspleniaceae</i>	Qawo	T
<i>Bersama abyssinica</i> Fresen.	<i>Melianthaceae</i>	Lolchisa	S
<i>Calpurnia aurea</i> (Aiton) Benth.	<i>Capparidaceae</i>	Harangaa	L
<i>Clausenia anisata</i> (Willd.) Hook.f. ex Benth.	<i>Rutaceae</i>	Ulayi	S
<i>Clematis longicauda</i> Steud. ex A. Rich.	<i>Ranunculaceae</i>	Hida gagura	L
<i>Coffee arabica</i> L.	<i>Rubiaceae</i>	Buna	S
<i>Croton macrostachyus</i> Hochst. ex Delile	<i>Euphorbiaceae</i>	Makanisa	T
<i>Culcasia falcifolia</i> Engl.	<i>Araceae</i>	Omboroko	S
<i>Diospyros abssinica</i> (Hiern) F. White	<i>Ebenaceae</i>	Loko	T
<i>Discopodium penninervum</i> Hochst	<i>Solanaceae</i>	Qomonyo	T
<i>Dombeya torrida</i> (J.F. Gmel.) Bamps	<i>Sterculiaceae</i>	Danisa	T
<i>Dovyalis verrucosa</i> (Hochst.) Warb.	<i>Flacourtiaceae</i>	Wantafulas	T
<i>Dracaena afromontana</i> Mildbr.	<i>Dracaenaceae</i>	Alge	S
<i>Ehretia cymosa</i> Thonn.	<i>Boraginaceae</i>	Ulaga	S
<i>Embelia schimperi</i> Vatke	<i>Myrsinaceae</i>	Hanqu	L
<i>Ficus sur</i> (F. capensis)	<i>Moraceae</i>	Harbu	T
<i>Galineria saxifraga</i>	<i>Rubiaceae</i>	Simararu	T
<i>Gouania longispicta</i> Engl.	<i>Rhamnaceae</i>	Homachesa	L
<i>Hippocrata africana</i> (Willd.) Loes	<i>Celasteraceae</i>	Hida gale	L

<i>Hypoestes forskalii</i> (Vahl) R. Br.	Apocynaceae	Yebo	L
<i>Justicia schimperiana</i> (Hochst. ex Nees) T. Anders	Acanthaceae	Dhuuga	S
<i>Maesa lanceolata</i> Forssk.	Myrsinaceae	Abayi	T
<i>Maytenus</i> sp.	Celastraceae	Xiroftu	S
<i>Maytenus undata</i>	Celastraceae	Kombolcha	S
<i>Millettia ferruginea</i> (Hochst.) Baker	Fabaceae	Askira	T
<i>Mimusopis kummel</i> A. DC	Sapotaceae	Mixo/Qoladi	T
<i>Monotheций glandulosum</i> Hochst.	Acanthaceae	Xobbe	S
<i>Olea capensis</i> L.	Oleaceae	Gaja	T
<i>Olea hochstetteri</i> Baker	Oleaceae	Gagama	T
<i>Olea welwitschii</i> (Knobl.) Gilg & Schellenb.	Oleaceae	Baya	T
<i>Oncoba spinosa</i> Forssk.	Flacourtiaceae	Akaku	T
<i>Oxyanthus speciosus</i> DC	Euphorbiaceae	Birango jaldesa	S
<i>Polyscias fulva</i> (Hiern) Harms	Araliaceae	Kariyo	T
<i>Pouteria adolfi-friederici</i> (Engl.) A. Meeuse	Sapotaceae	Qararo	T
<i>Prunus africana</i> (Hook.f.) Kalkman	Rosaceae	Hexo	T
<i>Psychotria orophila</i> Petit	Rubiaceae	Xumame	T
<i>Rhoicissus tridentata</i> (L.F.)	Vitaceae	Lalu	L
<i>Rhus glutinosa</i> Hochst. ex A.Rich	Anacardiaceae	Xaxesa	T
<i>Schefflera abyssinica</i> (Hochst. ex A. Rich.) Harms	Araliaceae	Butto/Gatame	T
<i>Sida rhombifolia</i> L.	Malvaceae	Karaba	S
<i>Solanum tarderemotum</i> Bitter	Solanaceae	Beco	S
<i>Syzygium guineense</i> (Willd.) DC.	Myrtaceae	Badesa	T
<i>Teclea nobilis</i> Del.	Rutaceae	Hadhesa	T
<i>Tectaria gemmifera</i> (Fee) Alston.	Tectariaceae	Gixo	S
<i>Vernonia amygdalina</i> Delile	Asteraceae	Ebicha	S
<i>Vernonia auriculifera</i> Hiern	Asteraceae	Reeji	T

Appendix table 3 Families of Woody species in natural forest and Semi-coffee forest

Faily Name	No.Species %	Family Name	No.Species %
Acanthaceae	1.6	Acanthaceae	0.61

<i>Anacardiaceae</i>	0.96	<i>Anacardiaceae</i>	0.92
<i>Apocynaceae</i>	0.96	<i>Apocynaceae</i>	0.31
<i>Aquifoliaceae</i>	0.96	<i>Araceae</i>	0.31
<i>Araceae</i>	1.12	<i>Araliaceae</i>	2.30
<i>Araliaceae</i>	4.00	<i>Aspleniaceae</i>	0.31
<i>Asparagaceae</i>	0.64	<i>Asteraceae</i>	4.13
<i>Aspleniaceae</i>	0.48	<i>Boraginaceae</i>	0.15
<i>Asteraceae</i>	2.40	<i>Capparidaceae</i>	0.46
<i>Boraginaceae</i>	2.00	<i>Celastraceae</i>	7.66
<i>Capparidaceae</i>	0.64	<i>Combretaceae</i>	0.15
<i>Celastraceae</i>	7.00	<i>Dracaenaceae</i>	2.30
<i>Combretaceae</i>	0.32	<i>Ebenaceae</i>	0.15
<i>Cuppressaceae</i>	0.32	<i>Euphorbiaceae</i>	4.75
<i>Dracaenaceae</i>	10.00	<i>Fabaceae</i>	7.35
<i>Ebenaceae</i>	2.50	<i>Flacourtiaceae</i>	0.46
<i>Euphorbiaceae</i>	6.00	<i>Icacinaceae</i>	0.61
<i>Fabaceae</i>	10.40	<i>Malvaceae</i>	0.31
<i>Flacourtiaceae</i>	1.28	<i>Melianthaceae</i>	2.30
<i>Icacinaceae</i>	0.80	<i>Moraceae</i>	2.45
<i>Laminaceae</i>	0.64	<i>Myrsinaceae</i>	0.77
<i>Meliaceae</i>	0.48	<i>Myrtaceae</i>	2.14
<i>Melianthaceae</i>	2.40	<i>Oleaceae</i>	3.37
<i>Menispermaceae</i>	0.64	<i>Ranunculaceae</i>	0.31
<i>Moraceae</i>	3.00	<i>Rhamnaceae</i>	0.46
<i>Myrsinaceae</i>	2.50	<i>Rosaceae</i>	0.61
<i>Myrtaceae</i>	1.90	<i>Rubiaceae</i>	47.17
<i>Oleaceae</i>	8.00	<i>Rutaceae</i>	2.60
<i>Oliniaceae</i>	0.64	<i>Sapindaceae</i>	0.61
<i>Piperaceae</i>	0.32	<i>Sapotaceae</i>	2.91
<i>Podocarpaceae</i>	0.16	<i>Solanaceae</i>	0.31
<i>Rhaniceae</i>	0.64	<i>Sterculiaceae</i>	0.15
<i>Ranunculaceae</i>	0.32	<i>Tectariaceae</i>	0.31
<i>Rosaceae</i>	1.60	<i>Vitaceae</i>	0.31
<i>Rubiaceae</i>	2.40		
<i>Rutaceae</i>	9.00		
<i>Sapindaceae</i>	3.00		
<i>Sapotaceae</i>	4.00		
<i>Solanaceae</i>	1.28		
<i>Sterculiaceae</i>	0.80		

<i>Tectariaceae</i>	1.12		
<i>Ulmaceae</i>	0.80		
<i>Vitaceae</i>	0.96		

Appendix table 4: Common woody species in both Natural forest and semi-coffee forest

Species Name	Family Name
<i>Albizia grandibracteata</i> (Taub.)	<i>Fabaceae</i>
<i>Albizia gummifera</i> (J.F. Gmel.) C.A. Sm.	<i>Fabaceae</i>
<i>Allophylus abyssinicus</i> (Hochst.) Radlk	<i>Sapindaceae</i>
<i>Anogeissus leiocarpus</i> (DC.) Guill. & Perr.	<i>Combretaceae</i>
<i>Apodytes dimidiata</i> E. Mey. ex Arn.	<i>Icacinaceae</i>
<i>Asplenium protensum</i> Schard.	<i>Aspleniaceae</i>
<i>Bersama abyssinica</i> Fresen.	<i>Melianthaceae</i>
<i>Caparis tomentosa</i> Lam.	<i>Capparidaceae</i>
<i>Clausenia anisata</i> (Willd.) Hook.f. ex Benth.	<i>Rutaceae</i>
<i>Clematis longicauda</i> Steud. ex A. Rich.	<i>Ranunculaceae</i>
<i>Croton macrostachyus</i> Hochst. ex Delile	<i>Euphorbiaceae</i>
<i>Culcasia falcifolia</i> Engl.	<i>Araceae</i>
<i>Diospyros abssinica</i> (Hiern) F. White	<i>Ebenaceae</i>
<i>Discopodium penninervum</i> Hochst	<i>Solanaceae</i>
<i>Dombeya torrida</i> (J.F. Gmel.) Bamps	<i>Sterculiaceae</i>
<i>Dovyalis verrucosa</i> (Hochst.) Warb.	<i>Flacourtiaceae</i>
<i>Dracaena afromontana</i> Mildbr.	<i>Dracaenaceae</i>
<i>Ehretia cymosa</i> Thonn.	<i>Boraginaceae</i>
<i>Embelia schimperi</i> Vatke	<i>Myrsinaceae</i>
<i>Ficus sur</i> (F. capensis)	<i>Moraceae</i>
<i>Galineria saxifraga</i>	<i>Rubiaceae</i>
<i>Gouania longispicta</i> Engl.	<i>Rhamnaceae</i>
<i>Hippocrata africana</i>	<i>Celastraceae</i>
<i>Hypoestes forskalii</i> (Vahl) R. Br	<i>Apocynaceae</i>
<i>Justicia schimperiana</i> (Hochst. ex Nees) T. Anders.	<i>Acanthaceae</i>
<i>Maesa lanceolata</i> Forssk	<i>Myrsinaceae</i>
<i>Maytenus</i> sp.	<i>Celastraceae</i>
<i>Maytenus undata</i>	<i>Celastraceae</i>
<i>Millettia ferruginea</i> (Hochst.) Baker	<i>Fabaceae</i>
<i>Mimusopis kummel</i> A. DC.	<i>Sapotaceae</i>
<i>Monotheций glandulosum</i> Hochst.	<i>Acanthaceae</i>
<i>Olea capensis</i> L.	<i>Oleaceae</i>
<i>Olea hochstetteri</i> Baker	<i>Oleaceae</i>
<i>Olea welwitschii</i> (Knobl.) Gilg & Schellenb.	<i>Oleaceae</i>

<i>Oncoba spinosa</i> Forssk.	Flacourtiaceae
<i>Polyscias fulva</i>	Araliaceae
<i>Polyscias fulva</i> (Hiern) Harms	Araliaceae
<i>Pouteria adolfi-friederici</i> (Engl.) A. Meeuse	Sapotaceae
<i>Prunus africana</i> (Hook.f.) Kalkman	Rosaceae
<i>Psychotria orophila</i> Petit	Rubiaceae
<i>Rhoicissus tridentata</i> (L.F.)	Vitaceae
<i>Rhus glutinosa</i> Hochst. ex A.Rich.	Anacardiaceae
<i>Schefflera abyssinica</i> (Hochst. ex A. Rich.) Harms	Araliaceae
<i>Solanum tarderemotum</i> Bitter	Solanaceae
<i>Syzygium guineense</i> (Willd.) DC.	Myrtaceae
<i>Teclea nobilis</i> Del.	Rutaceae
<i>Tectaria gemmifera</i> (Fee) Alston	Tectariaceae
<i>Vernonia amygdalina</i>	Asteraceae
<i>Vernonia amygdalina</i> Delile	Asteraceae
<i>Vernonia auriculifera</i> Hiern	

Appendix Table 5: Relative Frequency, Relative dominance, Relative Abundance and Important Value Index of woody species in the natural forest

Botanical.Name	RD	RF	R A	IVI
<i>Albizia grandibracteata</i> (Taub.)	3.754	3.756	4.618	12.127
<i>Albizia gummiifera</i> (J.F. Gmel.) C.A. Sm.	5.330	2.347	2.070	9.748
<i>Allophylus abyssinicus</i> (Hochst.) Radlk	1.627	3.286	3.025	7.938
<i>Anogeissus leiocarpus</i> (DC.) Guill. & Perr.	0.000	0.469	0.318	0.788
<i>Apodytes dimidiata</i> E. Mey. ex Arn.	8.058	0.704	0.796	9.558
<i>Asparagus racemosus</i> Willd.	0.025	0.469	0.637	1.131
<i>Asplenium protensum</i> Schard.	0.551	2.817	0.478	3.845
<i>Bersama abyssinica</i> Fresen.	0.075	0.469	2.389	2.933
<i>Calpurnia aurea</i> (Aiton) Benth.	0.150	0.939	0.796	1.885
<i>Caparis tomentosa</i> Lam.	0.000	0.939	0.637	1.576
<i>Celtis africana</i> Burm. f.	0.551	1.408	0.796	2.755
<i>Clausenia anisata</i> (Willd.) Hook.f. ex Benth.	0.150	3.521	3.503	7.174
<i>Clematis longicauda</i> Steud. ex A. Rich.	0.000	0.235	0.318	0.553
<i>Clematis simenis</i> Fresen	0.000	0.469	0.318	0.788
<i>Cordia africana</i> Lam.	1.194	0.235	0.159	1.588
<i>Croton macrostachyus</i> Hochst. ex Delile	14.014	4.930	5.732	24.676

<i>Culcasia falcifolia</i> Engl.	0.043	1.174	1.115	2.331
<i>Diospyros abessinica</i> (Hiern) F. White	0.826	1.878	1.274	3.978
<i>Discopodium penninervum</i> Hochst	0.250	0.469	0.318	1.038
<i>Dombeya torrida</i> (J.F. Gmel.) Bamps	0.538	1.174	0.796	2.508
<i>Dovyalis verrucosa</i> (Hochst.) Warb.	0.576	0.704	0.478	1.758
<i>Dracaena afromontana</i> Mildbr.	0.876	4.695	9.713	15.284
<i>Ehretia cymosa</i> Thonn.	1.151	1.643	1.911	4.705
<i>Ekerbergia carpendis</i> Sparrm.	1.176	0.704	0.478	2.358
<i>Embelia schimperi</i> Vatke	0.000	2.113	1.592	3.705
<i>Euclea schimperi</i> (A. DC.) Dandy	0.175	1.408	1.274	2.858
<i>Ficus sur</i> Forssk.	6.957	3.286	3.185	13.428
<i>Galineria saxifraga</i>	0.576	0.939	0.637	2.151
<i>Gouania longispicta</i> Engl.	0.000	0.469	0.318	0.788
<i>Hagenia Abyssinica</i> (Bruce) J.F. Gmel.	0.125	0.235	0.159	0.519
<i>Hippocrata africana</i> wild	0.000	0.235	0.478	0.712
<i>Hypoestes forskalii</i> (Vahl) R. Br.	0.000	0.704	0.955	1.660
<i>Ilex mitis</i> (L.) Radlk.	1.076	1.174	0.955	3.205
<i>Jasminum abyssinicum</i> Hochst. ex DC.	0.000	1.174	2.070	3.244
<i>Juniperus procera</i> Hochst.ex A.Engl.	0.225	0.469	0.318	1.013
<i>Justicia schimperiana</i> (Hochst. ex Nees) T. Anders.	0.050	1.408	1.115	2.573
<i>Maesa lanceolata</i> Forssk.	0.826	0.704	0.955	2.485
<i>Maytenus</i> sp.	0.175	1.408	1.59	3.176
<i>Maytenus undata</i>	0.190	3.052	3.822	7.063
<i>Maytenus undata</i> (Thunb.) Blackelock	0.100	0.939	1.115	2.154
<i>Millettia ferruginea</i> (Hochst.) Baker	3.754	2.347	2.866	8.967
<i>Mimusopis kummel</i> A. DC	1.301	1.643	1.115	4.059
<i>Monotheceium glandulosum</i> Hochst.	0.000	0.469	0.478	0.947
<i>Olea capensis</i> L.	0.250	0.704	0.478	1.432
<i>Olea hochstetteri</i> Baker	2.447	3.286	3.981	9.715
<i>Olea welwitschii</i> (Knobl.) Gilg & Schellenb.	0.901	1.174	0.955	3.030
<i>Olinia rochetiana</i> A.Juss.	0.626	0.939	0.637	2.202
<i>Oncoba spinosa</i> Forssk.	0.375	0.939	0.796	2.111
<i>Pavetta oliveriana</i> Hiern	0.075	0.704	0.955	1.735
<i>Piper capense</i> L.f.	0.050	0.469	0.318	0.838
<i>Podocarpus falcatus</i> (Thunb.) R. Br. ex Mirb.	2.377	0.235	0.159	2.771
<i>Polyscias fulva</i> (Hiern) Harms	4.905	4.225	3.025	12.156
<i>Polyscias fulva</i> (Hiern) Harms	0.043	0.469	0.318	0.830
<i>Pouteria adolfi-friederici</i> (Engl.) A. Meeuse	10.811	3.756	2.548	17.114

<i>Prunus africana</i> (Hook.f.) Kalkman	6.481	2.113	1.433	10.027
<i>Psychotria orophila</i> Petit	0.100	0.939	0.796	1.835
<i>Pycnostachys meyeri</i> Gurke.	0.038	0.469	0.637	1.144
<i>Rhoicissus tridentata</i> (L.F.)	0.000	0.235	0.955	1.190
<i>Rhus glutinosa</i> Hochst. ex A.Rich.	0.175	0.939	0.955	2.070
<i>Ricinus communis</i> L	0.050	0.235	0.318	0.603
<i>Schefflera abyssini</i> (Hochst. ex A. Rich.) Harms	7.808	1.174	0.796	9.778
<i>Solanum tarderemotum</i> Bitter	0.025	1.408	0.955	2.389
<i>Stephania abyssinica</i> (Dillon & A. Rich.) Walp.	0.025	0.704	0.637	1.366
<i>Syzygium guineense</i> (Willd.) DC	3.579	2.113	1.911	7.602
<i>Teclea nobilis</i> Del.	2.077	4.930	5.255	12.261
<i>Tectaria gemmifera</i> (Fée) Alston	0.020	0.939	1.115	2.074
<i>Vernonia amygdalina</i> Delile	0.020	0.704	0.478	1.202
<i>Vernonia auriculifera</i> Hiern	0.275	2.582	1.911	4.768

Appendix Table 6: Relative Frequency, Relative dominance, Relative Abundance and Important Value Index of woody species in the Semi-Coffee forest

Botanical Name	RD	RF	RA	IVI
<i>Albizia grandibracteata</i> (Taub.)	5.222	5.265	5.738	16.225
<i>Albizia gummifera</i> (J.F. Gmel.) C.A. Sm.	5.529	3.240	3.279	12.048
<i>Allophylus abyssinicus</i> (Hochst.) Radlk	1.474	2.430	1.639	5.544
<i>Allophylus abyssinicus</i>	0.092	0.405	0.273	0.770
<i>Anogeissus leiocarpus</i> (DC.) Guill. & Perr	0.246	0.405	0.273	0.924
<i>Apodytes dimidiata</i> E. Mey. ex Arn	11.641	1.620	1.093	14.354
<i>Asplenium protensum</i> Schrad.	0.399	0.810	0.546	1.756
<i>Bersama abyssinica</i> Fresen	0.061	3.645	4.098	7.805
<i>Caparis tomentosa</i> Lam.	0.000	0.810	0.820	1.630
<i>Clausenia anisata</i> (Willd.) Hook.f. ex Benth	0.031	2.430	3.279	5.740
<i>Clematis longicauda</i> Steud. ex A. Rich	0.000	0.405	0.273	0.678
<i>Clematis simenis</i> Fresen	0.000	0.405	0.273	0.678
<i>Croton macrostachyus</i> Hochst. ex Delile	10.966	6.885	7.650	25.501
<i>Culcasia falcifolia</i> Engl	0.031	0.810	0.546	1.387
<i>Diospyros abssinica</i> (Hiern) F. White	0.092	0.405	0.273	0.770

<i>Discopodium penninervum</i> Hochst	0.276	0.405	0.273	0.955
<i>Dombeya torrida</i> (J.F. Gmel.) Bamps	0.154	0.405	0.273	0.832
<i>Dovyalis verrucosa</i> (Hochst.) Warb.	0.399	0.810	0.546	1.756
<i>Dracaena afromontana</i> Mildbr.	0.246	4.860	4.098	9.204
<i>Ehretia cymosa</i> Thonn.	0.009	0.405	0.273	0.687
<i>Embelia schimperi</i> Vatke	0.000	1.215	0.820	2.035
<i>Ficus sur</i> (F. capensis)	7.986	5.265	4.372	17.623
<i>Galineria saxifraga</i>	0.184	0.405	0.273	0.86
<i>Gouania longispicta</i> Engl.	0.000	1.215	0.820	2.035
<i>Hippocrata africana</i>	0.000	0.405	0.273	0.678
<i>Hypoestes forskoolii</i> (Vahl) R. Br	0.000	0.810	0.546	1.356
<i>Justicia schimperiana</i> (Hochst. ex Nees) T. Anders.	0.000	0.405	0.546	0.951
<i>Maesa lanceolata</i> Forssk	0.921	0.810	0.546	2.278
<i>Maytenus</i> sp.	0.018	0.405	0.273	0.697
<i>Maytenus undata</i>	0.031	4.860	12.842	17.733
<i>Maytenus undata</i> (Thunb.)	0.000	0.405	0.273	0.678
<i>Millettia ferruginea</i> (Hochst.) Baker	2.918	3.240	3.825	9.983
<i>Mimusopis kummel</i> A.DC	0.584	1.215	0.820	2.61
<i>Monotheций glandulosum</i> Hochst.	0.000	0.405	1.093	1.498
<i>Olea capensis</i> L.	0.061	0.405	0.273	0.740
<i>Olea hochstetteri</i> Baker	1.920	4.455	4.372	10.747
<i>Olea welwitschii</i> (Knobl.) Gilg & Schellenb.	1.413	1.620	1.366	4.399
<i>Oncoba spinosa</i> Forssk	0.061	0.405	0.273	0.74
<i>Oxyanthus speciosus</i> DC	0.000	0.810	0.546	1.356
<i>Polyscias fulva</i> (Hiern) Harms	3.778	5.670	3.825	13.274
<i>Pouteria adolfi-friederici</i> (Engl.) A. Meeuse	22.239	6.885	5.464	34.588
<i>Prunus africana</i> (Hook.f.) Kalkman	5.836	1.620	1.093	8.549
<i>Psychotria orophila</i> Petit	0.009	0.405	0.273	0.687
<i>Rhoicissus tridentata</i> (L.f.) Wild & R.B.Drumm	0.000	0.810	0.546	1.356
<i>Rhus glutinosa</i> Hochst. ex A.Rich.	0.276	1.215	1.639	3.131
<i>Schefflera abyssinica</i> (Hochst. ex A. Rich.) Harms	5.068	0.810	0.546	6.425
<i>Sida rhombifolia</i> L.	0.000	0.810	0.54	1.356
<i>Solanum tanderemotum</i> Bitter	0.009	0.405	0.273	0.687
<i>Syzygium guineense</i> (Willd) DC.	8.232	4.455	3.825	16.512
<i>Teclea nobilis</i> Del.	0.768	4.455	3.005	8.229
<i>Tectaria gemmifera</i> (Fee)Alston	0.154	1.215	2.459	3.828
<i>Vernonia amygdalina</i> Dalile.	0.123	1.620	2.186	3.929
<i>Vernonia auriculifera</i> Hiern	0.553	4.050	4.645	9.248

Appendix Table 7: Analysis of Variance Table for Regeneration status in Natural Forest and Semi coffee Forest

	An ova Response for regeneration Density									
Seedling Density	Df		Sum Sq		Mean Sq		F value		Pr(>F)	
	SITE		1	151050667	151050667		77.412	2.857e-12 ***		
	Residuals		58	113173333	1951264					
	MS error		Df	Mean	CV		MSD			
	1951264		58	2040	68.47435		721.9634			
	parameters									
	test name.t ntr		Student zed		Range		alpha			
	Tukey SITE		2	2.830856		0.05				
	Means									
			std	r	min	max	Q25	Q50	Q75	
	NF		3626.6667	1813.	30	400	8000	2500	3400	4400
	SCF		453.3333	784	30	0	2400	0	0	700
Sapling Density	Response: Sapling per plot									
	Df		Sum Sq		Mean Sq		F value		Pr(>F)	
	SITE		1	303.75	303.750		26.325	3.492e-06 ***		
	Residuals		58	669.23	11.539					
	parameters									
	test name.t ntr		Student zed		Range		alpha			
	Tukey SITE		2	2.830856		0.05				
	\$means									
	Sapling per plot		std	r	Min	Max	Q25	Q50	Q75	
	NF		7.066667	3.493179	30	2	18	4	7	9
	SF		2.566667	3.297683	30	0	14	0	2	4
Mature tree Density	Response: Density									
	Df		Sum Sq		Mean Sq		F value		Pr(>F)	
	Site		1	715042	715042		21.159	0.55		
	Residuals		58	939167	16193					
	\$statistics									
	MS error		Df	Mean	CV		MSD			
	16192.53		58	414.1667	30.724		31 65.76798			
	parameters									
	test name.t ntr		Studentized		Range		alpha			
	Tukey site		2	2.830856		0.05				
	means									
	Density /ha		std	r	Min	Max	Q25	Q50	Q75	
	NF		585.3333	142.	30	325	925	425.00	487.5	575.00
	SFC		552.0000	137	30	315	825	331.25	400.0	468.75

Appendix Table 8: woody species provided NTFP in both Natural forest and semi-coffee forest with types of uses and parts of the usage.

No.	Scientific name	Habit	Uses	Part of usage	Site	
					NF	SFC
1	<i>Albizia grandibracteata</i>	T	FW	stem	*	*
2	<i>Albizia gummifera</i>	T	CSH,FW and HC	stem,	*	*
3	<i>Allophylus abyssinicus</i>	T	FW and HC	stem	*	*
4	<i>Allophylus abyssinicus</i>	T	CSH,FW and HC	stem	*	*
5	<i>Anogeissus leiocarpus</i>	L	F and BH	Stem and flower	*	*
6	<i>Apodytes dimidiata</i>	T	HF	flower	*	*
7	<i>Asplenium protensum</i> Schard.	T	F and BH	Stem and Flower	*	*
8	<i>Bersama abyssinica</i>	S	MV and FW	root and stem	*	*
9	<i>Calpurnia aurea</i>	S	M V FW and FT	leaf, stem	*	-
10	<i>Caparis tomentosa</i>	L	F	leaf	*	*
11	<i>Celtis africana</i>	T	Ft	stem	*	
12	<i>Clausenia anisata</i>	S	Tc	stem	*	*
13	<i>Clematis longicauda</i> ST.	L	F and BH	Seed,	*	*
14	<i>Clematis simenis</i>	L	F , BH and FT	leaf for medicine	*	*
15	<i>Coffee arabica</i>	S	Coffee	seed	-	*
16	<i>Cordia africana</i>	T	T, HHU, and Fu and EF	timber, stem and fruit	*	-
17	<i>Croton macrostachyus</i>	T	MV,FW ,HF, and C	leaf,wood, flower, and stem	*	*
18	<i>Diospyros abyssinica</i>	T	HC and to put hive on it	wood and stem	*	*
19	<i>Dombeya torrida</i>	T	FT	stem	*	*
20	<i>Dovyalis verrucosa</i>	T	EF	fruit	*	*
21	<i>Dracaena afromontana</i> Mild	S	AF and HF	leaf, flower	*	*
22	<i>Ehretia cymosa</i>	S	MV and FT	leaf and stem	*	*
23	<i>Ekerbergia carpensia</i>	T	HHU,FT FT, for smoking	wood and stem, bark	*	

24	<i>Embelia schimperi</i> Vatke	L	MV	root and seed	*	*
25	<i>Euclea schimperi</i>	S	MV	seed	*	
26	<i>Ficus sur</i> (<i>F. capensis</i>)	T	AF, make bee hive and to put on it	fruit, and stem	*	*
27	<i>Galineria saxifraga</i>	T	FW and HC	wood and stem	*	*
28	<i>Gouania longispicta</i> Engl.	L	F		*	*
29	<i>Hagenia Abyssinica</i>	T	FT and MV	stem and seed	*	*
30	<i>Hippocrata africana</i>	L	F	seed	*	*
31	<i>Hypoestes forskalii</i>	L	F ,HF and for bee hive making		*	
32	<i>Jasminum abyssinicum</i> Ho.	L	MV	root	*	
33	<i>Juniperus procera</i> Hochst.	T	FW and HHU		*	
34	<i>Justicia schimperiana</i>	S	MV	root	*	*
35	<i>Maytenus</i> sp.	T	MV	root	*	*
36	<i>Maytenus undata</i>	S	MV, HC and F	root and stem	*	*
37	<i>Millettia ferruginea</i>	T	CH, and FW and CSH	stem	*	*
38	<i>Mimusopis kummel</i>	T	EF, and C	fruit, and stem	*	*
39	<i>Monotheceium glandulosum</i> Ho	S	AF	leaf	*	*
40	<i>Olea capensis</i> L.	T	HC and FT	stem	*	*
41	<i>Olea hochstetteri</i>	T	HC and FT	stem	*	*
42	<i>Olea welwitschii</i>	T	beehive attractive smell and stem to put bee hive on it	bark and stem	*	*
43	<i>Olinia rochetiana</i>	T	FT		*	
44	<i>Oncoba spinosa</i>	T	F and HC	stem	*	*
45	<i>Oxyanthus speciosus</i> DC	S	C	stem	*	*
46	<i>Podocarpus falcatus</i>	T	HHU, FT,	stem	*	
47	<i>Polyscias fulva</i>	T	HF and timber	flower and timber	*	*
48	<i>Pouteria adolfi-friederici</i>	T	HC, timber and Fu	stem	*	*
49	<i>Prunus africana</i>	T	MV and HF	leaf and bark, flower	*	*

50	<i>Psychotria orophila</i> Petit	S	HF	flower	*	*
51	<i>Pycnostachys meyeri</i> Gurke.	T	HF	flower	*	
52	<i>Rhoicissus tridentata</i> (L.F.)	L	F		*	*
53	<i>Rhus glutinosa</i>	T	HF and FW	flower and stem	*	*
54	<i>Ricinus communis</i>	S	HHU	seed	*	
55	<i>Schefflera abyssinica</i>	T	HF and HC	flower and stem	*	*
56	<i>Stephania abyssinica</i> Dillon	S	MV	root	*	
57	<i>Syzygium guineense</i>	T	EF,HC,and timber	fruit, stem and timber	*	*
58	<i>Teclea nobilis</i> Del.	T	FT and MV	stem and root	*	*
59	<i>Tectaria gemmifera</i> (Fee) Al.	S	AF	leaf	*	*
60	<i>Vernonia amygdalina</i>	S	MV, AF and HF	leaf/root, flower	*	*
61	<i>Vernonia auriculifera</i>	T	HF	flower	*	*

Appendix Table 9: Woody species recorded and use categories in natural forest and semi-coffee forest with their, density and frequency and parts of used as NTFPs

Medicinal						Site	
				NF		SFC	
No.	Scientific N	habit	part of usage	Den.	Fre.	Den.	Fre.
1	Bersama abyssinica	S	root	24.2	53.3	12.5	30.0
2	Calpurnia aurea . Clematis simenis	T	leaf	0.8	3.3	0.0	0
3	Fresen	L	leaf	1.7	6.7	23.3	56.7
4	Croton macrostachyus	T	leaf	30.0	70.0	0.8	3.3
5	Ehretia cymosa Embelia schimperi	S	leaf	10.0	23.3	2.5	10.0
6	Vatke	L	root	8.3	30.0	1.7	3.3
7	Euclea schimperi	S	Seed	0.8	3.3	0.0	0.0
8	Hagenia Abyssinica Jasminum abyssinicum	T	Seed	39.2	40.0	0.0	0.0
9	.	L	root	3.3	13.3	0.0	0.0
10	Justicia schimperiana	S	root	5.8	20.0	9.2	36.7
11	Maytenus sp.	T	flower	8.3	20.0	6.7	13.3
12	Maytenus undata	S	root a	20.0	43.3	4.2	13.3
13	Prunus africana Stephania abyssinica	T	leaf and bark,	7.5	30.0	6.7	20.0
14	Dill.	S	root	0.8	3.3	0.0	0.0
15	Teclea nobilis Del.	T	root	27.5	70.0	10.8	16.7
16	Vernonia amygdalina	S	leaf/root	2.5	10.0	3.3	10.0
Fuelwood	Scientific Name	Habit	Part of usage	Den.	Fre.	Den.	Fre.
1	Albizia grandibracteata	T	whole part	24.17	53.33	17.50	43.33
2	Albizia gummifera	T	whole part	10.83	33.33	10.00	26.67
3	Allophylus abyssinicus Allophylus abyssinicus	T	whole part	15.83	46.67	5.00	20.00
4	(Hochst.)	T	whole part	0.00	0.00	0.83	3.33
5	Bersama abyssinica Calpurnia aurea (Ait.)	S	whole part	12.50	6.67	12.50	30.00
6	Benth.	T	whole part	4.17	13.33	0.00	0.00
7	Croton macrostachyus	T	whole part	30.00	70.00	23.33	56.67
8	Euclea schimperi	S	whole part	6.67	20.00	0.00	0.00
9	Galineria saxifraga	T	whole part	3.33	13.33	0.83	3.33
10	Juniperus procera	T	whole part	1.67	6.67	0.00	0.00

	Hochst.						
11	Rhus glutinosa	T	whole part	5.00	13.33	5.00	10.00
12	Vernonia auriculifera	T	whole part	10.00	36.67	14.17	33.33
			part of				
HHU	Scientific Name	Habit	usage	Den.	Fre.	Den.	Fre.
1	<i>Albizia grandibracteata</i>	T	stem	24.17	53.33	17.50	43.33
2	<i>Albizia gummifera</i>	T	stem	10.83	33.33	10.00	26.67
3	<i>Allophylus abyssinicus</i>	T	stem	15.83	46.67	5.00	20.00
4	<i>Cordia africana</i>	T	wood	0.83	3.33	0.00	0.00
5	<i>Croton macrostachyus</i>	T	wood	30.00	70.00	23.33	56.67
6	<i>Diospyros abessinica</i>	T	stem	6.67	26.67	0.83	3.33
7	<i>Ekerbergia carpendis</i>	T	wood	2.50	10.00	0.00	0.00
8	<i>Galineria saxifraga</i>	T	wood	3.33	13.33	0.83	3.33
	<i>Juniperus procera</i>						
9	Hochst.	T	wood	1.67	6.67	0.00	0.00
10	<i>Maytenus undata</i>	S	stem	20.00	43.33	39.17	40.00
11	<i>Mimusopis kummel</i>	T	wood	5.83	23.33	2.50	10.00
12	<i>Olea capensis L.</i>	T	wood/stem	2.50	10.00	0.83	3.33
13	<i>Olea hochstetteri</i>	T	wood/stem	20.83	46.67	13.33	36.67
14	<i>Olea welwitschii</i>	T	wood/stem	5.00	16.67	4.17	13.33
15	<i>Podocarpus falcatus</i>	T	wood	0.83	3.33	0.00	0.00
	<i>Pouteria adolfi-</i>						
16	<i>friederici</i>	T	wood	13.33	53.33	16.67	56.67
17	<i>Ricinus communis</i>	S	seed	1.67	3.33	0.00	0.00
18	<i>Schefflera abyssinica</i>	T	wood	4.17	16.67	1.67	6.67
19	<i>Syzygium guineense</i>	T	wood/stem	10.00	30.00	11.67	36.67
	<i>Allophylus abyssinicus</i>						
20	(Hochst.)	T	stem	0.00	0.00	0.83	3.33
Animal fodder		habit	part of usage	Dens.	Fre.	Den.	Fre.
	<i>Dracaena afromontana</i>						
1	Mild	S	leaf	50.83	66.67	12.50	40.00
2	<i>Ficus sur</i> (F. capensis)	T	seed	16.67	46.67	3.33	3.33
	<i>Monotheceum</i>						
3	<i>glandulosum</i> Hochst.	S	leaf/stem	2.50	6.67	3.33	13.33
	<i>Tectaria gemmifera</i>						
4	(Fee) Alston.	S	leaf	5.83	13.33	7.50	10.00
5	<i>Vernonia amygdalina</i>	S	leaf	2.50	10.00	6.67	13.33
			part of				
smoking	Scientific Name	Habit	usage	Den.	Fre.	Den.	Fre.

	1	<i>Clausenia anisata</i>	S	leaf	18.33	50.00	10.00	20.00
	2	<i>Ekerbergia carpensia</i>	T	bark	2.50	10.00	0.00	0.00
	3	<i>Olea welwitschii</i>	T	bark	5.00	16.67	4.17	13.33
	4	<i>Vernonia amygdalina</i>	S	leaf	2.50	10.00	6.67	13.33
Coffee shade		Scientific Name	Habit	Part of usage	Den.	Fre.	Den.	Fre.
	1	<i>Albizia gummifera</i>	T	Branch/ leaf	10.83	33.33	10.00	26.67
		<i>Allophylus abyssinicus</i>						
	2	(Hochst.)	T	Branch/ leaf	0.00	0.00	0.83	3.33
	3	<i>Croton macrostachyus</i>	T	Branch/ leaf	30.00	70.00	23.33	56.67
	4	<i>Millettia ferruginea</i>	T	Branch/ leaf	15.00	33.33	11.67	26.67
	5	<i>Polyscias fulva</i>	T	Branch/ leaf	15.83	60.00	11.67	46.67
Honeybee		Scientific Name	Habit	Part of usage	Den.	Fre.	Den.	Fre.
	1	<i>Anogeissus leiocarpus</i>	L	flower	1.67	6.67	0.83	3.33
	2	<i>Apodytes dimidiata</i>	T	flower	4.17	10.00	3.33	13.33
	3	<i>Croton macrostachyus</i>	T	flower	30.00	70.00	23.33	56.67
		<i>Dracaena afromontana</i>						
	4	Mild	S	flower	50.83	66.67	12.50	40.00
	5	<i>Polyscias fulva</i>	T	flower	15.83	60.00	11.67	46.67
	6	<i>Prunus africana</i>	T	flower	7.50	30.00	3.33	13.33
		<i>Psychotria orophila</i>						
	7	Petit	S	flower	4.17	13.33	0.83	3.33
		<i>Pycnostachys meyeri</i>						
	8	Gurke.	S	flower	3.33	6.67	0.00	0.00
	9	<i>Rhus glutinosa</i>	T	flower	5.00	13.33	5.00	10.00
	10	<i>Schefflera abyssinica</i>	T	flower	4.17	16.67	1.67	6.67
	11	<i>Syzygium guineense</i>	T	flower	10.00	30.00	11.67	36.67
	12	<i>Vernonia amygdalina</i>	S	flower	2.50	10.00	6.67	13.33
wild fruit		Scientific Name	Habit	Part of usage	Den.	Fre.	Den.	Fre.
		<i>Dovyalis verrucosa</i>						
	1	(Hochst.)	T	fruit	2.50	10.00	1.67	6.67
	2	<i>Ficus sur</i> (F. capensis)	T	fruit	16.67	46.67	13.33	43.33
	3	<i>Mimusopis kummel</i>	T	fruit	5.83	23.33	2.50	10.00
	4	<i>Syzygium guineense</i>	T	fruit	10.00	30.00	11.67	36.67
Farm tool		Scientific Name	Habit	part of usage	Den.	Fre.	Den.	Fre.
		<i>Calpurnia aurea</i> (Ait.)						
		Benth.	T	stem	4.17	13.33	0.00	0.00
		<i>Celtis africana</i>	T	stem	4.17	20.00	0.00	0.00

Clematis simenis						
Fresen	L	whole part	1.67	6.67	0.83	3.33
Dombeya torrida	T	stem	4.17	16.67	0.83	3.33
Ehretia cymosa	S	stem	10.00	23.33	0.83	3.33
Ekerbergia carpensis	T	stem	2.50	10.00	0.00	0.00
Hagenia Abyssinica	T	stem	0.83	3.33	0.00	0.00
Olea capensis L.	T	stem	2.50	10.00	0.83	3.33
Olea hochstetteri	T	stem	20.83	46.67	13.33	36.67
Olinia rochetiana						
A.Juss.	T	stem	3.33	13.33	0.00	0.00
Podocarpus falcatus	T	stem	0.83	3.33	0.00	0.00
Teclea nobilis Del.	T	stem	27.50	70.00	9.17	36.67



Questionnaires'

House hold Identification and their socioeconomic condition

Part one: general background and information

Date of Interview-----month-----year-----

District-----kebele -----type of forest-----site/sub village

Can you provide the following information?

A) Respondent

1. Name _____ 2. Mobile No. _____

B) Household head

1) Name: _____ 2) Sex: _____ 3) Age _____

4) Marital Status: 1. Single----- 2. Married-----3. Divorced----- 4. Widowed-----

5) Educational status: 1. No education----- 2. Primary (grade 1 to 8) -----

3. High school 4. Higher education-----

5) Religion _____

6) Family size _____

7) Land size _____

8) Income _____

Part II: Woody species access to household survey questionnaire

1. How do you rate semi-coffee forest and natural forest access use?

Access use	Natural forest	Semi-coffee forest
Timber(restricted/common)		
Ownership felling (private/common)		
Household benefit(low/high)		

Do you use natural forest now..? 1) Yes 2) No, If yes, for what purpose_____if No-----
-----why-----

2. Woody species usage in natural forest and semi-coffee forest

No	Species local name	Type of uses	Part of uses	Site	
				Natural forest	Semi-coffee forest

3. List important woody species used for NTFPs in this area

4. What kinds of forest products you get across natural forest and semi-coffee forest?

No	Species name	Natural forest Products type/timber/non-timber	Semi-coffee forest (Products type/timber/non-timber)
1			
2			
3			
4			
5			

5. Others socioeconomic benefits of tree species from Natural forest and semi-coffee forest

usage	Natural forest		Semi-coffee forest	
	yes	No	Yes	No
Firewood				
Honey production/beekeeping				
Medicinal value				
Timber production				
Biodiversity conservation				
Wild fruit				
Charcoal production				