DIVERSITY, POPULATION STATUS AND SOCIO-ECONOMIC IMPORTANCE OF GUM AND RESIN BEARING WOODY SPECIES AT LARE AND ITANG DISTRICT OF GAMBELLA REGIONAL STATE, SOUTHWEST, ETHIOPIA

MSc. THESIS

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Diversity, Population Status and Socio-Economic Importance of Gum and Resin Bearing Woody Species at Lare and Itang District of Gambella Regional State, Southwest Ethiopia

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MSc. Thesis

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Abiyot Mamo was born on June 10, 1984 in Bedele District, Iluababora Zone, Oromia Regional State. He attended primary school in Ras Tessema primary School and secondary education at Bedele high school. Passing the Ethiopian School Leaving Examination (ESLCE) he joined Gambella ATVET College in 2004 and graduated with diploma in Natural Resource Management in 2006. He then assigned by ministry of Agriculture in the Lare woreda (Gambela regional state) where he served as Development Agent. Then he joined Mekelle University in 2008 and graduated in July 2011with B.Sc degree in natural resources economics. Soon After graduation he was employed by Gambella agricultural college as instructor and worked there for one year. He then joined Gambella natural resource and agricultural college, Mettu University as an assistant lecturer in November, 2012. After serving for one year, Mettu University sent him to pursue his post graduate study at Jimma University leading him to Master of Science (MSc.) in Natural Resource Management (Forest and Nature Conservation).

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LIST OF ABBREVIATIONS/ ACRONOMY

BA	Basal Area
CSA	Central Statistical Agency
FAO	Food and Agricultural Organization
D	Density/ha
DBH	Diameter at Breast Height
EPA	Environmental Protection Authority
GRSBoLR	Gambella Regional State Bureau of Land Resources and Environment Protection
GPS	Geographical positioning system
Ha	Hectare
HH	Household
KM^2	Kilometer Square
M asl	Meter Above Sea Level
M	Meter
mm	Millimeter
NTFP	Non Timber Forest Product
PET	Potential Evapo Transpiration
P	Precipitation
UNDP	United Nation Developmental Program
USD$	United States Dollar
PET	Potential Evapo-transpiration
SNNPR	Southern Nations, Nationalities and Peoples Region

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ABSTRACT

Ethiopia has a large coverage of gum and resin bearing species widely distributed throughout its arid and semi-arid agro-ecological zones. Different studies show that, about 420,000 ha of gum and resin producing vegetation distributed along Gambella lowland region. But there is scarce data on their population structure, density, dominancy and regeneration status as well as the diversity of species available in the region. Therefore, this study was conducted to investigate the specie composition diversity, Population status and socio-economic importance of gum and resin bearing woody species in two districts, Lare and Itang Gembella Region, southwest Ethiopia., A total of 74 quadrates (38 at Lare and 36 at Itang) with an area of 20m x20m were established at 200 m interval along transect line to collect vegetation data. In each quadrant, vegetation data such as identity, abundance, DBH, height, and counting of seedlings and saplings were collected. To assess the socio-economic importance of the study species, 120 households were randomly selected from four kebeles (two from each district) who's surrounding the selected study vegetation areas. A semis structured questionnaire was used to interview the household respondents. In addition 9 key informants, 5 from Lare and 4 from Itang were invited for group discussion. Based on the analyses of the vegetation data, a total of 52 woody species (30 at Lare and 22 at Itang) distributed in 25 families and 38 genera. A total of 9 woody species, were belonging to the genus Acacia, Boswellia and Sterculia were identified as sources of gum and resins bearing species. Gum and resin bearing species were found to be the dominant species comprising 76% and 81% of the species composition, 58.5% and 61.4% of density ha-1 and 56% and 63% of the IVI of the study sites at Lare and Itang, respectively. The Shannon-Wiener diversity and Shannon evenness values (H'=3.09 and 1.69) at Lare and (H'= 2.80 and 1.56) at Itang respectively showed the most diverse and even distribution of the population of gum and resin bearing species in the area. The socio-economic survey analysis also indicate that agro pastoral activity is the major livelihoods occupation in the study area; while wood land products such as fuel wood collection, charcoal production, wild fruit collection, construction materials and grazing wood land products are playing a significant role in the overall socio-economic conditions of the community and identified as the second predominant occupation. On the other hand, collection and sell of other non-timber forest product in the form of gums and resins rarely practiced and insignificant role in the livelihoods' of the community in the area; unlike other agro pastoralist gum and resin bearing woody vegetation species areas of the country.

Keywords: **Woodland Vegetation, Gum and Resins, Socio-economic importance, Southern Ethiopia**

1. INTRODUCTION

1.1. Background Information

Ethiopia is endowed with a wide range of ecological and edaphic factors which has favored the formation of different habitats and vegetation zones. It is estimated that there are between 6,500 and 7,000 species of higher plants in the Ethiopian flora, of which about 12% are endemic (Egziabhere 1991). Different study reports that, in this wide range of ecological and edaphic factors endowed with various species of *Acacia*, *Boswellia* and *Commiphora* that are known to produce gum arabic, frankincense and myrrh, respectively.

Gum- and resin-producing species cover substantial areas of Ethiopia. The country also has vast areas that can be considered potentially suitable for cultivating these tree crops all the country's arid and semi-arid lands , which cover an area of 560 000–615 000 km2. For instance, available estimates indicate that the total area of oleo-gum resin bearing woodlands species cover about 2.9 million ha of land in the country (Tadesse, *et al.*, 2007). In terms of regional distribution, gum- and resin producing species are found in the Afar, Amhara, Benishangul-Gumuz, Gambella, Oromia, Somali, Southern Nations and Nationalities and Tigray Regional States (Lemenih *et al.,* 2003). In its economic importance, oleo-gum resin collection and sale is reported to provide an income which ranked second after livestock in the livelihood of the pastoral community (Lemenih *et al.,* 2003).

It is even more pressing in dry-lands of Ethiopia where there is only few options to survive and desertification is expanding at an alarming rate. However, Ethiopia has a large coverage of gum and resin bearing species, widely distributed throughout its arid and semi-arid agro-ecological zones there is no full national inventory on the resource bases economic utilization (Tadesse *et al.*, 2002).

Gambella has rich natural resources. Particularly dry wood land vegetation is a high value of economy in the region (Paul *et. al*, 2012). According to WBISPP (2000, 2005) report; from total areas of land cover (vegetation) types in the region, lowland dry forest and woodland species cover larger areas of land in the region. Different studies also show that, about 420,000 ha of estimated area of gum and resin producing vegetation (especially *Commiphora*, *Acacia* and *Sterculia*) occur in Gambella region (Fitwi 2000, Lemenih *et al.* 2003). But there is scarce data on their population structure, density, dominancy and regeneration status as well as specific species available in the region.

Consequently, limited information and lack of quantitative data on their population structure, regeneration status, potential production, livelihood importance and development opportunities of the species in the region as well as national level has been reported as one of the major impediments in resource identification to planning and implementing sustainable forest management interventions in Ethiopia (EPA, 2008).

Moreover, it is also a threat to plan for future promotion and sustainable utilization of the resources without researchable data (GPRSGAR 2010). On the other hand, severe deforestation rate is also another threats in the area, that affecting the productivity of gum and resin bearing species, genetic diversity of woodland species composition and ecological importance of dry land (WBISPP, 2005). Like arid and semi arid lowland areas of the country, there are plenty of wood land vegetation with different composition of commercial tree species are available in the region. However; the way it is used by dweller right now will sweep its present to null in the future. Hence, appropriate management of these resources could contribute to efforts to conserve biodiversity and protect the environment (Bekele, 2007).

Therefore, the aim of this study was to provide quantitative data on diversity, abundance, distribution, and regeneration status and population structure of gum- and resin-bearing species in Lare and Itang districts of Gambella Regional State, Ethiopia.

1.2. Objectives

1.2.1. General objective

The general objective of this study was to provide quantities information on population status and socio-economic importance of gum and resin bearing woody species in Gambella lowland.

1.2.2. Specific objectives

The specific objectives of the study were:-

- To identify gum and resin producing woody species in the study area
- To determine the current population structure, regeneration status, density, frequency, dominance and importance value index of gum bearing species.
- To investigate the socio-economic importance of the species for the livelihood of local community and factors that hampers the local utilization level of the resource

1.2.3. Research question

The following research questions are emanated from the above objectives:

1. What is the composition and diversity of gum and gum resin yielding woody species among the woodlands?
2. What is the abundance, frequency, dominance, importance value of gum and gum resin bearing species in the study areas?
3. What are the population structure and regeneration statues of gum and resin bearing species at the study species?
4. What are the major factors that have impact on the species in general and hamper the regeneration status of the species in particular of the study area?
5. What is the socio-economic importance of the species to local livelihoods of the area and factors that hamper local utilization capacity?

2. LITERATURE REVIEW

2.1. Definition and coverage of dry lands

Dry lands are areas, areas where the ratio of mean annual precipitation (P) to potential Evapo-transpiration (PET) is less than 0.65 (Middleton and Thomas, 1997) or areas having lengths of growing period ≤ 180 days or areas with seasonal climate having several months of drought (Murphy and Lugo, 1986). Temperature is also very high in dry land areas. Such high temperature play a great role in increasing the Evapo-transpiration as a result limits plant growth and development. Dry land environment covers areas that fall under hyper-arid, arid, semi-arid and dry sub-humid ecosystems (Hawando, 1997). Approximately 40% of the global land area (excluding Greenland and Antarctica) is considered dry land (White and Nackoney, 2003). Out of this total area, the arid, semi-arid and dry sub-humid zones covers 12%, 18% and 10% respectively.

Commonly recognized dry lands include the African Sahel, the Middle East, Australian Outback, South American Patagonia, and North American Great Plains. Dry lands are inhabited by over two billion people worldwide. As lands that sometimes are poorly understood and thought of as unproductive and barren, they support nearly 40 percent of the world's population. The distribution pattern of these dryland populations vary within each region and among the aridity zones comprising dry lands (White and Nackoney, 2003). Drylands are also home for significant amount of our world's livestock and wild life population. But due to rising human and livestock population in connection with global climate change dry land ecosystems are facing serious problem (Edmund, 1997). Drylands in Africa covers 43% of the landmass with about 65% of the countries classified as dry land (UNDP, 1997).

2.2. Dry lands of Ethiopia

Ethiopia hosts one of the largest dryland areas in Eastern Africa (Lemenih and Teketay, 2004). Drylands in Ethiopia stretch from north to south and from east to west mostly at the peripheral parts of the country including a significant portion of the Rift system. In these regions of the country, arid and semi-arid are predominating. Arid and semi-arid rangelands serve as the resource basis for the livestock production system known as the pastoral production system (Kassahun *et al.,* 2008).

Drylands are among the major agro-ecological zones in the country. The arid, semi-arid and dry sub-humid areas of Ethiopia account for about 70% of the total land mass and 46% of the total arable land. These areas are found in the northern, north eastern, north western, eastern, southern and south western parts of the country (EPA, 1998).

Table 1: Data on rain fall, evapo-transpiration and coverage of dry lands in Ethiopia

Zone	Mean rainfall (Mm/YR)	Mean Evapo-transpiration (MM/YR)	Aridity index	Land area Km^2 x 1000
Hyper-arid	70	2831	<0.05	53-55
Arid	266	2213	0.05-0.20	300-310
Semi-arid	656	1700	0.20-0.50	207-250
Dry-sub humid	900	1510	0.05-0.65	300

Source: (Lemenih and Teketay (2004)

2.3. Low land woodlands of Ethiopia

Lowland woodlands are the largest remaining forests in Ethiopia, covering an estimated 55million ha (48.6 per cent) of land (WBISPP, 2004). Woodlands are lands covered by the open stand of trees taller than 5 m but shorter than 20 m and with a canopy cover of more than 20 % (EFAP, 1994**).**

The lowland woodlands are largely restricted to the agro-pastoral and pastoral areas. They are distributed over large areas in the rift valleys, Borena plain, South Omo, Somali, Gambella, and Benishangul-Gumuz regions, within the altitude range of 1000-2000 m. Woodlands are estimated to cover around 5 million ha, and bush lands 20 million ha. The woodlands are important sources of fuel wood and construction materials for the rural as well as for the urban community. They are also sources of non-timber forest products such as natural gums, myrrh and honey. Woodland provides habitat for large number of plant and animal species. Woodland is a low-density forest forming open habitats with plenty of sunlight and limited shade. Woodlands may support an understory of shrubs and herbaceous plants including grasses. Woodland may form a transition to shrub land under drier conditions or during early stages of primary or secondary succession.

Higher densities and areas of trees, with largely closed canopy, provide extensive and nearly continuous shade and are referred to as forest. Conservationists have worked hard to preserve woodlands.

The plant and animal species are adapted to these areas and it may be difficult for them to survive out of the areas that make them important for biodiversity conservation. In addition, they are important for buffering function between arid areas and highland plateau. Unfortunately, these areas are rapidly depleting by wildfire, shifting cultivation and growth of human population due to resettlement to these areas and other reasons. Woodlands are characterized by low annual incremental yield (1.2m3/ha) (EFAP, 1994). The increasing number of human population in these areas may lead to extraction of the resource beyond its annual growth and eventually its disappearance.

Constraints and issues concerning the management, conservation/protection of woodlands include lack of knowledge of the location and extent of these resources and the management system of these lands by the local communities. Because of these, the establishment of sustainable woodlands is one of the most difficult tasks facing the country at large including the region.

Table 2: woodland areas of Ethiopia

Region	Area (ha)	% of total woodland
Oromiya	9,823,163	34%
SNNR	1,387,759	5%
Gambella	861,126	3%
Amhara	1,040,064	4%
Tigray	254,455	1%
Benishangul-Gumuz	2,473, 064	8%
Afar	163,667	1%
Somali	13,199,662	45%
Total	29,202,960	

Sources: WBIPP, (2000)

2.4. Wood land vegetation distribution in Gambella region

The woodland is distributed through the central plain of the region with the altitudes below 600 m.a.s.l. Jikawo, Itang, Dimma and Akobo wereds completely fall in to savannah woodland while only few portions of Gambella, Abobo, Gog and Jor are included. The woodland also includes variety of woody vegetations in which the major constituents are varies species of *Acacia, Commiphora, Ziziphus, Sterculia, Balanites, Combretum terminalia, Croton, Cussonia, Tamarinds* (Woldeselassie 1999).

There are some 1,167,192ha of woodland and 148,951ha of shrub land in the region. The main type of woodland /shrub land comprises *Combretum-terminalia* woodland. This is found between the interfluves between the Akobo, Gillo, Baro rivers and different part of the study area. Apart from the two dominant species, others include: *Oxytenanthera abyssinica*, *Boswellia payrifera*, *Lannea schimperi*, *Anogeissus leiocarpa*, *Stereospermum kunthianum* (WBISPP, 2001).

2.5. Non-Timber Forest Products and their use

Dryland forest resources with the potential to improve rural communities' livelihoods in Sub-Saharan Africa include plant gums (gum arabic) and resins (myrrh, hagar and frankincense). Millions of people worldwide, especially in developing countries, depend on the harvest of NTFPs products such as gum, resins and latex for their livelihood (Richman, 2004). A Food and Agricultural Organization of the United Nations (FAO) report indicates that NTFPs are widely traded in the international markets with a total world trade value estimated at US$ 11 billion (FAO, 1995).

The most important Non-Timber Forest Products in Ethiopia include honey and wax, Bamboo (*Arundinaria alpina* and *Oxytenanthera abyssinica*), reeds (*Arundo donax*), wild date (*Phoenix reclinata*), Gum Arabic (from *Acacia senegal*), resin from soft-wooded species, coffee and spices, incense and myrrh (various species of *Boswellia* and *Commiphora),* edible plant products (fruits, seeds, edible oil, fat, fodder, etc.), fibers, essential oils, tannins and dyes and latex, ornamental plants, giant/long grasses which could be used to produce panel products and the raw grass as roofing cover for local house construction, edible and non-edible animal products, medicine, mushrooms, various extractives, flavorings, sweeteners, balsams, pesticides, etc (Teketay *et al.*, 2002).

Gum arabic is a dried exudates obtained from the stems and branches of *Acacia senegal*. It is the oldest and best-known of the natural gums, having been an important article of commerce for thousands of years. Its high solubility combined with low viscosity in water gives gum arabic the highly valued emulsifying, stabilizing, thickening and suspending properties that have enabled it to withstand international market competition from other natural gums and semi-synthetic substitutes. Gum Arabic is in demand both in producing countries and internationally. Traditionally, it is eaten by children and herders in the bush, and is also used as medicine to ease joint and back pain. Its major uses are in the food and pharmaceutical industries (Caracalla, 2010).

Commercial gum resins; myrrh, frankincense and hagar are also known as oleo-gum resins; they contain an essential oil component, a water-soluble gum and an alcohol-soluble resin. Myrrh is an oily resin exudates produced from trees of *C. myrrha*. Traditionally, myrrh is used to make ink, repel snakes and dangerous insects, and as a medicine. Commercially, it is an expensive highly prized ingredient used in perfumes, cosmetics, flavors and medicines. Hagar is oilier resin exudates than myrrh, and is produced from trees of *Commiphora holtiziana*. Hagar is essentially medicinal, and is used to kill ticks and treat wounds and snake bites. Commercially it is used in medicines, cosmetics, and incense and mosquito repellents. Frankincense (commonly known as olibanium) is a resin exudates from *Boswellia* species. Traditionally, it is used as chewing gum, incense and medicinally, for a wide range of ailments. The essential oil is used in the perfumery, cosmetics and flavoring industries (Caracalla, 2010).

2.6. Gum and resin bearing vegetation resources of Ethiopia

In Ethiopia, Dry forests, which comprise the largest forest resources in the country, are known for their varieties of NTFPs, which long played significant roles in subsistence, culture, medicine, food diet and income generation both at local and national scales. Their contribution to rural livelihoods, the national economy and ecosystem stability is significant, although not yet properly accounted for. Of the multitude of NTFPs obtained from the dry vegetations, natural gums and resins are probably the most valuable commodities locally, and nationally, they are the most important export commodities of the Ethiopian forestry sector. Gums and resins are tapped from a considerable number of trees and shrubs of the genera *Acacia*, *Boswellia* and *Commiphora*, and sometimes from the genus *Sterculia* **(**FfE, 2011)

Over 52 species of *Commiphora* and six species of *Boswellia* were identified in Ethiopian dry lands (Vollesen, 1989). There is a significant variation in species richness from place to place in the country. Great diversity of *Acacia*, *Boswellia* and *Commiphora* resources were reported from south and south eastern part of the country. For instance, in Liben zone of Ethiopian Somali

Regional State, a total of seven gum-resin bearing species, four *Boswellia* species: *B. neglecta*, *B.rivae*, *B. microphyla*, and *B. ogadensis* were reported, indicating the high diversity compared to the northern parts of the country for frankincense production (Lemenih *et al.*, 2003). In Borana, Oromia Regional State a total of 14 gum-resin producing species were reported (Worku, 2006). *B. papyrifera*, source for almost 90% of the export frankincense is reported from Northern Ethiopia (G/Hiywote, 2003, Eshete *et al.*, 2005, Lemenih *et al.*, 2007). Gum and resin producing species cover substantial areas of Ethiopia. The country also has vast areas that can be considered potentially suitable for cultivating these tree crops all the country's arid and semi-arid lands (ASALs), which cover an area of 560,000–615,000km^2. Although estimates differ, because of the lack of a national scale forest inventory, naturally growing *Acacia*, *Boswellia* and *Commiphora* species are believed to predominate across an area of 28,550–43,350km^2 (Fitwi 2000). Gum-producing species occur virtually all over the low-lying zones in the country's west, south, north, east, central (Rift Valley) areas and in the major river gorges such as the Blue Nile, Tekeze, Genale and Wabi Sheblle Rivers. In terms of regional distribution, gum and resin producing species are found in the Afar, Amhara, Benishangul-Gumuz, Gambella, Oromia, Somali, Southern Nations and Nationalities and Tigray Regional States (FFE, 2011).

Table 3: Estimated areas containing vegetation with gum and resin producing species in Ethiopia

National Regional State	Genus	Estimated area (ha)
Tigray	Boswellia, Sterculia, Commiphora & Acacia	940,000
Amhara	Boswellia, Commiphora, Acacia & Sterculia	680,000
Oromia	Boswellia, Acacia, Commiphora & Sterculia	430,000
Gambella	Sterculia, Acacia & Commiphora	420,000
Somali	Boswellia, Acacia & Sterculia	150,000
Benishangul-Gumuz	Boswellia, Acacia & Sterculia	100,000
SNNP	Boswellia, Acacia & Sterculia	70,000
Afar	Commiphora & Acacia	65,000
Total		**2,855,000**

Source: (Fitwi 2000)

2.7. Socio-economic importance of wood land in dry part of Ethiopia

The ever-increasing number of human population and the associated stress on the natural environment in the world, has led to the complete lose and/or decrease in productivities of various ecosystems. Such a phenomenon showed that, agriculture and livestock rearing alone are no longer the main sources of income. Furthermore, the current situation of decline in productivity of land is unlikely to improve as pressure on land resources increase with the population growth. It is therefore, essential for rural households to look for other alternatives that could contribute to the livelihood of the society while maintaining the balance of ecosystems (Vivero and Jose, 2002, Arnold and Perez, 2001).

As a matter of fact, the livelihood of the majority of rural households and a large proportion of urban households in African dry lands, including Ethiopia, depend on the forest and woodland products to meet some of their needs (FAO, 1988, Chikamai, 1997). The use of NTFPs, in general and gum and resin in particular is as old as human existence. In subsistence and rural economies the role and contributions of gum and resin collection is crucial because of their variety of application as food, herbal potions, hygiene, cosmetic and cultural values. Gums and resins provide raw material to support processing enterprises. They include internationally important commodities used in food and beverages products, flavorings, perfumes, medicines, paints, polishes and even more. Some 80 percent of the population of the developing world, who do not have access or capital to buy medicines, depends on traditional medication for their primary health (Balemie *et al,* 2004). They are also involved in the national and international markets, contributing to the country's export earnings.

In Gambella low land woodland has also great contribution to the local community livelihood for who are living around it. The result revealed that Lare wereda woodland is very important in that, it contributes significantly to the livelihood of the local communities at various levels for income generation and subsistence (Gatluak *et. al*, 2012).

2.8. Population structure

Population structure is the numerical distribution of individuals of differing size or age classes within a population of a given species at a given moment of time. It can also be defined as the distribution of individuals of each species within a population in arbitrarily defined diameter and height size classes (Peters, 1996). Regeneration of any species is confined to a peculiar range of habitat conditions and the extent of those conditions is a major determinant of its geographic distribution. The population structure of a species in a forest can convey its regeneration behavior. The population structure, characterized by the presence of sufficient population of seedlings, saplings and adults, indicates successful regeneration of forest species and the presence of saplings under the canopies of adult trees also indicates the future composition of a community. The density of seedlings and saplings is considered as an indicator of the regeneration potential. Regeneration status of trees can be predicted by the age structure of their populations. Regeneration of a particular species is poor if seedlings and saplings are much less than the mature trees. The study of regeneration of forest trees has important implications for the management of natural forests, and is one of the thrust areas of forestry. A species is considered as not abundant if the species has no tree representatives, but only saplings and/or seedlings. Regeneration is the process of silvigenesis by which trees and forests survive over time (Pokhriyal, *et al.,* 2010).

The three life stages (seedlings, saplings and trees) for different species suggested their possible future status in the forest. The status of regeneration of species will be determined based on population size of seedlings and saplings. Good regeneration, i.e. if particular species is present in seedling > sapling > tree; fair regeneration, i.e. if species present in seedling > sapling < tree; poor regeneration, i.e. if a species survives only in sapling stage, but not as seedling; if a species is present only in adult form it is considered as not regenerating, (Pokhriyal, *et al.*, 2010).

According to (Peters, 1996) there are two methods of obtaining the population structure of a given population. One method is monitoring the frequency and abundance of seedling establishment over a period of several decades and to record the resultant increase or decrease in population size over time. The second method is obtained by analyzing the size or age distribution of the individuals within its population on the basis of static vegetation data. This method is based on the analysis of size or age class distributions of trees and shrubs to achieve information about the regeneration status of a number of species. This is because the recruitment history of a particular tree species is reflected by the size or age distribution of the individuals within its population. It can show the regeneration status of a species and whether the recruitment occurs continuous or periodical (Peters, 1996). The first method gives reliable information on the age distribution of individuals and is a good indicator of future population trends. The second method is less laborious and time consuming than the first method.

2.9. Species diversity, evenness and similarity

Biodiversity is the variety of life on Earth. It includes diversity at the genetic level, such as between individuals in a population or between plant varieties, the diversity of species, and the diversity of ecosystems and habitats. Biodiversity encompasses more than just variation in appearance and composition. It includes diversity in abundance (such as the number of genes, individuals, populations or habitats in a particular location), distribution (across locations and through time) and in behavior, including interactions among the components of biodiversity, such as between pollinator species and plants, or between predators and prey (Ash and Fazel, 2007).

The diversity of species present in an ecosystem can be used as one gauge of the health of an ecosystem. The description of plant community involves the analyses of species diversity, evenness and similarity (Whittaker, 1975). Species richness is a measure of the number of different species present in an ecosystem, while species evenness measures the relative abundance of the various populations present in an ecosystem. When used in combination with diversity indices, a species richness assessment can reveal other trends in plant diversity that the more complex indices may not reveal. At certain points in serial development, it is possible for the Simpson's and Shannon-Wiener indices to decrease while the species richness increases i.e. plant communities transitional between serial stages can result in a more diverse assemblage of species, captured only by the richness measure (Reich *et al.,* 2001). Many measures exist for the assessment of similarity or dissimilarity between vegetation samples or quadrants. Some are qualitative and based on presences /absences. Many will cater for both data types. Similarity indices measure the degree to which the species composition of quadrants or sample matches is alike. Dissimilarity coefficients assess the degree to which two quadrants or samples differ in composition.

According to Magurran, (1988), most methods for measuring diversity actually consist of two components. The first is species richness but the second is the relative abundance (evenness or unevenness) of species within the sample or community. Diversity is thus measured by recording the number of species and their relative abundances. However, of the indices that combine species richness with relative abundance, probably the most widely used is the Shannon index (Kent & Coker, 1992). Shannon diversity is widely used index for comparing diversity between various habitats (Clarke and Warwick, 2001). The index makes assumption that individuals are randomly sampled from an ‘infinitely’ large population and also assumes that all the species from a community are included in the sample. Shannon-Wiener function stands the most popular measure of species diversity, which combines species richness and evenness, yet not, affected by sample size (Shannon and Wiener, 1949; Kent and Coker, 1992). Value of this index usually lies between 1.5 and 3.5, although in exceptional cases, the value can exceed 4.5. The higher the evenness values the more even distribution of the species within the quadrant (Kent & Coker, 1992).

3. MATERIALS AND METHODS

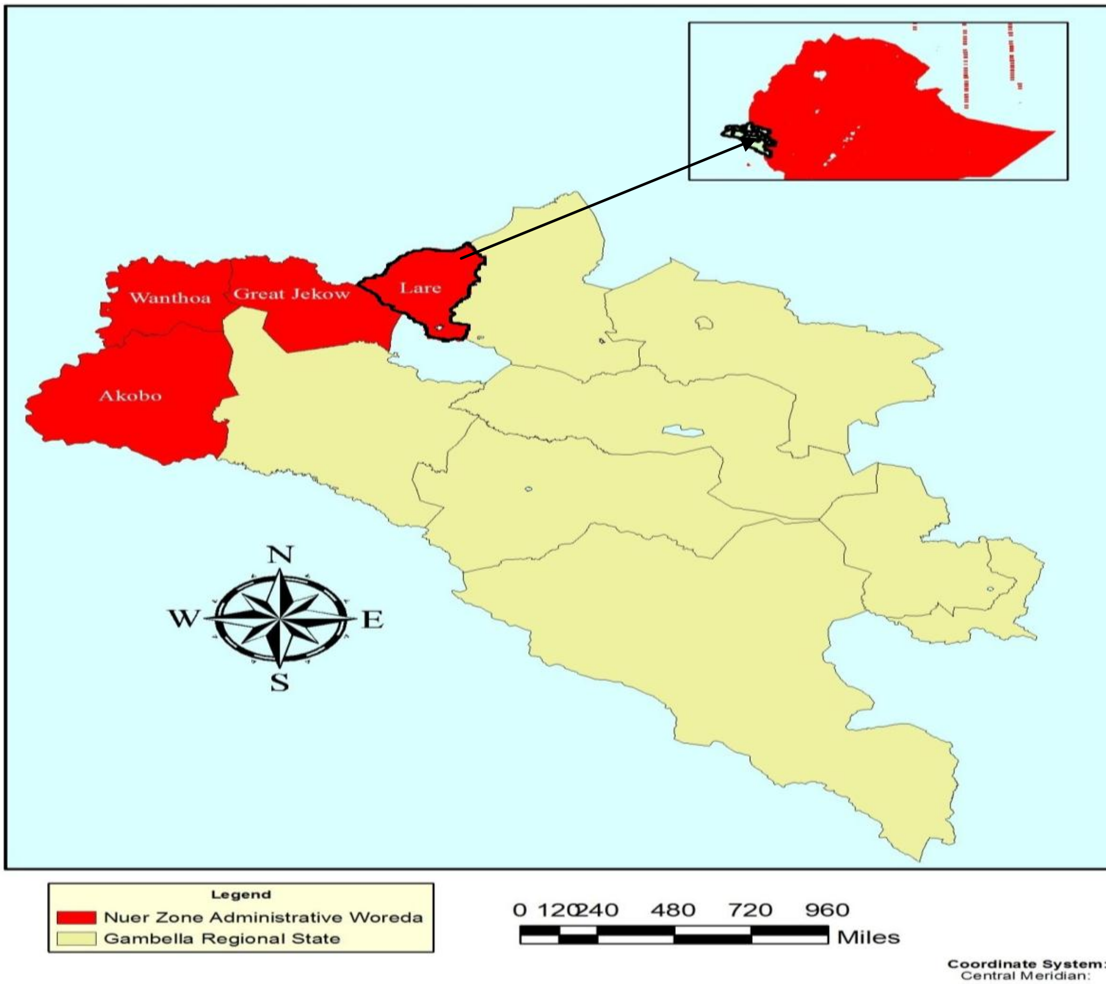
3.1. Description of the study area

The Gambella People's Regional State (GPNRS) is located in south west Ethiopia between the geographical coordinates of $6^{0}28'38"$ to $8^{0}34''$ North Latitude and 33^{0} to $35^{0}11'11''$East Longitude, which covers an area of about 34,063 km^2 about 3% of the nation. The Region is bounded to the North, North East and East by Oromia National Regional State, to the South and Southeast by the Southern Nations Nationalities and People's Regional State and to the Southwest, West and Northwest by the Republic of South Sudan (GRSBoLR, 2011)

The study was conducted in Nuer zone of Lare wereda and Itang special wereda of Gambella regional state in Ethiopia. We selected these two zones based on preliminary information indicating the presence of extensive dry land woody vegetations predominated by diverse and abundant gum- and resin-bearing species (GPRSGAR, 2010). Field reconnaissance surveys and discussions with key informants were carried out to obtain an overall picture of the zone. The two districts, Lare and Itang were purposively selected using the list of the gum and resin potential districts within the zone. Previous studies conducted on wood land vegetations of dry land were follow more or less similar procedures in selecting study sites (e.g. Lemenih, *et al*. 2003; Worku, *et al.* 2006, Adem *et al.* 2014)

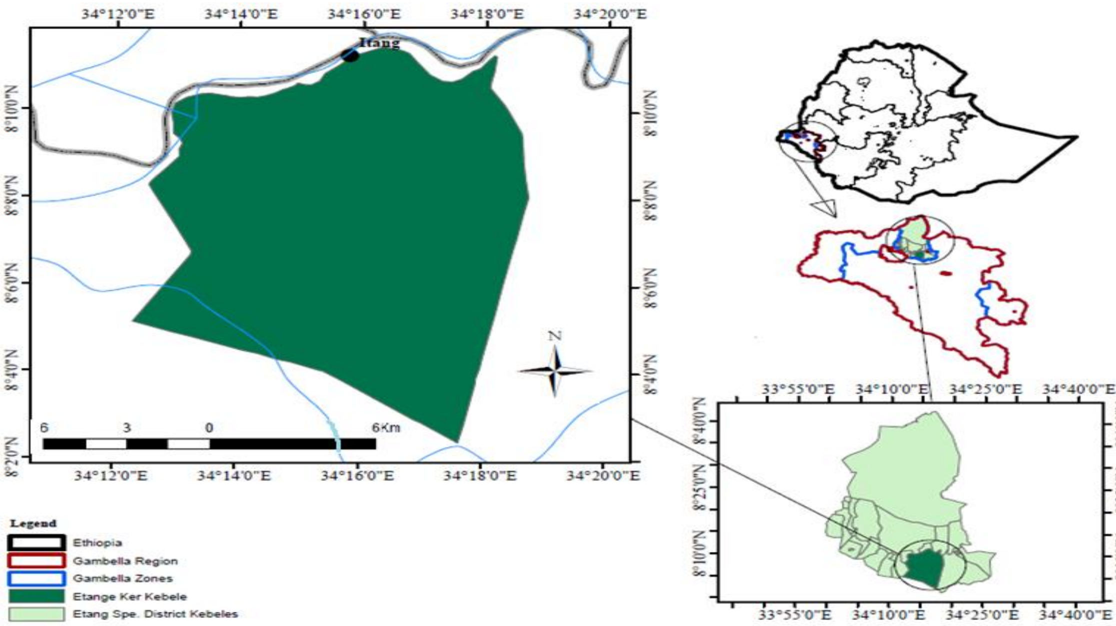
Lare is one of Nuer Zone districts in the Gambella People's National Regional State located in south-western Ethiopia (Fig. 1). The district is bordered with Anuak Zone on the south and east, on the west by the Baro River which separates it from Jikawo. The Woreda is located at 100 km away from the regional town Gambella. The terrain in Lare consists of marshes and grasslands; elevations range from 300 to 450 meters above sea level. A notable landmark is Gambella National Park, which occupies part of the area south of the Baro River. It extends between 6'N to 8.17'N latitude and 34'E to 35.02'E longitude. The study area receives average annual rainfall of 645.3 mm and annual temperature ranges from 32.71-41.32^{O}C (GBOA, 2010).The study area has wet season (May-Oct) and dry season (November-April).

Figure 1: Map of study district (Lare)



Another site of this study was Itang Special Woreda. The study area is located in the western part of Ethiopia situated at about 45 km distance from Gambella city in the west direction and at about 823 km west of Addis Abeba and at an altitude ranging from 425 to 470 meters above sea level (masl). The terrain in Itang mostly consists of woodland vegetation and grasslands and rainy season starts at the end of April and lasts in the end of October with maximum rainfall in the months of July and August. The mean annual maximum and minimum temperatures are 38.9 ^{0}C and 15.8 ^{0}C, respectively (Yeshi Ber Consultant, 2003). The Itang special woreda covers an area of 2,188 km^2 with a total population size of about 42,000. The Itang town and most of other villages are located in the left and right banks of the river which provides ecological importance and sources of livelihood to the inhabitants (GBOA, 2010).

Figure 2: Map of study district (Itang)



Socio-economically, both districts have, high dependency on wood land vegetation and traditional pastoralist and caching fish (Gatluak *et. al*, 2012), but also with evolving traditions of crop production, mainly along the river banks and wet land areas. The vegetations of the study districts can be broadly classified as, *Acacia-Commiphora* woodland and *Combretum-Terminalia* woodland. It is a mixture of *Acacia, Boswellia, Commiphora, Balanites* and various other woody species and long grasses at varying densities. The dry forests wood land in both districts supports diverse and abundant wildlife (GPRSGAR, 2010).

3.2. Methods of Vegetation Data Collection

Field reconnaissance survey was conducted at lare and Itang districts of Gambella regional state, to select specific sites where entire woodland vegetation species and specific gum bearing vegetation resources are abundantly found following the procedures used by Lemenih and Kassa, 2011).

3.3. Method of household Data collection

To assess the socio-economic importance of gum and resin bearing species and local utilization level of the resource semi structured questionnaire was used to interview household respondents. Interview was made using local language (Nuer and Agnwak). A total of four kebels were selected, two from each district (Lare and Itang) those households who live within and adjacent to the woodland and abundant gum and resin bearing vegetation area were selected. In order to select the sample size from the population size, a Krejcie and Morgan, (1970) formula was used.

$S=X^2NP(1-P)/D^2(N-1)+X^2P(1-P)$. Where,

S = required sample size.

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the population size.

P = the population proportion (assumed to be .50 since this would provide the maximum Sample size).

D^2 = the degree of accuracy expressed as a proportion (.05).

3.4. Vegetation data sampling

In this study, a systematic sampling method was used to locate the sample plots and to generate the required vegetation and environmental data. After the specific research areas were defined at both sites a systematic sampling method was used to locate the sample plots and to generate the required vegetation and environmental data. A total sample plots were determine by species area curve of the vegetation. Accordingly; 38 sample quadrants were established along 8 transect lines at Lare district and 36 sample quadrants were established along 6 transects lines at Itang district. The first plot was located randomly, then sample plots of square shapes with size of 20 x 20 meter (400 m^2) were established at 200 m interval along transect line and each transects were spaced at 400 m interval following (Eshete, 2002; Gebrehiywote *et al.,* 2002; Worku *et al* 2006; Adem *et al.,* 2014).

The altitude and position of each plot was measured by GPS. All encountered wood species were recorded and categorized into 1) seedling (if height <1.5 m), 2) sapling (if height 1.5 m - 3 m), and 3) tree (if height >3 m) (Adem *et al.,* 2014). The population structure and regeneration status of each tree species were determined by measuring and recording Diameter at Brest height (DBH) and height, using diameter tape and hypsometers an Clino meter, respectively. DBH was measured for individuals >1.5 m in height using diameter tape (Adem *et al.,* 2014). Seedlings (<1.5 m height) were counted and recorded

3.5. Household data sampling

The total number of households surveyed in this study was 120 households out of entire household's size of (1148) in selected four kebeles. The households' distribution in each kebele is shown in (Table 4). The total numbers of respondents for this study at each kebele was 37 households 30.8% in Adima, 33 households 27.5% in Pal bol, 26 households 21.6% in Adong and 24 households 20% in Tendar of the number of households in the respective Kebele. This can be considered satisfactory coverage. However, in order to determine the number of house hold from each kebele (four), kothari, (2004) formula was used.

N. P/I Where,

N = total required sample size and

P = the population size at each kebele

I = the population size that's proportion to the required sample size (since "I" indicated the Constance number of population size = 1148). The sample sizes which drawn from population size of four kebeles were summarized below (Table 4)

Table 4: Number of respondents' interviewed at each kebeles

kebeles	**Total No. of households**	**No. of respondents**	**respondents Percentage (%)**
Adong	241	26	21.6
Adima	363	37	30.8
Tendar	228	24	20
Pal bol	316	33	27.5
Total	**1148**	**120**	**100**

In addition, 9 key informants, 5 from Lare and 4 from Itang were invited for group discussion following (Worku 2006). Discussions with the regional and wereda officials were also served as source of information. The respondents were interviewed on different issues like community economic dependence of entire wood land and specifically gum and resin bearing vegetation species, local knowledge and experience about gum and resin production and sell. The selected households at each site were also asked to group themselves into different categories of wealth status and about 25% of the respondents were categorized as rich, 41.67% medium and 33.33% poor households on average. The major criteria they used were number of livestock a household possesses because in the study area the community accord high value to the keeping of cattle as it is the sign of prestige and asset. Accordingly; if the person own greater than 50 cattle he is entitled to be rich and if he has 30 cattle he is considered to be medium income and if he has 10 cattle he is considered to be poor and if he has no cattle he is said to be very poor (GPRSGAR, 2010), (Gatluak *et al.,* 2012), (Yeshi Ber Consultant, 2003). The selected respondents had an average family size of 6.5. The average level of education of the interviewed respondents was only about 12% can write and read indicating that a considerable proportion of the members of the households did not received any formal education and cannot be write and read. From the total selected respondents, male accounted for 64 % and female 36%.

3.6. Plant species identification

Plants were identified at the field (on the study quadrants), together with indigenous knowledgeable people who knows local name of the species well. Later converted to scientific name with the help different trees identification manuals and with the help of previous studies conducted on plant species in the area. Accordingly tree identification manual/Flora of Ethiopia and Eritrea (Tadesse and Hedberg 1995); Edwards *et al.,* (1997), published guides of useful trees and shrubs of Ethiopia (Bekele *et al.,* 2007) and Manual of dendrology for the south, south-east and south west of Ethiopia (Souane, 1994) were used. Moreover, on identified species and plants local names registration confirmation were made at Gambella research institution center.

3.7. Data processing and analysis

3.7.1. Vegetation data analysis

The collected data was analyzed considering ecological variables following (Magurran 1988) were made with Microsoft excel 2007 using descriptive statistics such as percentages and tables. Each measuring criteria were computed as follows:

(1) Density (DE) it is the total number of individual stems per hectare

Abundance: which is the number of stems per given species at a given quadrant. It was calculated as average abundance and relative abundance. Average abundance was calculated as the sum of the number of individual stems of a given species from all quadrants divided by the total number of quadrants. Relative abundance was calculated as the percentage of the abundance of each species divided by the total stem number of all species (Gebrehiwot, 2003)

$$\text{Relative abundance} = \frac{\text{number of individuals of a species}}{\text{Total number of individuals in the sample}} \times 100$$

(2) Frequency: is the presence of a given species in individual test plots (quadrants). It was computed as absolute frequency and relative frequency. Absolute frequency was calculated as the number of quadrants at which the species were recorded (Tadesse, 2003) while relative frequency of a species was calculated as the percentage of the frequency of a species divided by the sum total of the frequency of all species. Frequencies of gum and resin bearing species were determined by calculating the proportion of quadrants in which their individuals were encountered at each of the sites.

$$\text{Relative frequency} = \frac{\text{frequency of a single species}}{\text{Sum of all species frequencies}} \times 100$$

(3) Dominance: it is the degree coverage of a species in the sample area. It was determined by stem basal area (Kent and Coker, 1992). It was calculated as absolute dominance and relative dominance. Absolute dominance was calculated as the sum of basal areas (BA) of the individual tree species in m^2 /ha, and relative dominance is the percentage of the total basal area of a given species divided by the total measured basal areas of all species. BA was calculated for all woody species $BA=\Pi d^2/4$

Where BA = Basal area in m^2

d = Diameter at breast height in cm.

Π = 3.14

Relative dominance = $\frac{\text{basal area of a species}}{\text{Total basal area in the sample}} \times 100$

(4) Importance value index: (IVI): it was calculated to know the overall ecological importance and vegetation status of study species in the study area. IVI was calculated as the sum of relative abundance (%), relative dominance (%), and relative frequency (%) of the study species and presented in percentage (Curtis and McIntosh 1951; Lamprecht 1989; Kent and Coker 1992; Akwee *et al*. 2010).

(5) Population structure: is the numerical distribution of individuals at arbitrary given diameter/height classes that are different in size or age within a population of a given species at a given moment of time (Peters, 1996). Population structures of the entire and selected gum and resin bearing species were constructed by grouping into different arbitrary diameter classes of 5 cm interval until the sixth diameter class then 8 cm (1: <5cm, 2: 6-10cm, 3: 11-15cm, 4:16- 20 cm, 5: 21- 25cm, 6: 26 - 30cm, 7: 31 - 40cm, 8:41- 50cm, 9:>51cm) and six height classes of 2 m interval (1:<2m, 2:2- 4m, 3: 4 - 6m, 4: 6 - 8m, 5 : 8 - 10m, and 6: 10 - 12m) and six height classes of 2 m interval (1:<2m, 2:2- 4m, 3: 4 - 6m, 4: 6 - 8m, 5 : 8 - 10m, and 6: 10 - 12m).

(6) Frequency histogram of both diameter and height class distributions were used to construct population structure by using diameter and height class versus number of individuals categorized in each class. In addition, population structure of the entire vegetation and gum- and resin-bearing species alone was investigated via constructing diameter frequency histograms, where the densities of all individuals were presented on the Y-axis and diameter classes on the X-axis (Eshete *et al.* 2011; Adem *et al.*, 2014).

Finally, (7) Diversity of species: Species diversity refers to variation that exists in an ecosystem. It is an indicator of the extent of biodiversity. Diversity is often represented in the form of indices. These indices incorporate both species richness and abundance into a single numerical value. These are also referred to as the heterogeneity indices. Shannon Wiener index gives the probability of occurrence of two individuals belonging to two different species in a habitat, when selected at random. The diversity indices consider the number of species, the number of individuals of a species as well as the total number of individuals of all species.

The diversity of the whole and gum and resin bearing species was calculated using (Shannon and Wiener, 1949). This diversity formula was used to compute heterogeneity of the study species composition.

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

Where,

H'=Shannon-Wiener index

S= the number of species

Pi=the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of the total

Ln =log $base_n$

Species richness: it is defined as the number of species found in a community. The Shannon average uncertainty increases as the number of species increases. In this particular case, the numbers of observed species across the whole sample quadrants were used as a representation of species richness.

Evenness: This index describes the quality of species abundance in a community. Maximum evenness arises when all species are equally abundant. The more the relative abundance of the species differs the lower the evenness. It helps to quantify the unique representation of a given species against a hypothetical community in which all species are equally common, such that if all species have equal abundance in the community, it was calculated following (Kent and Coker 1992).

$$\text{Equitability (evenness) } J = \frac{-\sum_{i=1}^{s} pi \ln pi}{\text{LnS}}$$

Species (floristic) similarity index: it helps to compare the different habitat types or communities based on their similarity species composition. The floristic similarity of gum and resin bearing species was compared using the Sorensen's similarity coefficient (Ss) as following (Kent and Coker, 1992).

Accordingly, it was computed as: $S_S = \frac{2a}{(2a + b + c)}$

Where, S_S = Sorensen similarity coefficient

a = number of species common to both sites

b = number of species present in one study site

c = number of species present in another site

3.7.2. Socio-economic data analyses

To arrive on conclusion about socio-economic importance of entire woodland and gum and resin bearing species in the study area the data collected four villages (two each study area) in the form of household representative interview and key informants were summarized and discussed using descriptive statistics such as percentages and tables.

4. RESULTS AND DISCUSSION

4.1. Floristic composition of wood species

In this study, a total of 52 woody species (30 at Lare and 22 at Itang) distributed in 25 families and 38 genera were identified and recorded of which 18 wood species were common to both study areas (Table 5). The family Fabaceae was the most diverse family represented by 11 species (36.6%) at Lare and 8 species (34.8%) at Itang district. Combretaceae was the second diverse family with 3 species (10%) at Lare and 3 species (13%) at Itang. Rhamnaceae was the third diverse family represented with 3 species (10%) at Lare and 2 species (9%) at Itang. The rest 11 families at Lare and 9 families at Itang were represented by one species each (Table 6 &7). Among the recorded genera from entire vegetation genus *Acacia* was the most diverse representing 35% of the species Lare and 35.5% at Itang study site.

The study areas are rich in species composition (34 woody species) as compared to what was found in different parts of Ethiopia, the present study recorded better species composition next to Borana wood-lands which had reported 64 woody species (Worku, 2006). In Metema district of North Gondar wood-lands only the existence of 34 woody species had reported (Eshetu, 2002) and (Adem, *et al.*, 2014) had also reported the occurrence of 27 wood species in South Omo, Hamer and Bena-tsemay districts. Similarly, (Argaw *et al.* 1999) and (Eshete, 1999) made a study in the woodlands of the upper Rift Valley and found only six woody species along the established quadrants. Likewise, studies conducted in the woodlands of the northern part of the country had also reported only 13 species (Gebrehiwot, 2003). When compared to other wood lands of the country, Gambella lowland woody species composition was by far better in woody species composition. Such difference may be due to the physical and edaphic characteristics of the area as well as the difference in the degree of human interferences.

The Gum- and resin-bearing species are also more diverse at both study sites, especially those of the *Acacia* species compared to other sites. A total of 9 woody species (8 at Lare and 7 at Itang), were identified as sources of gum and resins; though 6 wood species were common for both site. The Genus *Acacia* was the most diverse at both sites represented by 6 species 75 % and 5 species 71.43 % at Lare and Itang district respectively. *Sterculia* and *Boswellia* were the second diverse, represented by one specie each (12.5%) and (14.3%) at Lare and Itang respectively.

In general, gum and resin bearing species comprised in term of families and genera 33.3% and 39.4% at Lare and Itang district, respectively (Table 5).

Table 5: Summery of entire and gum and resin bearing vegetation family, genera and species

	Whole vegetation		**Gum and resin bearing species**	
	Lare	Itang	Lare	Itang
Number of families	13	12	3	3
Number of genera	21	17	3	3
Number of species	30	22	8	7
Proportion of the study species composition (%)			28.7	31.8
Proportion of associated woody species (%)			71.3	68.2

Referring to those species responsible for production of gum and resins, they were much diverse in Lare woodland. In this study, a total of 9 woody species (8 at Lare and 7 at Itang) were recorded. Among these gum and resin bearing species, 6 species belong to the genus *Acacia*, 1 species belong to genus *Sterculia* and genus *Boswellia* and 5 species were belonging to the genus *Acacia*, 1 species belong to the genus *Sterculia* and genus *Boswellia* in Lare and Itang study area respectively. Four of the *Acacia* species namely*; Acacia Polyacantha*, *Acacia senegal*, *Acacia sieberiana & Acacia seyal*, one of *Sterculia* species namely*; Sterculia setigera* and one species of *Boswellia papyrifera* were common to both study site while *Acacia oerfota* and *Acacia tortilis* were not found in any of the study quadrants at Itang district (Table 6 & 7).

Tree was the dominant life form with 19 species (63.3%), tree-shrub was represented by 8 species (26.5 %), and shrub was represented by 2 species (6.7%) in Lare, while 15 species tree (65.2%), tree-shrub was represented by 7 species (30.4 %), and shrub was represented by 2 species (4.3%) in Itang study site area (Table 6 & 7).

Table 6: woody species recorded and RD, RF, ROD and IVI of vegetation at Lare district

Species scientific name	Family	Plant form	Lare					
			DE/h	N	N%	RDO	RFR	IVI%
Acacia Polyacantha	Fabaceae	*Tree	334	9	12.5	30.004	6.190	16.22
Acacia senegal	Fabaceae	*Tree	242	7	9.1	13.271	5.222	9.18
Acacia seyal	Fabaceae	*Tree	210	6	7.9	11.788	5.222	8.40
Acacia sieberiana	Fabaceae	*Tree	209	6	7.8	12.930	4.449	8.29
Ziziphus spina-christ	Rhamnaceae	Shrub/tree	138	4	5.2	2.675	3.675	4.09
Boswellia papyrifera	Burseraceae	*Tree	132	4	5.0	2.539	3.288	3.84
Acacia oerfota	Fabaceae	*Shrub/tree	117	3	4.4	1.013	4.255	3.66
Ziziphus pubescens	Rhamnaceae	Tree	110	3	4.1	2.154	3.482	3.59
Lonchocarpus laxiflorus	Fabaceae	Tree	105	3	3.9	1.391	3.095	3.25
Erythroxylum fischeri	Erythroxylacea	Shrub/tree	100	3	3.8	1.235	4.062	3.23
Albizia malacophylla	Fabaceae	Tree	94	3	3.5	0.890	3.675	3.22
Balanites aegyptiaca	Balanitaceae	Tree	92	3	3.4	1.829	4.449	3.01
Acacia bussei	Fabaceae	Tree	92	3	3.4	1.330	3.482	2.80
Combretum aculeatum	Combretaceae	Shrub	91	3	3.4	1.649	3.288	2.78
Acacia tortilis	Fabaceae	*Tree	78	2	2.9	1.453	3.095	2.75
Combretum molle	Combretaceae	Tree	77	2	2.9	2.279	2.901	2.69
Sterculia setigera	Sterculiaceae	*Tree	68	2	2.6	3.404	5.029	2.69
Senna obtusifolia	Fabaceae	Tree	67	2	2.5	5.344	4.449	2.48
Dalbergia melanoxylon	Fabaceae	Shrub/tree	47	1	1.8	0.194	3.482	1.90
Tamarindus indica	Rhamnaceae	Tree	45	1	1.7	1.504	2.515	1.87
Flueggea virosa	Euphorbiaceae	Shrub	37	1	1.4	0.063	2.128	1.81
Piliostigma thonningii	Fabaceae	Tree	33	1	1.3	0.176	2.321	1.52
Strychnos innocua	Loganiaceae	Tree	33	1	1.2	0.450	2.901	1.25
Ximenia americana	Meliaceae	Shrub/tree	27	1	1.0	0.142	4.449	1.19
Pithecellobium dulce	Combretaceae	Shrub/tree	26	1	1.0	0.099	1.741	1.17
Dichrostachys cinerea	Fabaceae	Shrub/tree	25	1	0.9	0.063	2.515	0.93
Sclerocarya birrea	Anacardiaceae	Tree	22	1	0.8	0.086	1.547	0.81
Cadaba farinose	Capparaceae	Tree/shrub	12	0	0.4	0.025	1.741	0.74
Celtis toka	Ulmaceae	Tree	10	0	0.4	0.006	0.967	0.45
Ficus sycomorus	Moraceae	Tree	6	0	0.2	0.012	0.387	0.21
Total			**2678**	**74**	**100**	**100**	**100**	**100**

Total density per ha (DE) = 2678, (N) = Abundance/plot, N (%) = relative Abundance, RFR (%) = relative frequency, RDO (%) = relative dominance, IVI = Importance Value Index (%). *Gum- and resin-producing species.

Table 7: Woody species recorded and RD, RF, ROD and IVI of vegetation at Itang district

Species scientific name	Family	Plant form	Itang					
			DE/ha	N	N%	RDO	RFR	IVI%
Acacia seyal	Fabaceae	*Tree	378	10	18.4	29.743	8.038	18.945
Acacia Polyacantha	Fabaceae	*Tree	264	7	12.9	14.388	4.787	11.758
Acacia sieberiana	Fabaceae	*Tree	199	5	9.7	12.621	8.747	10.036
Acacia senegal	Fabaceae	*Tree	120	3	5.8	9.663	7.801	7.256
Acacia nilotica	Fbaceae	*Tree	118	3	5.7	8.014	2.837	6.195
Balanites aegyptiaca	Balanitaceae	Tree	113	3	5.5	5.18	4.492	5.307
Boswellia papyrifera	Burseraceae	*Tree	111	2	3.8	3.802	7.092	5.147
Combretum molle	Combretaceae	Tree	78	2	3.6	2.532	2.128	5.046
Sterculia setigera	Sterculiaceae	*Tree	73	2	3.5	1.85	2.6	3.518
Senna obtusifolia	Fabaceae	Tree	71	2	3.4	1.491	5.201	3.097
Dalbergia melanoxylon	Fabaceae	Shrub/tree	70	2	3.2	1.402	2.364	3.06
Tamarindus indica	Rhamnaceae	Tree	66	1	2.6	1.112	6.383	2.187
Flueggea virosa	Euphorbiaceae	Shrub	53	1	2.5	0.839	1.655	1.85
Strychnos innocua	Loganiaceae	Tree	51	1	2.5	0.709	4.728	1.746
Ximenia americana	Meliaceae	Shrub/tree	51	1	2	0.618	2.6	1.724
Pithecellobium dulce	Combretaceae	Shrub/tree	41	1	2	0.618	1.891	1.641
Dichrostachys cinerea	Fabaceae	Shrub/tree	40	1	1.9	0.481	2.364	1.578
Celtis toka	Ulmaceae	Tree	38	1	1.8	0.419	3.783	1.562
Ziziphus spina-christ	Rhamnaceae	Shrub/tree	37	1	1.6	0.373	5.674	1.387
Crateva adansonia	Combretaceae	Tree	34	1	1	0.308	3.546	1.314
Sarcocephalus latifolius	Rubiaceae	Shrub/tree	20	1	1	0.214	2.6	1.268
Vitellaria paradoxa	Sapotaceae	Tree	20	0	0.6	0.214	1.891	1.08
Total			**2059**	**54**	**100**	**100**	**100**	**100**

Total density per ha (DE) = 2059, (N) = Abundance/plot, N (%) = relative Abundance, RFR (%) = relative frequency, RDO (%) = relative dominance, IVI = Importance Value Index (%). *Gum- and resin-producing species

In sum up, both study area supported high diversity of gum and resin bearing species, a total of 9 woody species (8 at Lare and 7 at Itang), of which 6 species were common to both study districts, were found to yield gum and resin. According to the result of species diversity, Gambella lowland woody vegetation species is the richest area in gum and resin bearing species compared to other woodlands which having similar agro-climatic conditions. For instance, only *B. papyrifera* had reported as incense bearing species in woodlands of the northern part of the country Eshete *et al*. (2005), and Gebrehiwot (2003). Similarly, only two species *(A. senegal* and *A. seyal)* had reported as gum bearing species at the upper Rift Valley zone of the country, Eshete (1999). Likewise, Lemenih *et al.* (2003) reported 7 species as source of gum and incense at Liben zone, in Somali area and 16 woody species had reported in South Omo, Hamer and Bena-tsemay districts (Adem *et al* 2014).

4.2. Density, dominance frequency and importance value of woody species

The total density of all woody species was found to be 2678 individuals' ha-^{1} and 2059 individuals' ha-^{1} at Lare and Itang, respectively. Like species composition, total density/ha of Lare is greater than Itang. This difference may be due to the difference in land use system between as well as the level of human disturbance difference between two districts. From the species dominating the density of the study areas were *Acacia Polyacantha, Acacia senegal, Acacia seyal, Acacia sieberiana, Ziziphus spina-christ, Boswellia papyrifera, Acacia oerfota, Ziziphus pubescens,* and *Lonchocarpus laxiflorus* constituting 60% of the entire density at Lare. *Acacia seyal, Acacia polyacantha, Acacia sieberiana, Acacia senegal, Acacia nilotica, Balanites aegyptiac, Boswellia papyrifera, Combretum molle, and Sterculia setigera* were the dominating species of the total density by contributing 70 % of the recorded species at Itang (Table 6 &7).
The fourth top species dominating the density of the entire vegetation in Lare were *Acacia Polyacantha, Acacia senegal, Acacia seyal* and *Acacia sieberiana* with contributing 12.5%, 9.1%, 7.9% and 7.8%. While *Acacia seyal, Acacia Polyacantha, Acacia sieberiana* and *Acacia senegal* were the fourth top species dominating the density of the entire vegetation with 18.3%, 12.8%, 9.7% and 5.8 in Itang (Table 6 &7).

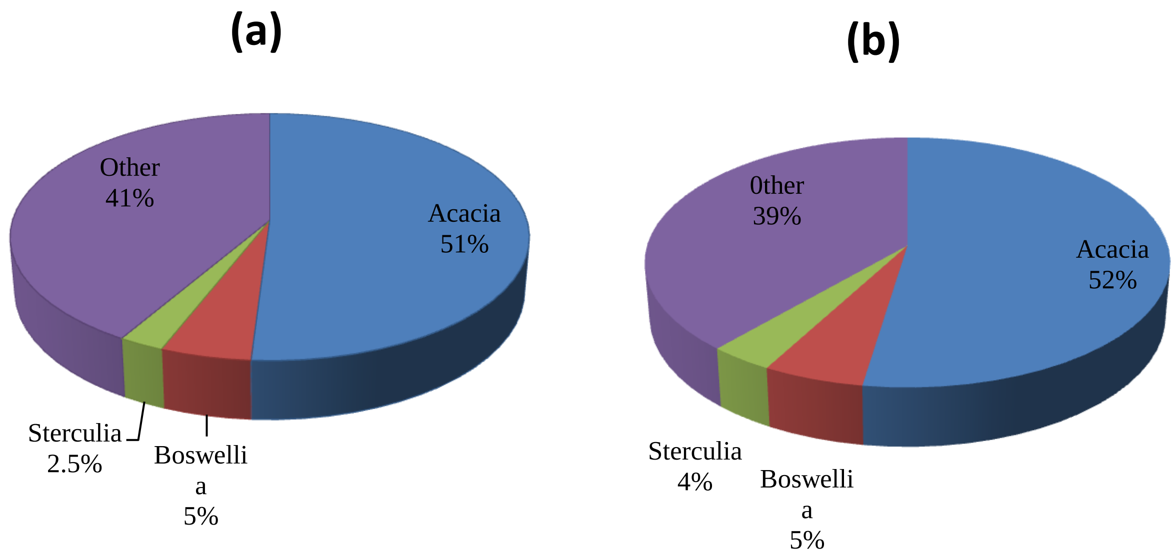
The proportion of gum and resin bearing species in density ha-^{1} was 58.5% and 61.4% of the individuals recorded at Lare and Itang respectively. The contribution of the species from the genus *Acacia*, genus *Boswellia* and *Sterculia* were 51%, 5% and 2.5%, respectively at Lare and that of genus *Acacia,* genus *Sterculia* and *Boswellia* were 52.4%, 5.5%, 3.5%, respectively at Itang (Figure 3).

In comparison of gum and resin bearing species, more or less comparable results reported from other gum and resin production localities in different parts of Ethiopia. For instance, Worku *et al*. (2006) and Adem *et al.,* (2014) reported total density per ha of 1017 and 882 (49% and 68% of the total woody stems density) at Arero and Yabello districts in Borana zone, Oromia region in Ethiopia and 919 and 1085 ha-^{1} (48% and 50% of all species density) at Hamer and Bena-Tsemay of south Omo zone, southern region in Ethiopia.

In density per hectare the most densely populated individual of gum and resin bearing species were *Acacia Polyacantha* 334 ha -^{1}, *Acacia senegal* 242ha -^{1}, *Acacia seyal* 210, ha -^{1} *Acacia sieberina* 209 ha -^{1} and the second abundant ones were *Boswellia papyrifera* 132ha -^{1} and *Acacia oerfota* 117 ha -^{1} at Lare. *Acacia seyal* 378 ha -^{1} *Acacia Polyacantha* 264 ha -^{1} and *Acacia sieberina* 199 ha -^{1} and *Acacia senegal* 120 ha -^{1} were the four most abundant ones, while *Acacia nilotica* 118 ha -^{1}, *Boswellia papyrifera* 113 ha -^{1}, and *Sterculia setigera* 113 ha -^{1} were the second abundant species at Itang (Table 6&7).

However, density typically varies greatly by species as compared to other studies conducted at different parts of Ethiopia. For instance, it reported stem densities per ha ranged from 11 to 313 ha -^{1} at South Omo (Adem *et al*., 2014) and 12 to 162 ha -^{1} at Borana (Worku *et al*., 2006), ranged from 87 to 175 at Amhara region, northern Ethiopia Eshete *et al*., (2005) while Gebrehiwot (2003) counted between 100 and 254 stems per ha for similar agro-ecological zone in Tigray region, northern Ethiopia. Such great variation in stem densities might be due to the effect of agriculture expansion, climate regime and species characteristics. Generally gum and resin bearing species cover more than half of the total species in terms of density/ha in both study area of Gambella region.

Figure 3: Proportion of density/ha of entire vegetation at Lare (a) and Itang (b)



The result of the analyses of dominance (as calculated from the basal area data) revealed that, total gum and resin bearing species were 76.4% and 81% dominant over entire species in Lare and Itang respectively (Tables 6 &7). Dominance which indicates the ground coverage of gum and resin bearing species was by far higher than associated species in both study areas. *Acacia Polyacantha*, *Acacia senegal*, *Acacia seyal* and *Acacia sieberiana* were the four top dominant species at Lare by 30%, 13.3%, 12.9% and 11.8% respectively While *Acacia seyal*, *Acacia Polyacantha*, *Acacia sieberiana and Acacia senegal* were the four top dominant species at Itang district by 29.7%, 14.4%, 12.6% and 9.6% respectively (Table 6 &7). *Boswellia papyrifera* and *Acacia oerfota* were the second dominant species at Lare representing *2.5%* and 2% respectively, while *Acacia nilotica* and *Boswellia papyrifera* were representing 8% and 5% at Itang and Acacia *oerfota* and *Acacia tortilis* were found to be the least dominant species among the study species at Lare, while *Sterculia setigera* at Itang (Tables 6 &7). The high dominance of gum and resin bearing species over associated species indicates the higher the production of gums and resins in the area.

As compared to what was found in different woodland part of Ethiopia, the present study recorded high dominance (76% at Lare and 81% at Itang) of gum and resin bearing species next to the dominance of gum and resin bearing species at south Omo which had reported 95 % and 96 % at Hamer and Bena-Tsemay, respectively (Adem *et al.*, 2014).

Frequency is not similar from quadrant to quadrant within study area since frequency of the recorded species ranges from two to thirty two at Lare out of 36 sample quadrants and from seven to thirty seven at Itang out of 38 sample quadrants (Tables 6&7). The most frequent gum and resin bearing species at Lare were *Acacia Polyacantha (*32) *Acacia senegal* (29), *Acacia seyal* (27), *Acacia sieberiana* (26) and *Boswellia papyrifera* (22). The most frequent species at Itang were *Acacia seyal* (37) *Acacia Polyacantha* (34) *Acacia sieberiana* (33) and *Acacia senegal* (31) While *Sterculia setigera* (11) was the least frequent gum and resin bearing specie at Itang study area. From the associated growing species *Balanites aegyptiaca*, *Tamarindus indica* and *Strychnos innocua* were the top frequent species at both sites (Tables 6&7). The high frequency indicates regular horizontal distribution of the species in the woodland. Frequency analyses in the present study revealed that the horizontal distribution of the gum and resin bearing species was more or less similar at both study sites (Lare and Itang) and more or less good distribution across the site.

IVI of gum and resin bearing species was 56% and 63% at Lare and Itang respectively (Table 6&7). The top four important species in terms of their IVI were *Acacia Polyacantha*, *Acacia senegal*, *Acacia seyal*, *Acacia sieberiana* at Lare. They showed high ecological significance by contributing 42.8% of the entire IVI of the site. *Boswellia papyrifera and Acacia oerfota* other important species while *Sterculia setigera and Acacia tortilis* were the least species in terms of their IVI in Lare study area (Table 6). *Acacia seya*, *Acacia Polyacantha*, *Acacia sieberiana* and *Acacia senegal* were the four top important gum and resin bearing species at Itang in terms of their IVI by contributing 47.9% from the total IVI (Table 7). Others like *Acacia nilotica* and *Boswellia papyrifera* were also important in term IVI at Itang. While *Sterculia setigera* were the least species in terms of their IVI at Itang(Table 7). Summary of quantitative analysis of density, dominance, frequency and IVI of all recorded plant species is presented in and (Table 6 and 7).

IVI value is an important parameter that reveals the ecological significance of species in a given ecosystem, since it reflects the combined effect of species abundance, frequency and dominance (Kent and Coker 1992; Gebrehiwot, 2003; Shibru and Balcha, 2004) and Akwee *et al*. 2010). It enables prioritizing species for management and conservation interventions. Species with lowest IVIs might benefit from conservation and management interventions (Lamprecht 1989 and Shibru 2002). In this study area the IVI coverage of gum and resin bearing species was 56% and 63% at Lare and Itang respectively. Itang study site was better IVI in gum and resin bearing species as compared to Lare study area. In both study area, more than half of the IVI value is covered by gum and resin bearing species, it shoes how much these species are ecologically important to the area as well as the region is potential areas in gum and resin products.

When we compare the IVI value with other wood lands harboring oleo-gum bearing species, 69.8% and 60.2% at Arero and Yabello districts of Borana respectively, as reported by (Worku, 2006), and 63.63% at Hamer and 55.79% at Bena-Tsemay South Omo (Adem *et al*. 2014) due to this the IVI value of gum and resin bearing species at Lare and Itang were comparable IVI with both south Omo and Borena woodland.

4.3. Diversity, evenness and similarity of species

Diversity of a given species at given plant community helps to know the relative variation of those species within and between the communities (Adem *et al* 2014). Diversity can express based on the species richness (the number of species present) and based on species abundance (the number of individuals per species). Based on species richness Lare site was more diverse both in entire vegetation and particularly in gum and resin bearing species (Table 8). Similarly based on species abundance (the number of individuals per species) genus *Acacia* was more diverse in both sites. The comparison of diversity and evenness computed by Shannon-Wiener diversity H' and Shannon evenness J' showed higher diversity in Lare than Itang both in entire vegetation and gum and resin bearing species. The Shannon-Wiener diversity H' of the entire and gum and resin bearing species were (H'=3.09 and 1.69) at Lare and (H'= 2.80 and 1.56) at Itang respectively. The Shannon evenness J' of the entire and gum and resin bearing species were (J= 0.91 & 0.50) at Lare and (J= 0.88 & 0.71) at Itang respectively (Table 8).

The result showed that the existence of high diversity in the case of the whole woody species as well as gum and resin bearing species at Lare as compared to Itang. The Shannon-Weiner diversity index normally varies between 1.5 and 3.5 and rarely exceeds 4.5 (Kent and Coker 1992). In this particular study, the diversity of vegetation of both districts was more or less in the normal diversity ranges according to Kent and Coker (1992). This indicates the existence of normal distribution among individuals of species encountered at a given study areas.

When compared to studies conducted in the other wood lands of Ethiopia comparative results had reported in Arero (H’= 3.22) and Yabello (H’=2.77) districts of Borena Lowland of southern Ethiopia (Worku *et al.* 2006). On the other hand, recent study conducted in south Omo zone of Somali lowland had reported lower diversity index as compared to this study result both in entire and gum and resin bearing species (H’=2.48 and 1.28) at Hamer and (H’= 2.61 and 1.4) at Bena-Tsemay respectively (Adem *et al* 2014). Such representation in a natural stand in Gambella lowland may probably indicate less disturbance and healthy regeneration of the vegetation in the study area as compared to Somali low land.

Table 8: Summery of diversity parameters for the entier and oleo-gum bearing species at both

	Sites			
	Lare		**Itang**	
Characteristics	All encountered species	Gum and resin bearing species	All encountered species	Gum and resin bearing species
Species richness	30	8	22	7
Density/ha	2678	1649	2059	1332
Shannon diversity (H')	3.09	1.69	2.80	1.56
Shannon Evenness (J')	0.91	0.50	0.88	0.71

Sorensen’s Similarity coefficient is another parameter used to identify the similarity of species composition between two study sites. Sorensen’s similarity coefficient of the entire species between two sites were 0.42 (42%), while gum and resin bearing species between two sites were 0.80 (80%) (Table 9). The Sorensen’s similarity coefficient value reveals that the closer the value is to 1, the more the communities have in common or in similar. Accordingly those gum and resin bearing species between two sites were more or less similar (80%) as compared to entire species (42%) between two sites. This may probably due to species richness and diversity similarity in gum and resin bearing species between two sites. The dissimilarity in entire vegetation between two sites may arise due to the existence of more number of species that was encountered at Lare (30) than at Itang (23).

Table 9: Sorensen's similarity coefficients for the entire and gum and resin baring species b/n two site Sorensen's

	Entire species	Gum and resin bearing species
Site	**Lare**	**Itang**
Itang	0.42	-
Lare	-	0.8

4.4. Population structure

4.4.1. Population structure of the entire vegetation

The comparative patterns of the entire woody plant species population structure (stem diameter and stem height class distributions) at both study sites is presented in (Figure 4&5). Analysis of the diameter and height size class distribution shows more or less similar distribution at both districts by being uniform in declining stem density as diameter and height class increases. Densities of stems were very high at the first and third diameter classes at Lare, while first and second at Itang districts. As the diameter and height classes increase, both density of stems and species richness drastically decreases. Generally there is an inverse relation between the pattern of species distribution and increasing diameter and height classes. The population structure of the entire vegetation depicts the existence of more number of individuals at lower diameter classes which were happened due to the occurring high number of individuals of the associatively vegetation species. The patterns of diameter and height class distribution in both study area indicate more or less inverted J –shape which show a health population pattern (Figure 4&5).

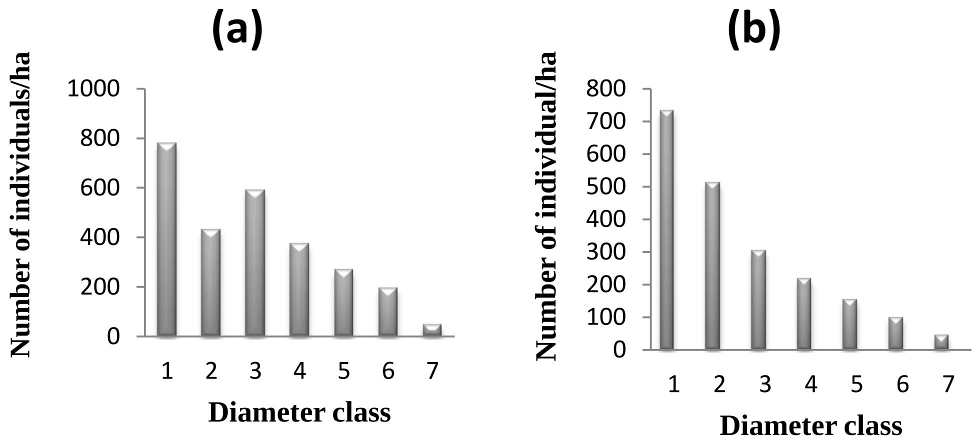


Figure 4: Diameter class distribution of the entire vegetation at Lare (a) and Itang (b)

Diameter size class in (cm) 1: 0<5cm, 2: 6<10cm, 3: 11<15cm, 4:16<20cm, 5: 21<25cm, 6: 26<30cm, 7: 31<40cm

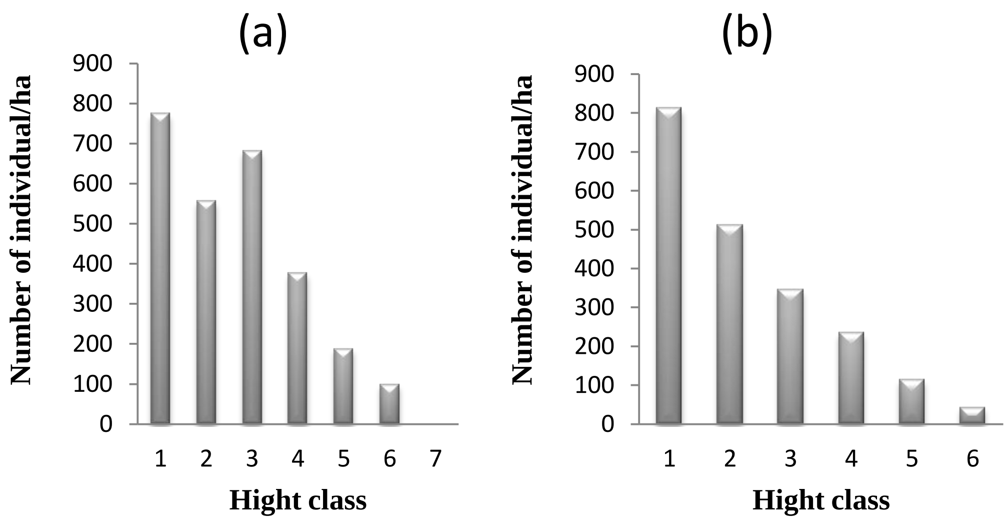


Figure 5: Height class distribution of the entire vegetation at Lare (a) and Itang (b)

Height size classes in (m), 1 :< 2m, 2:2<4m, 3: 4<6m, 4: 6<8m, 5: 8<10m, and 6: 10<12m

The first and second classes were dominated by shrubs like *Flueggea virosa* and *Combretum aculeatum* and seedlings and sapling of different tree species. The third and fourth height classes were dominated by gum and resin bearing species especially those Fabaceae families. The last height class was represented by few stems of *Balanites aegyptiaca, Ficus sycomorus, Tamarindus indica, Celtis toka* and *Sterculia setigera* this was also shows inverse relation between height distribution and density of stem.

4.4.2. Stem diameter and height class distribution of gum and resin bearing species

Information on population structure (diameter and height class distribution) of a tree species indicates the history of the past disturbance to that species and the environment and hence, used to forecast the future trend of the population of that particular species (Teketay, 1997 and Bekele, 1994). The population structure of diameter / height class distribution of gum- and resin-bearing species can be categorized more or less into three groups: inverted J-shape, J-shape and bell-shape distribution patterns at both districts (Figure 7&8). *Boswellia papyrifera* and *Sterculia setigera* were exhibited J-shape at both districts, which was an unhealthy distribution due to lack of seedlings and had minimum number of individuals in the first and second diameter / height class distribution.

This reflects a hampered regeneration status of the species due to possible reasons like human pressure, over grazing (livestock trampling or browsing), annual fire and flooding in the area. *Acacia seyal* and *Acacia Polyacantha* were exhibited an Inverted-J-shape pattern at both Lare and Itang site. *Acacia sieberiana* at Lare and *Acacia senegal* at Itang, were exhibited an inverted-J-shape. The rest major gum and resin bearing species in both districts more or less demonstrated a bell-shape distribution, where there was small number of individuals in the lower and higher diameter classes (Fig. 7&8).

Eshete *et al*. (2005) and Worku *et al*., (2006) argued that sustainable supply of gum and resins from dry forests could be achieved given the current population structure of the entire forest and/or particular species. To achieve stable levels of trade volume in gum and resin, a species needs many seedlings and saplings in comparison to the stem counts for higher diameter / height class to ensure species perpetuation. Simultaneously, the forest must support many trees in the middle and higher diameter classes because these trees are the ones that are tapped right-away to produce commercial products (Lemenih *et al*. 2003; Yebeyen, 2006; Worku *et al.,* 2006).

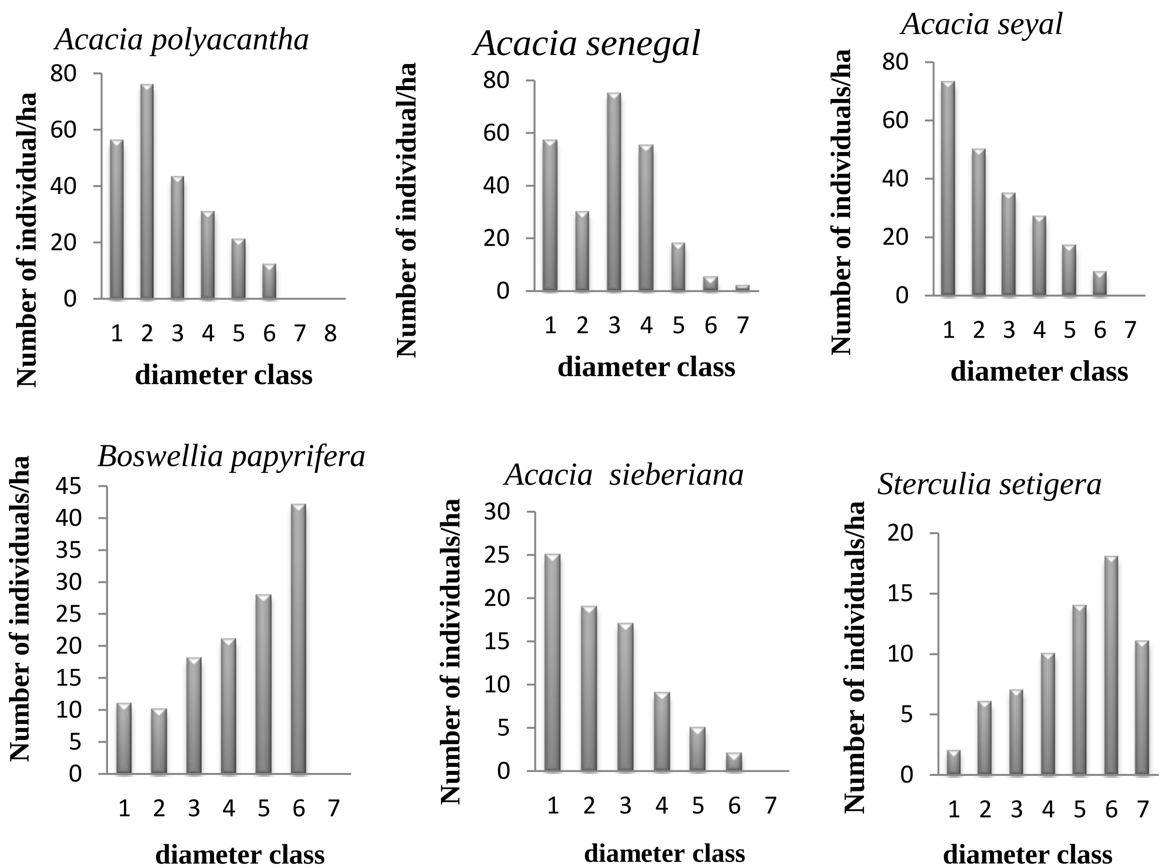
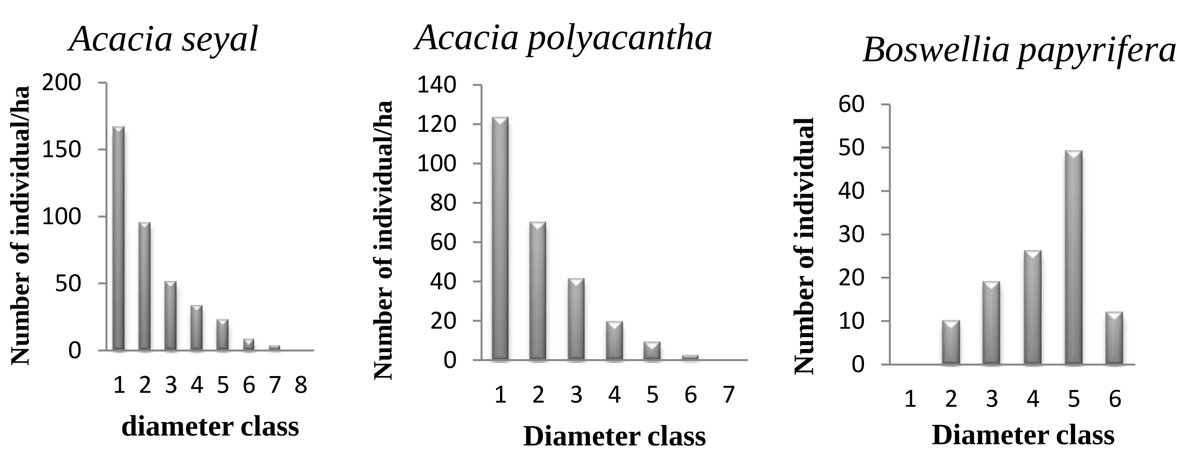


Figure 6: Diameter class distribution of selected oleo-gum species at Lare district. Diameter class in (cm) 1:0 < 5 cm, 2: 6 – 10 cm, 3: 11 – 15 cm, 4:16 – 20 cm, 5:21 – 25 cm, 6: 26 – 30 cm, 7: 31 – 38 cm



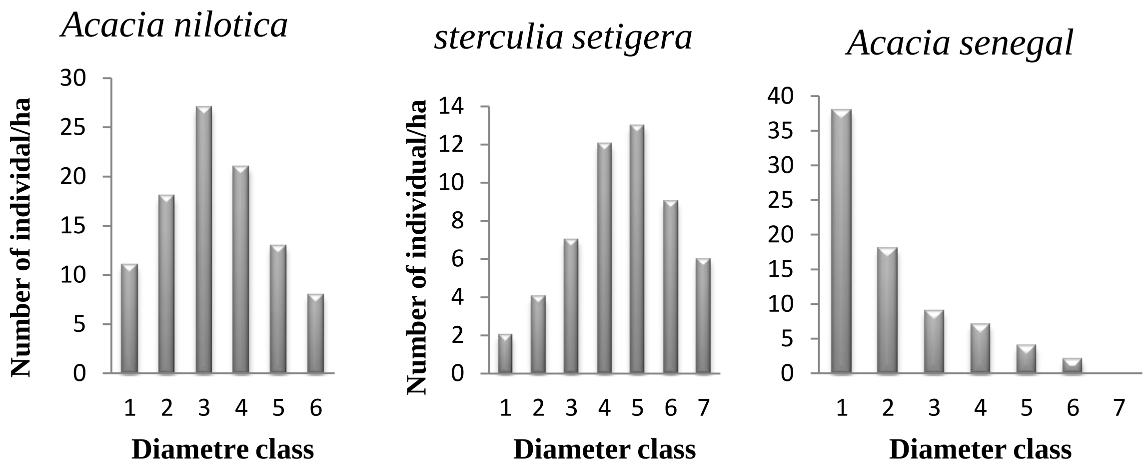


Figure 7: Diameter class distribution of gum and resin bearing species at Itang district

Diameter class in (cm) 1:0 < 5 cm, 2: 6 – 10 cm, 3: 11 – 15 cm, 4:16 – 20 cm, 5:21 – 25 cm, 6: 26 – 30 cm, 7: 31 – 38 cm

In this study numerous lower diameter /height class distribution (seedlings) were counted for *Acacia* species. Regeneration such species might also correlate with abundant seed production and soil seed bank formation of species (Teketay, 1997). In this case, as most of the *Acacia* species are able to form soil seed bank, this might also contribute to the good regeneration after rain (Worku *et al.* 2006), Argaw *et al.*, (1999) and Eshete (1999) had also reported the thorny nature of *Acacia* species help the seedling to escape from browsing by cattle. The others declining regeneration profile of gum and resin species on this study areas was similar to the situations reported for the various gum and resin belts in the country (Argaw *et al*. 1999; Yebeyen 2006; Eshete *et al*. 2011; Worku *et al*. 2006).

In general, the proportion of population structures in entire vegetation as well as gum- and resin-bearing species (those *Acacia* species) were exhibit normal population structure in Itang as compared in Lare. This was possibly, due to the occurrences of normal proportion profile in seedling, sapling and trees with the ratio of (44%), (33%) and (23%) in Itang respectively. While seedling, sapling and tree were occurs in the proportion of (37%), (27%) and (36%) respectively in Itang which depicted abnormal proportion of population structures (Figure 9). This may probably occurs, due to heavy grazing, frequent flooding and fire regime as major factors limiting regeneration of most woody species in Lare.

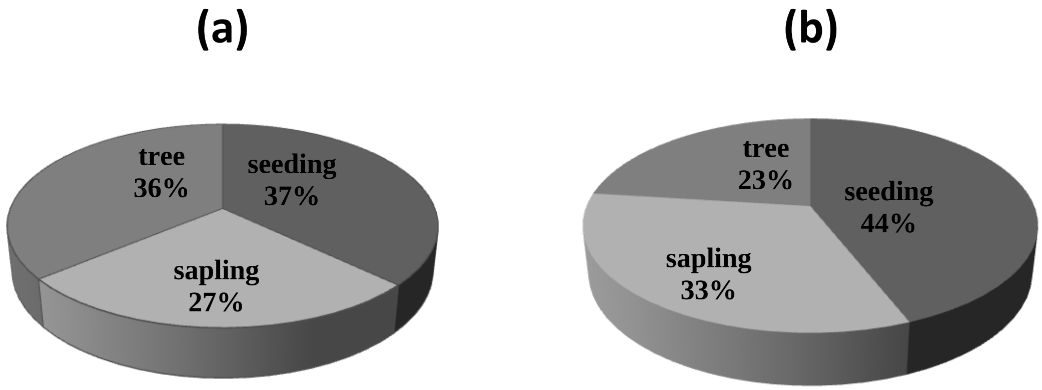


Figure 8: proportion of proportion structure of entire species at Lare (a) and Itang (b**)**

Figure 9: photo on some yield collected from selected species in the study area

4.5. Socio-economic importance of gum and resin bearing species

4.5.1. Major livelihoods occupations of household in the study area

The livelihood of the community in the study areas were more of less subsistent pastoralist and agro-pastoralist nature in both districts (Lare and Itang). Almost 42% of households respondents were dependent on livestock production, 50% of the respondent households were combinations of crop production and livestock rearing and 8% of the respondents were engaged on crop production in Lare; While, 23% of the household respondents were dependent on livestock, 65.83% of the respondent households were the combinations of crop production and livestock and 13.3% of the respondents were engaged on crop production in Itang (Table 10). The average size of the households owning farmland was 0.5 hectares in Lare and 0.25 hectares in Itang. Comparing the two districts, the numbers of households with farmland are fewer at Itang as compared at Lare. Fortunately more than 95 % of the inhabited area is situated in the left and right banks of the Baro River in Itang wereda. In this area most of the community numbers were becomes diversified their livelihoods' activity by choosing rearing of cattle and cultivating crops at banks of the Baro River. Because dependence on livestock only had become risk in Itang due to a lot of cattle raider risk had happen annually since last 10 years ago. The average livestock possession was 54 heads per household. Agro-pastoralist identified as the major economic activity in both of the studied districts following livestock rearing and crop production (Table 10)

Table 10: Major livelihoods activities and source of income in Lare and Itang Wereda

Household livelihood strategy	AG%	RANK	LS%	RANK	CR%	RANK
Lare	50	1	42	2	8	3
Itang	65.83	1	20.83	2	13.3	3

Note; AG=agriculture (crop production and livestock together), LS=livestock rearing only and CR=crop production. Numbers show the rank: 1 means main, 3 means least source of livelihood).

4.5.2. Knowledge of the local people on the study species

The majority of the respondents in the study area (92.5%) had knowledge about the diversity of gum and resin bearing species associated with low lands of woody vegetation in their area (Table 11). But according to respondent voice none of them (100%) were not collect gum and resin for sale. As a result they were used most of woodland species for other purpose like (charcoal, fire wood and local construction materials) in addition to expansion of agricultural investments in the area; this may leads to environmental degradation and shrinking the total coverage of wood land vegetation in the area.

Table 11: summery of household's knowledge about gum and resin utilization in the study area

Knowledge assessments				
Item	**F**	**Yes (%)**	**F**	**No (%)**
Do you know the existence of gum and resin bearing species associated with woodland in your area?	111	92.5	9	7.5
Do you collect gum and resin?	20	16.6	100	83.4
Do you collect for sale?	0	0	120	100

4.5.3. Livelihood Economic importance of wood land vegetation in the study area

Next to agro-pastoralist, collection of wood and NTFPs from woodland were also share a significant portion in daily life of households activities in the study area. The major socio-economic importance of wood land vegetation of inhabited community in the study areas were highly used for construction materials, fuel wood collection, medicinal plants, fodder, wild edible fruit, charcoal and gum and resin production (Table 12).

Table 12: Households economic dependence on woodland vegetation in wealth categories

Items of wood land product and purpose of use by HH	wealth catagory			
	Rich%	Medium%	Poor%	average
Fodder and rang land	100	92	55	82.3
Medicinal plants	72	85	96	84.3
Gum and resins	27.5	17.5	2.5	15.83
Fuel wood and Timber	82	88	100	90
Charcoal	21	61	98	60
Local Construction materials	100	100	100	100
Wild fruit	43	69	94	68.7

The results of household voice in wealth category; 100% of rich and 92% of medium income households were more exploit fodder product including range land from woodland and poor income households were more dependent in Fuel wood (100%), charcoal (98%) and Medicinal plants (96%) exploitation (Figure 12). Utilization of woodland for Construction materials was common for both wealth categories in high percentage (100%). Medicinal plants and wild edible fruits collection from woodland were also high significances in the livelihoods of poor income household (96% and 94%) respectively. This shows the high dependency of local community to woodland consumption for different purpose in this study area.

In comparing such conclusion; the result of this study is strongly agreed with current research report conducted in the area on "Benefits Gained from Woodland Resource in Gambella region of Lare wereda" (Gatluak *et. al*, 2012). It had reported as that 85% of households were dependent on woodland in fire wood exploitation, 86% for construction materials and 65% of households were used and utilized the wood land for medicinal purpose in the area. Similarly, in this finding the average woodland product exploitation of the study area were ranges from most used for Local construction materials (100%), Fuel wood (90%), Medicinal plants (84.3%), and fodder (82.3%) while Gum and resins bearing vegetation resources are least utilized resource (15.83%) in the area. Likewise, gum and resin production and sale were insignificant role in the livelihoods economy of household in the study area. Hence, only an average 15.83% of respondents were answer as they were merely collect and chewed gum from *Acacia seyal*, and

Acacia senegal during hardships period and resin from *Boswellia* for home consumption (traditional medicinal, hygienic purposes) most of the time for spiritual and social ceremonies. No more evident about market purpose rather than household home consumption.

In comparing with similar agro ecological zone and potential gum and resin bearing species area of the country; For instance, the study conducted in south Omo of Hamer and Bena-Tsemay district had reported as the resources were untapped and it's not utilized by local communities due to different reasons (Adem *et al.,* 2014) this is strongly agree with Gambella lowland community. But the research conducted in Borena lowlands of Arero and Yabello district had reported as most of the community had collect and sell gum and resin in the area. Hence, gum and resin play significant role in the livelihoods of household next to livestock production in Boreba low land (Worku *et al.,* 2006) and also a significant role of gum and resin bearing species had reported in livelihoods' of Somali low land community and had reported a significant role of gum and resin bearing species in Metema areas of North Gonder (Lemenih *et al.,* 2003 and Abeje Eshet *et al.* 2005)

Figure 10: Photo of wood land product sell at local market in Lare

Figure 11: Photo of Land product sell at Local market in Itang

4.5.4. Constraints to local people in producing gum and resin in the area

In this study area respondents were respond and ranked as knowledge about the resource and lack of awareness and Market access were the main factors that was challenging the local utilization level of community in Gambella low land wood vegetation with the range of 96.7% , and 74.6% (Table 13).

Table 13: summery of respondents' attitude about constraints of gum and resin resource utilizations in the study area

HH response ranking about Constraints to local resource utilization	No. of Households	Households voice%	Rank
Knowledge gap and Lack of awareness	116	96.7	1
Market access	89	74.6	2
Others	3	2.5	3

The result of this study suggests that the resources were not utilized by local communities in the area. Knowledge gap, lack of awareness about the role of the resources to their economy and low performance of the sector in creating awareness to the society is ranked as major constraints in the area. Similar results had reported in different study conducted in different parts of dry wood land resource utilization. For instance, According to, (Center for International Forestry Research 2011) report lack of awareness and inadequate knowledge about the importance of dry wood land vegetation, sustainable production and marketing is the major constraints on promoting sustainable dry wood land vegetation management and their valuable tree species in Ethiopia.

In comparing with other gum and resin wood land community; According to (Worku *et al*. 2006), Lemenih *et al* (2003), Adem *et al* (2014) in other gum and resin producing woodland of Ethiopia the majority of the community had good knowledge about the diversity, abundance, and regeneration status of gum and gum resin bearing species in their vicinity. It had also reported as local community were able to identify the important species and type of gum they produce and factors affecting quality and quantity and good collection seasons.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

In this gum and resin bearing vegetation based study a total of 15 woody species (8 at Lare and 7 at Itang), belonging to the genus *Acacia, Boswellia* and *Sterculia* were identified as sources of gum and resins bearing species. Gum and resin bearing species were found to be the dominant species comprising 76% and 81% of the species composition, 58.5% and 61.4% of density ha-1 and 56% and 63% of the IVI of the study sites at Lare and Itang, respectively. The Shannon-Wiener diversity and Shannon evenness values (H'=3.09 and 1.69) at Lare and (H'= 2.80 and 1.56) at Itang respectively; which showed the most diverse and even distribution of the population of gum and resin bearing species in the area.

The results of this study revealed that both study areas are rich in gum and resin bearing vegetation resources, with high similarity (80%) in gum and resin bearing species composition and diversity between two sites. The entire woodland vegetation of the area was found in good population structure, species diversity, dominance and density as compared to other woodland vegetation area. However; gum and resin bearing species are dominant over entire woodland vegetation in both sites. These indicate more or less the wood lands of the study areas are dominantly covered by gum and resin bearing species, which reflects high potential of gum and resin product in the area.

In regarding to livelihoods' socio-economic importance; in this study area agro pastoral is the major livelihoods occupation of the community while wood land products such as fuel wood collection, charcoal production, construction materials and grazing wood land products are playing a significant role in the overall socio-economic conditions of the community and identified as the second predominant occupation. On the other hand, collection and sell of other Non-timber forest product in the form of gums and resins from commercial woodland species are rarely practiced and insignificant role in the livelihoods' of the community in the area.

In different parts of Ethiopia with similar agro ecological zone and potential area in gum and resin bearing vegetation, such collection and sells of gum and resin has play significant role in livelihoods of the community. Unlike other agro pastoralist wood land communities in different parts of gum and resin bearing vegetation species areas of the country; the agro pastoral communities in this study area are not involved in collection and selling activity of gum and resins product. Unless, general woodland resources exploitation as rangeland and timber product for income generation as well as home consumption. This will leads to wood land degradation in addition to recurrent drought and the consequent fodder shortage there by leading to food insecurity and famine.

Hence, looking for other alternative strategies in resource base utilization system are very crucial in diversify the livelihoods of agro-pastoral society and simultaneously achieving sustainable dry land ecosystem management is very important. This is also crucial because dry land ecosystems are fragile in nature, and once it damaged their recovery is very costly or impossible unless especial care in selecting type of development strategies to be implemented in these areas.

To this end, this study revealed the fact that livelihoods' exploitation or utilization of woodland for gum and incense collection and sell was very poor and integrating this sector with development plan and other land use options will form one of the sustainable livelihoods to the community while leading to environmentally friendly resource management strategies.

5.2. Recommendation

Based on this study, the following recommendations can be forwarded:

1. Further research is needed to conduct on dry season, to provide further analysis on regeneration status and population structure to identify practicable sustainable dry-forest management options.
2. Looking for other alternative strategies in resource base utilization system are very crucial in diversify the livelihoods of agro-pastoral society and simultaneously achieving sustainable dry land ecosystem management. Therefore, all concerned bodies should be give attention for production and marketing of gum and resin product in Gambella lowland woody vegetation.
3. Creating community awareness for local community in identifying and utilization of gum and resin bearing species for sustainable production in fragile lowland environment and diversifying the livelihoods of local community is a mandatory strategy in this area.
4. Even though there is no information on annual yield per tree and Product quality will be need further investigation
5. Strategy must be devised for effective management of fire regime, flooding problem, deforestation and overgrazing to reduce their impact on natural regeneration of gum and resin bearing species.

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7. APPENDICES

Appendix 1: Lists of identified species and their scientific, local and Family name in Lare study area

Scientific Name	Local Name	Family name
Acacia bussei Harms ex S. jostedt	kaye	Fabaceae
Acacia oerfota (Forssk.)Schweinf	woor	Fabaceae
Acacia polyacantha Wild	Ngure	Fabaceae
Acacia senegal (L.) Willd	Chuay	Fabaceae
Acacia seyal Del.	Lore	Fabaceae
Acacia sieberiana DC Var. woodii (Burtt Davy) K.	Ciep	Fabaceae
Acacia tortilis (Forssk.) Hay	Sheap	Fabaceae
Albizia malacophylla (A.Rich.) Walp.	Reep	Burseraceae
Balanites aegyptiaca (L.) Del.	Thow	Balanitaceae
Boswellia papyrifera Eng.	Rier	Burseraceae
Cadaba farinosa (forssk)	Net	Capparaceae
Celtis toka (Forssk)	Riak	Ulmaceae
Combretum aculeatum Vent.	Nhiany	Combretaceae
Combretum molle R.Br.ex G.Don	Yong	Combretaceae
Dalbergia melanoxylon(Guill.& per.)kuntez	Gnoany	Fabaceae
*Dichrostachys cinerea.*Wight et Arn.	Juet	Fbaceae
Erythroxylum fischeri Engl.	Minychol	Erythroxylaceae
Ficus sycomorus(L)	Gnop	moraceae
Flueggea Virosa (Wild).Voigt	Waak	Euphorbiaceae
Lonchocarpus laxiflorus Guill. & Perr	Riak	Fbaceae
Piliostigma thonningii(Schum.) Milne-Redh	Ngoany	Fabaceae
Pithecellobium dulce(Roxb.)Benth	Reed	Combretaceae
*Sclerocarya birrea (*A. Rich.) Hochst	Chobwe	Anacardiaceae
*Senna obtusifolia (*L)Irwin & Barneby	miaar	Fabaceae
Sterculia setigera(Lour.) Fiori	urimo	Sterculiaceae
Strychnos innocua subsp. Dysophylla(Benth)I.Verd	Magak	loganiaceae
Tamarindus indica (L)	Koat	Rhamnaceae
Ximenia Americana L.	Wuleng	meliaceae
Ziziphus pubescens	Rake	Rhamnaceae
Ziziphus spina-christ (Linn.) Desfe.	buaw	Rhamnaceae

Appendix 2: Lists of identified species and their scientific, local and Family name at Itang

Scientific Name	**Local Name**	**Family name**
Acacia nilotica(L.) Willd. ex Del.	Tiph	Fabaceae
Acacia polyacanta Wild	Tiph	Fabaceae
Acacia senegal Del.	Hachino	Fabaceae
Acacia seyal Del.	Lewit	Fabaceae
Acacia sieberiana DC Var. woodii (Burtt Davy) K.	Akugnow	Fabaceae
Balanites aegyptiaca (L.) Del.	Toow	Balanitaceae
Boswellia papyrifera Eng.	Lero	Burseraceae
Celtis toka(Forssk)	Lergn	Ulmaceae
Combretum molle R.Br.ex G.Don	Adew	Combretaceae
Crateva adansonii(DC.)	kech	Combretaceae
Dalbergia melanoxylon(Guill.& per.)kuntez	Ocheno	Fabaceae
*Dichrostachys cinerea.*Wight et Arn.	Ochero	Fabaceae
Flueggea virosa(Wild).Voigt	waak	Euphorbiaceae
Pithecellobium dulce(Roxb.)Benth	Lero	Fabaceae
Sarcocephalus latifolius(Sm.) E.A.Bruce	pok	Rubiaceae
Senna obtusifolia.(L)	miaar	Fabaceae
Sterculia africana(Lour.) Fiori	Taril	Sterculiaceae
Strychnos innocua subsp. Dysophylla(Benth)I.Verd	Agiga	Loganiaceae
Tamarindus indica.(L)	Chewal	Rhamnaceae
Vitellaria paradoxa Gaerth. F.	Odiboo	Sapotaceae
Ximenia americana(L)	Gaba	Olacaceae
Ziziphus spina-christi(L.) Desfe.	Lang	Rhamnaceae

Appendix 3: Vegetation data collection sheet

Name of the site -----------------transect no--------------plot no -------------altitude --------------GPS: easting -------------------northing --------------------

Tree inventory							No of sapling	No of seedling
Tree species (local name)	Tree species (scientific) name	Family	Growth habit	DBH (cm)	Height (m)	No of Dead/coppiced tree		

Data list include scientific name, local name, family name and growth habit of all woody species encountered

Scientific name	Local name (Hamer Language)	Family	Growth habit

Data sheet for Height and Diameter class distribution of encountered species

Species name	Height class (m)						Diameter class (cm)							
	<5m	6-10m	11-15m	16-20m	21-25m	26-30m	<2m	4-6cm	6-8cm	8-10cm	10-12cm	12-14cm	14-16cm	16-18cm

Vegetation data analyses sheet for Density, abundance, relative abundance, dominance, relative dominance, frequency, relative frequency and IVI

Species scientific name	D	N	N (%)	DO	DO (%)	F	F (%)	IVI	IVI (%)

Appendix 4: **Socio-economic data collection sheet**

Instrument 1: Questionnaire to be filled by Selected House Holds

- ✓ About the Questionnaire;
- ✓ This questionnaire asks for information about the socio-economic importance of woodland in Lare wereda.
- ✓ The person who completes this questionnaire should be the people who are living in the selected Kebeles.
- ✓ This questionnaire should take approximately 35 minutes to complete.

Dear sampled households;

I am an MSC candidate in natural resource management at Jimma University .As part of my study; I invite you to complete this questionnaire.

The purpose of this questionnaire is to collect relevant data to the study entitled Assessment of population structures, diversity of gum and resin bearing species and socio-economic importance of woodland forest in the case of Lare /Itang wereda. Your participation in this study is voluntary. Your responses are vital for the success of the study. So, you are kindly requested to fill the questionnaire with genuine response. Once you have completed the questionnaire, please return to the responsible body.

Thank you for your patience and dedication to fill the questionnaires

Part I- Questionnaire Identification

1.1. Region ____________________

1.2. Zone ______________________

1.3. City/woreda _______________

1.4. Peasant association __________

1.5. Village name ________________

Part II- Background Information

2.1. Sex Male Female

2.2. Age of the respondent ______ years

2.3. Size of household, ____________

2.4. Educational status (formal and non-formal)

2.4.1. Educational level of the respondent

Illiterate ☐ Read and write ☐ Grade 1-6

Grade 7-8 ☐ Grades 9-12 ☐ above grade 12 ☐

2.5. Wealth Categories: Poor ☐ Medium ☐ Rich ☐

Part III. Questionnaires regarding the livelihoods economic activities

3.1. What are your livelihoods economic activities? If yes! Rank them.

Activities		Yes			No
		1st	2nd	3rd	
1	livestock				
2	Crop cultivation				
3	Livestock and crop				
4	Wood land production				
5	Off farm activities				
6	Specify if others				

Part V Questionnaires about the assessment of local utilization level of gum and resin bearing species and Constraints of local utilization.

4.1. What types of energy you use for domestic consumption?

Charcoal and fire wood ☐ Crop residue ☐ Dry dung ☐

4.2. When did you collect firewood for your cooking consumption?

Daily ☐ weekly ☐ Monthly ☐ I don't use ☐

4.3. How do the rate woodland resource consumption in your area?

Very high ☐ High ☐ low ☐ very low ☐

4.4. What types of materials do you use for house construction?

Woodland tree& savannah grass ☐ Own plantation. ☐

4.5. Do you know the abundant existence of gum and resin bearing species associated with wood land in your area?

Yes ☐ No ☐

4.6. Do you collect gum and resin from woodland vegetation available in your village?

Yes ☐ No ☐

4.7. If your answer is No! For question 4.6, why does not you collect gum and resin from woodland?

Constraints to local utilization	**Yes**	**No**	**frequence**	**persentage**
Kowledge gap and Lack of awerness				
Market access				
Cultural restriction				
others				

Part IV: Questionnaires about the assessment of household economic dependence on woodland resource in the area.

5.1. What does your economic importance of woodland products in your area?

Rank them by mark under 1,2&3 from from the most important to the least important.

1, the most important; 2, mideum important; 3, the least important

Woodland products	**1**	**2**	**3**
Fodder and rang land			
Medicinal plants			
Gum and resins			
Fuel wood and Timber			
charcoal			
Local Construction materials			
Wild fruit			
If Other specify them			

Instrument 2: **Questionnaires for key informant interviews**

The purpose of interview guide was prepared to direct the interviews to be conducted with employee (Environmental experts) of woreda Agricultural Office, Elder people and leader of peasant Association in the selected Woreda.

Part I- Background Information

Date: ______________________________.
Name of the respondent: _________________
Age: _______________________________
Sex: _____________________________
Marital status: _______________________
Duration in the area: _________________
Village: ____________________________
Educational status: __________________

1. What is considered as a major problem leading to woodland destruction and in the study area? For what purpose the people need and use woodland resource in the study area?
   ____
2. What are the major causes of woodland degradation in the study area?
   ____
3. What actions have been taken recent to reduce woodland degradation?
   ____
4. What are the major's constraint to local communities to utilize gum and resin bearing species in the study area?
   ____

Additional question

1. For what purpose the local people need & use the entire woodland resources and specifically gum and resin bearing species?
2. What actions do you think need to be taken to reduce the risk of woodland resource degradation and to minimize its environmental impact?
3. What do you suggest to minimize woodland degradation in your local area?

Thank you for your cooperation!