CUSTOMARY FOREST CONSERVATION PRACTICES AROUND DEBRE LIBANOS MONASTERY: COMPARATIVE ANALYSIS OF THE CHURCH FORESTS AND SURROUNDING LANDSCAPE

MSC THESIS

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Customary Forest Conservation Practices around Debre Libanos Monastery: Comparative Analysis of the Church Forest and Surrounding Landscape

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I hereby certify that I have read and evaluated this Thesis entitled (Customary forest Conservation Practices around Debre Libanos Monastery: Comparative Analysis of the Church Forest and Surrounding Landscape) **prepared under my guidance by** Ayanu AsefaTsega**. I recommend that it be submitted as fulfilling the thesis requirement.**

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I. DEDICATION

This work is dedicated to my father, Asefa Tsega Dame and my mother, Gadise Mamo. Without their decision and endless assistance that allowed me to pass through modern education, from childhood to now, I would have never been in my present position. Thank you so much for being beside me at every step of my life. I wish you healthy and long life.

II. STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this thesis is my own work and all sources of materials used for it have been duly acknowledged. The thesis has been submitted in partial fulfillment of the requirements for Msc Degree in **Forest and Nature Conservation** at Salale University and is deposited at the University's Library to be made available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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III. BIOGRAPHICAL SKETCH

Ayanu Asefa Tsega was born in 1988G.C in Wachale Woreda, North shoa Zone of Oromia Region, Ethiopia. He started education at Jati Primary school followed by M/Turi Regassa Woyessa Senior and Secondary School. He received his BSc Degree in Natural Resources Management in July, 2010 fromDebre Markos University located at 299 Km distance from Addis Ababa.

Soon after, he was employed in Wachale Woreda Office of Agriculture and Natural Resources as Soil and Water Conservation Expert; he worked at different positions like PSNP and CALM P4R programmes Focal Person, Climate Resilient Green Economy (CRGE) Team Leader and Watershed Management and Forest Conservation Team Leader from November, 2010 to 2021. Even though he gained experience in planning and implementing soil and water conservation activities as well as nursery management, he wanted to know details of Forestand Nature Conservation, as it is time to conserve our landscape to have a clean and healthy environment for current and future generation, therefore hegot sponsorship from Woreda and Zonal Administration and joined the Forest and Nature Conservation Master's Program opened by Salale University.

Now, he has been assessing floristic composition, species diversity and vegetation structure of the church forest and the surrounding state forest, identifying socio-economic and spiritual values of forests under different tenure system (church forest and state forest) and assessing the current forest management and conservation practices in forests under different tenure system.

His further interest area of research is conducting Forest and Landscape Restoration activities, Climate change adaptation measures, Carbon Trading and Nursery establishment and Operation activities.

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V. LIST OF ACRONYMS AND ABBREVIATIONS

BA	Basal area
CALM	Climate Action through Landscape Management
CRGE	Climate Resilient Green Economy
DA	Development Agent
DBH	Diameter at Breast Height
DAF	Dry Evergreen Afromontane Forest
DGC	Department Graduate Council
DLM	Debre Libanos Monastery
DLMCF	Debre Libanos Monastery Church Forest
EBI	Ethiopian Biodiversity Institute
EOTC	Ethiopian Orthodox Tewahido Church
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
GPS	Global Positioning System
HHs	Household
LGSF	Lega Gur State Forest
IVI	Importance Value Index
PSNP	Productive Safety Net Programme
RBA	Relative Basal Area
RD	Relative Density
RF	Relative Frequency
SGS	Students Graduate Council
UNESCO	United Nations Educational Scientific and Cultural Organization
UTM	Universal Transverse Mercator

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Abstract

Ethiopia is a country endowed with great biological diversity of plant, animal and microbial genetic resources. Globally, the most altered and endangered ecosystems are Dry evergreen Afromontane forests.The effect of deforestation and degradation continuing within Debre Libanos monastery forest are influencing the forest structure and basal area. The objective of this study was to assess customary forest conservation practices around Debre Libanos Monastery with Comparative analysis of the church forests and surrounding landscape. Specific objectives include assessing floristic composition, species diversity and vegetation structure of the church forest and the surrounding landscape. Identifying socio-economic and spiritual values of forests under different tenure system (church and state forest) and assessing the current forest management and conservation practices in forests under different tenure system are also specific objectives. This study aims to have its contribution in creating a comprehensive species and adding up the current knowledge for successful implementation of forest restoration. The study applied forest inventory with combination of key informant interview, focus group discussion and household survey to collect primary data. 53 plots in Debre Libanos Monastery church forest and 20 in Laga Gur State Forest were used to collect trees from 20 m 20m and 2m *2m for shrub species data collection. 235 respondents were involved in survey conducted by using semi-structured interviews and discussion with respondents. Data were analyzed using R Statistical Software version 4.2.2. The plant species recorded indicated high taxonomic diversity as they belong to 42 families,63 genera and 71 plant species with 3509 number of individuals in Debre Libanos Monastery church forest and 20 families, 23 genera and 28 species with 957 individuals in Laga Gur state Forest. It is understandable that religious institution played a significant role in protecting and conserving forest while state forest is under pressure of human and livestock interference.*

Key words: ***Basal area, Diversity, Dry evergreen Afromontane, Flora, Similarity, Socio economic role, Vegetation structure,***

1. INTRODUCTION

1.1.Background and Justification

Ethiopia is a tropical country with a wide altitudinal range, great geographical diversity with high and rugged mountains, fat-topped plateaus and deep gorges, incised river valleys and rolling plains, and macro- and micro-climate variability. As a result, the country is endowed with great biological diversity of plant, animal and microbial genetic resources (Desalegn, 2022). It is also rich in vegetation diversification largely due to high range of altitudinal variation; ranging from 110 m below sea level at Dalol to 4543m above sea level at Simien Mountains National Park peak (Ras Dejen). Thus, the vegetation is extremely complex due to great variations in altitude resulting in great spatial differences in moisture regimes as well as temperatures (Getahun *et al.*, 2018).

Ethiopia has great geographic diversity and macro- and micro-climatic variability. The country has 10 ecosystems, and 18 major and 49 minor agro-ecological zones. As a result, the country is endowed with great diversity of plant, animal and microbial genetic resources. Ethiopia is one of biodiversity rich countries in the world. It hosts two of the biodiversity hotspots of the world, namely: the Eastern Afromontane and the Horn of Africa hotspots. The diverse ethnic groups in the country gave rise to the existence of cultural diversity such as community knowledge associated with conservation and sustainable use of plant, animal and microbial genetic resources (EBI, 2014).

Sacred groves are community-preserved, often small, forest patches in which certain spiritual, cultural or religious values contribute to the conservation of biodiversity and ecosystem services. Because sacred groves are usually protected by local institutions or by-laws that regulate resource use, such sites are often better protected than other small habitat patches, and can therefore play an intrinsic role in biodiversity conservation (Aerts *et al.*, 2019; Bhagwat and Rutte, 2018).

Sacred forests can have significant contributions to local communities, including material, non-material, and regulating provisions. Forest patches preserve indigenous species and old-growth forest trees with cultural and/or religious significance for local people. And even though many sacred forests' provisioning services have been reduced over time due to isolation and degradation, many scholars continue to see these forests as essential for

biodiversity conservation goals, as well as other globally significant ecological services such as carbon sequestration (Sahle *et al.*, 2021).

Today's world is facing an unprecedented environmental crisis of which deforestation is a typical example. The world is losing its forests at an alarming rate. All over the globe, many people now suffer from the destructive process that deprive them of the benefits from the natural resources on which they have always sustained their livelihood. Even though, deforestation is worldwide problem, the rate of deforestation is very great for developing countries. Africa also experience the highest deforestation rate in the world. Apart from Northern Africa, East African countries show the second highest decline rates of conservation forests in the continent (Menbere, 2011).

As stated by Menbere, 2011, even though, Ethiopia lost a considerable coverage of forest, still the contribution of institutions is significant in preserving the remnant's considerable area of forest of the country. Particularly considerable patches of forest still exist in some social institution like in Orthodox Church .Thus the Ethiopian Orthodox Church did a lot in protecting and preserving forests for centuries.

In Ethiopia, religious rules and regulations by church are playing great role in guiding the society how to manage natural resource in general and forest in particular. Some of the remaining forests of Ethiopia are located in monastery and church premises of the Ethiopian Orthodox Tewahido Church (EOTC) particularly in the central and northern parts of the country (Menbere , 2011).

Church forests are used and valued as social and spiritual places, because they belong to the church. The eco-theology of EOTC is contemplative and focus on life rather than knowledge and thus teaches the church forests of Ethiopia have survived and exist today as a testimony of God's promises, faithfulness, full redemption and symbol of true reconciliation with God (Alemayehu, 2020).

EOTC are visible from a great distance, with a majestic appearance, usually built on small hills "overlooking" the surrounding villages. The local people call the churches with the surrounding trees as '*deber* or *geddam'*, which is seen by the followers as the most holy place religiously as well as a respected and powerful institution socially. These churches are not only religious spots but are also biodiversity spots. It is also expected from outside to be a viable and a functioning site ecologically from the whole landscape in the area. The

Ethiopian Orthodox Tewahido Church has long history of planting, protecting and preserving of trees (Alemayehu, 2020).

Debre Libanos Monastery (DLM) is paramount of socio-cultural and natural assets. It is a place of God gifted natural assets, panoramic, scenic beauty of river basin, wild life, dense forest, cultural diversity and other attraction which may be of great interest for the tourists. It is a forest that is surrounded by urban and peri-urban population. Few researches were conducted by Seyoum and Zerihun (2014), Wakshum *et al.* (2019) and Hingabu and Shaoxian (2020). But there were no detailed study conducted on floristic composition, socioeconomic and spiritual importance of forest to local community. This study is therefore intended to investigate the customary forest conservation practices, floristic diversity and vegetation structure as well as socioeconomic and spiritual values of Debre Libanos Monastery; North Shoa Zone Oromia Regional State.

1.2.Statement of the problem

Globally, the most altered and endangered ecosystems are Dry evergreen Afromontane forests (DAF). Across the world, forests have been fragmented into small patches, and the forest structures have been influenced by this fragmentation and habitat loss (Wakshum *et al.,* 2019). Habitat conversion is a severe threat to DAF (EBI, 2014).

In Ethiopia, where more than 80% of the population is living in rural areas and depend on subsistence small-scale agriculture, securing food and livelihood is inseparably linked to the exploitation of natural resources. Intense pressure from various human activities *(*Zerihun *et al*., 1999), and the application of improper farming and management practices had been posing serious threats to the sustainability of the natural resources and maintenance of balanced ecosystems (Simachew, 2020). According to Reusing M. (1998), about 42 million hectares (35%) of the country's land area might have been once covered with high natural forests. However, the country has lost these resources at an alarming rate due to various reasons (Haile e*t al*., 2008). Historical sources indicate that the loss of forest cover in Ethiopia has been dramatic decries time to time. Some reports indicate that close to 40% of Ethiopia might have been covered by high forests as recently as the 16th century (Hingabu and Shaoxian, 2020).

In the Central and Northern Ethiopian highlands, high historical land use pressure has resulted in widespread deforestation and land degradation (Nyssen *et al.,* 2008). The problem

of deforestation and loss of biodiversity is more pronounced in the Central highlands of Ethiopia, particularly in the North Shoa Zone, where forests are downscaled to patches and strips on the tops of hills and heads of streams. As a result, very little of the natural forest of the Central Ethiopian highlands remains today. The deterioration of natural resources not only destroys the environment, but also undermines the very foundation on which economic growth and long-term prosperity depends (Abiyou *et al.*, 2015).

In Ethiopia, only very few patches of forest are remaining and these are almost entirely confined to the vicinity of churches, monasteries and other holy sites such as springs. Churches manage their forests independently, and management varies from strict protection (with some churches surrounded by walls and patrolled by paid forest guards) to weak protection with poorly controlled harvesting of trees (Aerts *et al.*, 2019).

In Debre Libanos Monastery (DLM), the areas that had been previously governed under the monastery forest and reduced from the monastery by Dergue regime; and currently they are under different management regime such as government and private. Gradually those forest resources that are under private and government are lost and remnant of eucalyptus tree is left behind. Even these areas lost their species diversity. Particularly the government forest is replaced with plantation trees of eucalyptus. In addition, the current privately owned forest areas lost both the diversity and density of species. In such devastated areas, conserving and maintaining woody diversity has been a very challenging task, and most approaches have not brought any significant results.

The effects of deforestation and degradation are also continuing within Debre Libanos Monastery forest patch due to intensive grazing and other anthropogenic activities. These are influencing the forest structure and basal area of individual woody species and thus as a whole the forests' basal areas (Wakshum *et al.*, 2019). The monastery forest is also used as the grazing area for cattle belonging to the monks and this has put another pressure on the forest. The expansion of the area occupied by modern graves has further reduced the undisturbed forest area (Menbere, 2011). These management practices coupled with different human interventions (e.g. expansion of arable land and settlement) aggravated degradation of remnant indigenous tree/shrub species. The influence of such management practices on vegetation composition, species diversity and productivity are not well studied in case of DLM.

1.3.Objectives of the study

1.3.1. General objective of the study

The overall objective of the study is to assess customary forest conservation practices around Debre Libanos Monastery with comparative analysis of the church forests and surrounding landscape.

1.3.2. Specific objectives of the study

- To assess floristic composition, species diversity and vegetation structure of the church forest and state forest
- To identify socio-economic and spiritualvalues of forests under different tenure system
- To assess the current forest management and conservation practices in forests under different tenure system

1.4.Research Questions

- ✓ What do floristic composition, species diversity and vegetation structure of the study area looks like?
- ✓ What are socioeconomic and spiritual values of DLM church Forest?
- ✓ What are forest management and conservation practices which are relevant for forest conservation?

1.5.Scope and Limitation of the Study

This study is limited to DLM church forest and surrounding landscape in Northern Shewa, Oromia Regional State with the objective of assessing customary forest conservation practices with comparative analysis of the church forest and state forest in Debre Libanos and Girar Jarso woredas.

This thesis is limited towards assessing comparative analysis of floristic diversity and vegetation structure of study area by using Shannon-Wiener Diversity Index, Floristic similarity with nearby landscape and other related forests was compared using Sorenson's similarity index. Tree height, DBH (Diameter at Breast Height), Basal area (BA), density and frequency are all measured to analyze vegetation structure and Importance Value Index (IVI).

Ordination analysis and Regeneration status of these forests was not covered by this study because it was broad besides time and budget limitations. Socio economic and spiritual role of DLM Church forest along with management practices relevant for forest conservation was assessed while other roles of forests was not studied.

1.6.Significance of the study

This research focused on identifying floristic diversity and vegetation structure of DLM with surrounding landscape, customary conservation practices related to forest conservation with theological justification as well as socioeconomic and spiritual values of forest was assessed and this will have a paramount significance, mainly in adding up to the current knowledge about customary forest conservation and gives some clues for its successful implementation of forest restoration in the study area. The study hence, provides information so that policy makers, government officials, experts and other concerned bodies engaged in the forest conservation and restoration can get some relevant information for further activities in the area. Academically it will help students, researchers, etc. as secondary data (reference) for further study.

Moreover, by identifying and documenting floristic composition, floristic diversity and vegetation structure of DLMCF (Debre Libanos Monastery Church Forest) and Laga Gur State Forest (LGSF), a base line information for the sustainable utilization and management of the forest resources can be provided.Furthermore, by examining floristic composition, species diversity and vegetation structure its analysis can contribute most in

By assessing vegetation

- A comprehensive species list can be created
- Plant communities and vegetation types can be defined hence understanding their ecoogy is useful for forest management, sustainable utilization
- Successional processes can also be identified.
- Floristic composition, species diversity, and community analysis, in particular, are critical for providing necessary information on forest species richness and diversity

2. LITERATURE REVIEW

2.1.Concept and definition of important terms

a. **Abundance** : - The number of individuals on the sample plot
b. **Basal area** is the area outline of a plant near the surface, is of particular interest for trees and can be used for tree volume estimations (Kuchler *et al.,* 1976).
   - It is a common term used to describe the average amount of an area occupied by tree stems. Moreover, it is the total cross-sectional area of all stems in a stand measured at breast height, and expressed as per unit of land area (typically m^2/ha)
c. **Canopy Cover -** The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of the foliage of plants.
d. **Cover** : - Percentage cover is the relative area occupied by the vertical projection of all aerial parts of plants, as a percentage of the surface area of the sample plot
e. **Cover-abundance** is a combined parameter of cover – in case the cover exceeds a certain level, e.g. 5% – and abundance. It reminds the importance value developed by Curtis (1959), the product of density, frequency and cover.
f. **Dry evergreen Afromontane forests -** The Ethiopian highlands contribute large coverage of land area with Afromontane vegetation, of which Dry Evergreen Afromontane Forests (DAF) form the largest part. DAF and Grassland complex vegetation type is complex system of succession with grassland rich in legume shrub and small to large trees to closed Forest with a canopy of several strata. It occurs in an altitudinal range of 1800-3000 m, with average annual temperature and rainfall of 14-25°C and 700-1100 (rarely up to 1700 mm), respectively.
g. **Diversity Index** - is a mathematical measure of species diversity in a community. The two main factors taken into account when measuring diversity are richness and evenness. A diversity index, must be sensitive to both factors, thus must also be sensitive to the different number of species in two or more communities(Kuchler *et al.,* 1976).
h. **Forest -** is land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ.
i. **Forest inventory**- is a tool that provides the information about size and shape of the area as well as qualitative and/or quantitative information of the growing stock.
j. **Forest structure** - as a complex system considered from the whole rather than any single part.

k. **Frequency** : - is the number of times a species occurs in subplots within the sample plot
l. **Shrub -** Woody perennial plant, generally more than 0.5 meters and less than 5 meters in height at maturity and without a single main stem and definite crown
m. **Similarity Indices :** - Measure the degree to which the species composition of quadrats or samples is a like. Sorenson is the most common binary similarity coefficients because it relies on presence or absence data. The coefficient of Sorenson differs from the other measurements since it gives more weight to species that are present in both quadrats/samples and therefore less weight to species that are present in only one quadrat.
n. **Species evenness** : - measures a relative abundance of different species making up the richness of the area(Kuchler *et al.,* 1976) . An evenness index is a function of the frequencies or proportions pertaining to the species; such an index increases when the proportions tend to be equal or perfect homogeneity and decreases when one species tend to dominate all the others.
o. **Species richness** : - is a measure of the number of different species in a given site and can be expressed in a mathematical index to compare diversity between sites. This index is essential in assessing taxonomic and ecological values of a habitat
p. **Tree -** A woody perennial with a single main stem, or in the case of coppice with several stems, having a more or less definite crown.

2.2.Church forests and their role in forest conservation and restoration

As stated by (Alemayehu, 2020), the phrase church forest is equivalent to the Amharic phrase *Atsede Betekristian'* to describe the forest around churches. The phrase refers to the entire church compound with its sacred geography consisting of the open space immediately around the church and the remaining space outside of it designated for burial and other services usually covered by forest.

The EOTC has long history of planting and conserving tree species. Church compounds are the monasteries of trees and other biodiversity resources where one can animate trees escaped from being destroyed forever under the shelter of the church value and esteem. Many indigenous trees and shrubs destroyed over the last century are still found standing in the compounds of rural churches. The area of forest cover preserved by the Ethiopian Orthodox churches in some parts of the country has been declined and found in patches. These patches of forests are used as sources of seeds for raising seedlings in nurseries (Abiyou *et al.,* 2015).

The survival to date of so many church forests in Ethiopia is a testament to the historical and contemporary importance of the cultural, spiritual and religious values with which they are associated. Nevertheless, given that both historical and present land use rights and religious and governmental laws apply, the legal conservation status of these forests is an extremely complex matter. Uncertainties in boundary and land ownership issues complicate conservation, especially along the edges of the forests.

According to Abiyou e*t al*. (2015) historically most of the church forests were destroyed and burned with the churches and other precious heritages by the anti-Christian expedition led by Ahmed Ibn Ibrahim also called 'Gragn Ahmed' meaning 'left handed' at the beginning of the 16th century. Gragn grew in vengeance and all what he did was to avenge his father's death (Mohammed, 2017). After 'Gragn' has been killed in 1543, most of the churches and monasteries were reconstructed together with their forests.

2.3.Forest's Spiritual, Cultural and Religious Values

Forests have spiritual values, as indicating 'hard-to define nature-based values that help maintain and renew the human spirit', and characterize them as 'hard to measure', 'intangible', 'ethereal', or 'psychologically deep' values associated with land. Spiritual values informed by deep-seated worldviews- Indigenous, Western nature-based, mainstream religious, or secular - are at the core of people's underlying concerns for forests (Pater, 2021). In the following table 1 dimensions of spirituality and its relation with forests is shown.

Table 1. Dimensions of spirituality and their relations with forests

Dimension of Spirituality	Sub-dimension / Relation with Forest & Nature (in theory	Relation with Forest & Nature (in practice)
1. Experiential/ emotional	1a. Aesthetic: The Sublime, beauty, awe, fear, the numinous	▪ Wilderness experience, Forests in art and 'dark forest'
	1b. Restorative: tranquility, rest, contact with inner self, 'spiritual' healing in nature	▪ Forest retreats, Vision Quests, Eco therapy and *Shinrin yoku* (forest bathing)
	1c. Relational: Connection (with the surrounding world or with the Ultimate), sense of place, meaning of life	▪ Education (e.g. *Natuurwijs* children's education in NL), Forest career choice as a vocation and Meaning making through nature walks
	1d. 'life-force'/ 'vital energy' in forests and trees	▪ *Fengshui*, Geomancy, Ley lines and Restoring the energetical balance of forests & nature
2. Practical/ ritual	▪ Forests & trees as locus / object of ritual practice ▪ Ancestral forests/trees	▪ Tree worship, Healing Trees, *Shamanism* ▪ Vedic rituals, Forest monks (SE Asia), Animal/bird rituals and augury ▪ Natural burials
3. Narrative/ Mythical	▪ Creation & cosmology ▪ Forest & tree symbolism ▪ Mythical foundation of sacred sites The Universe Story	▪ Tree symbolism & stories ▪ Myriads of creation & nature spirit stories Linked to (2): rituals to bring narratives & myths to life
4. Philosophical	▪ Environmental theology ▪ Environmental philosophy, e.g. biophilia ▪ Worldviews ▪ *Gvi'ilas* eco-spiritual ethical system (Heiltsuk Nation) ▪ Views on nature, e.g. ✓ Deep Ecology ✓ Nature-based spiritualties, e.g. Druidism, Wicca, Animism	▪ Traditional Ecological Knowledge ▪ Respect for & hence no exploitation of old- growth forest ▪ Selective cutting instead of clear-cut on spiritual motives ▪ Taboos on sacred sites ▪ *Chipko* Movement, India ▪ Movements for Indigenous peoples' rights to land and resources ▪ Plantation movements, e.g. Earth Keepers Zimbabwe ▪ Spiritual values of forests in sustainable forest mgt. certification schemes ▪ *Gviílas* eco-spiritual practices (Heiltsuk Nation, BC Canada)
5. Ethical	▪ Rules for access & use of sacred forests & trees ▪ *Arthashastra* (Hindu books on agriculture & forestry) ▪ Injunctions to conservation, tree planting, restoration (to a wider extent) religious food laws	

Dimension of Spirituality	Sub-dimension / Relation with Forest & Nature (in theory	Relation with Forest & Nature (in practice)
6. Social- institutional	▪ (Underlying) drivers of Community & Social Forestry and conservation movements ▪ Charismatic leadership	▪ Interfaith Rainforest Initiative ▪ Spiritually inspired forest restoration, e.g. Trees for Life, Scotland ▪ Faith-based environmental movements, e.g. Franciscan Environmental Project (NL) and Pilgrimages to sacred Natural sites and 'Spiritual governance' of Sacred Sites
7. Material	▪ Sacred forests, rivers, mountains, etc. ▪ Forests as provider of sacred materials	▪ Sacred trees and sites ▪ Sacred (forest) plants for healing and food ▪ Osun-Oshogbo Sacred Forest, Nigeria (and many others) ▪ Totem poles & other sacred objects

Source: (Pater, 2021)

A crucial element of the identity of local communities is their religion and its local manifestations as well as the traditions deriving from it. In building support for environmental projects, appealing to religious motivation to secure a broader and more engaged participation of the local communities greatly increases the chances of success of many environmental initiatives.

As stated by (Sadowski, 2014), religions are now widely seen as an important ally in the fight against the ecological crisis. The State of the World Report of 2003 points to five strong assets held by religious leaders and institutions in the environmental context 1) capacity to shape cosmologies (worldviews), 2) moral authority, 3) a large base of adherents, 4) significant material resources, 5) community-building capacity.

Sacred groves have well developed forest ecosystems, high degrees of species richness, and a rich biodiversity in general. Sacred groves are an asylum for endemic and endangered plant and animal species; they are storehouses of medicinal plants and wild plants that help the gene pool of cultivated varieties.

2.4.Concept of Vegetation structure

Vegetation structure is the three dimensional distribution of plant biomass. In order to describe the three-dimensional nature of vegetation, both horizontal and vertical cover will be described. Horizontal cover indicates cover on horizontal plain, while vertical layering/ arrangement of plant material in a vertical plain. Multiple measurements will be taken to measure vegetation structure and multiple measurements will be taken and combine that information. They include canopy cover, gap intercept, vegetation height and visual obstruction. Vegetation type and structure can influence microbial activity through direct and indirect mechanisms such as: (1) Modification of microclimate; (2) Alterations in the quantity and quality of litter; (3) The supply of root exudates, and/or; (4) The above-below ground allocation patterns of organic matter (Pankaj, 2018).

2.5.Floristic Diversity and its Measurement

Floral diversity refers to the diversity of plants occurring in a specific region during particular era. It generally refers to the diversity of naturally occurring indigenous or native plants. Management and conservation goals pertain to a particular targeted plant community and this can be described by plant composition or diversity. According to (Motuma, 2010), Ethiopia hosts the fifth largest floral diversity in tropical Africa. Plant diversity reflects variation within and among living organisms on a site.

Loss of biodiversity is a global issue and an elusive hazard. United Nations' Earth Summit held at The Rio de Janeiro in 1992, described biodiversity as "The variability among living organisms from all sources, including *inter alia* terrestrial, marine and aquatic systems and the ecological complexes of which they are a part: this includes diversity within species, between species and the ecosystems" (Thukral, 2017). The quantitative characterization of communities can be done using diversity indices. A diversity index takes into consideration the number of species, the number of individuals of different species in a sample, or habitat or a community. Change of diversity from one community to another, one of the most widely used diversity indices is Shannon – Wiener index proposed by Claude Shannon in 1948.

3. RESEARCH METHODOLOGY

3.1.Description of the study area

I. Debre Libanos Woreda

This study was conducted in the Debre Libanos Monastery Churh Forest (DLMCF), Debre Libanos woreda and Laga Gur State forest, North Shoa Zone of the Oromia National Regional State in Ethiopia and G/Jarso woreda.The total area of the Debre Libanos woreda is 29,776 ha. It encompasses ten peasant associations and one administrative town.

DLM is situated between 2341 m and 2500 m asl (Wakshum, 2019) see figure 1 below. The monastery is found at the edge of the highland plateau on the flat ground below the first escarpment of the Jama gorge. The sides of the gorge descend in a series of parallel escarpments towards the river. The forest at DLM is one of the few remaining DAF(Menbere, 2011). The total study area comprises of about 178.03 ha church forest. Church forest is located in the Debre Libanos woreda, Addis Alem Kebele.

Figure 1.Forest cover of Debre Libanos Monastery

Source: photo by Ayanu Asefa (May,2023)

A. Geographical Location of Debre Libanos Woreda

Debre Libanos Woreda is bordered on the North West by Girar Jarso, on the south west by Yaya Gulele, on the south and south east by Wuchale and on the north east by Amhara Region. It is located in central part of Ethiopia at about 104 km North of Addis Ababa,

situated between 38^0 05’ 01’’ to 38^0 05’ 51’’ E longitude and 9^0 40’ 11’’ to 9^0 40’ 51’’ latitude.

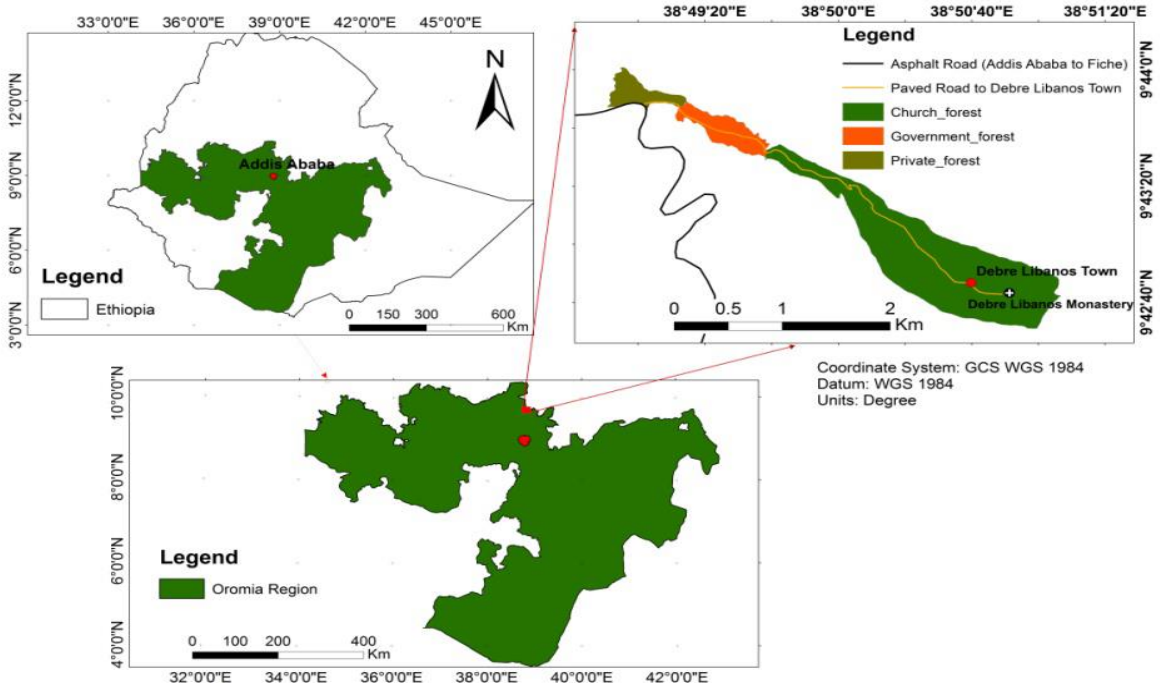

Figure 2. Location map of DLMChurch Forest

Source: Hingabu and Shaoxian, 2020

B. Land use

Land use land cover of the woreda shows 24,144 ha cultivated land, 1747 Ha pastureland, 2276 ha for miscellaneous (roads, river, settlement), 809 ha is forest and woodland and 800 ha is mountainous land.

C. Vegetation Cover

The vegetation of the study area is characterized by old remnant of DAF in the middle altitudes and grasslands dominant at higher elevations in the highlands. The common vegetation in the study area is mostly remnants of trees in agricultural fields, bushes, shrubs, and secondary forests. The common plant species of the study area include *Olea europaea subsp.cuspidata, Grevillea robusta, Ficus sycomorus, Podocarpus falcatus, Ficus sur, Juniperus procera, Croton macrostachyus* and *Cordia africana*.

D. Topography

It is the ups and downs of the earth's surface, is the result of the altitudinal variation of the land surface. Debre Libanos wereda is established on highland area. The altitudinal range of the wereda ranges from 1500 m to 2700 m asl.

E. Soil

Pellic vertisol (74.11%), eutric cambisols (13.36%) and eutric nitisols 6.01%are found in Debre Libanos woreda.

F. Population

The total population of D/Libanos woreda is 62,830 of this about 90.4% i.e., 56,798 people live in rural area (Seyoum and Zerihun, 2014).

G. Agro climatic condition

Debre Libanos woreda has three different agro ecologies. It comprises of Dega 60%, Weyna Dega 30% and Kolla 10% as data obtained from Woreda Office of Agriculture. The area is characterized by bimodal rainfall, the long rainy season (June to September) and shorter rainy season (March to April). The highest average monthly rainfall was recorded in July (353.99 mm) and the lowest in November (5.5 mm). The daily average maximum temperature is recorded in the month August (17.67°C) and daily average minimum temperature 6.14°C (Seyoum and Zerihun, 2014).

H. Economic Activity

The major economic activities in Debre Libanos Woreda are shown in the following table.

Table 2. Major Economic activities of Debre Libanos Woreda

NS	Economic Activity	Description
1	Agricultural sector development	➢ The major revenue of this woreda is from agriculture which is around 54.3%. It includes crop cultivation, Irrigation and livestock rearing sub sectors. Pastoral farming accounts for 36% of the total woreda revenue
2	Trading	➢ The livelihood of significant number of residents directly and indirectly relies on this sector that involve the transaction of highly diversified agricultural and livestock products ranging from small livestock like sheep and goat to large home animals. ➢ Another source of income is from selling milk and milk products as well as fruits and vegetables in nearby town, Debre Tsige. The goods like sheep skin, goat skin, and oilseed supplies to the central market from the rural kebeles.
3	Hand crafts and Products	➢ This includes mending and preparing hand tools and utensils as well as home furniture to market and it accounts for 5 %. See figure 5
4	Others	➢ Other sort of activities accounts for 0.7% of woreda revenue

Source: (Fanta Beyene, 2017)

Figure 3. Handcrafts sold around D/Libanos Monastery

Source: Photo taken by Ayanu Asefa (May, 2023)

II. Girar Jarso Woreda

Girar Jarso woreda is one of the sixteen woreda of North Shewa Zone, Oromia National Regional State. The Woreda lies along the highway to Addis Ababa to northern part of Ethiopia at a distance of 112 km from Addis Ababa. It shares border with Amhara Region in the North, Yaya Gullalle woreda in the East, Debre Libanos Woreda in the South and Degem Woreda in the West. The total area of the woreda is about 49,435 ha. The altitude of the Woreda ranges from 1300 to 3419 meters above sea level. Geographically, the Woreda occupies 9°35' -10000'N latitude and 38°39' -38039'E longitude (GJWWMEO, 2023). According to 2022 population projection, the population of Girar Jarso Woreda's other than Fitche town is close to 97,095 (Male 49,717& Female 47,378) with an average family size of 5. The average population density of the District was 157 persons per kilometer square (Population projection, 2022). The woreda has 17 rural kebele and 1 town i.e. Fitche. Vertisols, Nitosols and Cambisols are dominant soil types in G/Jarso woreda.

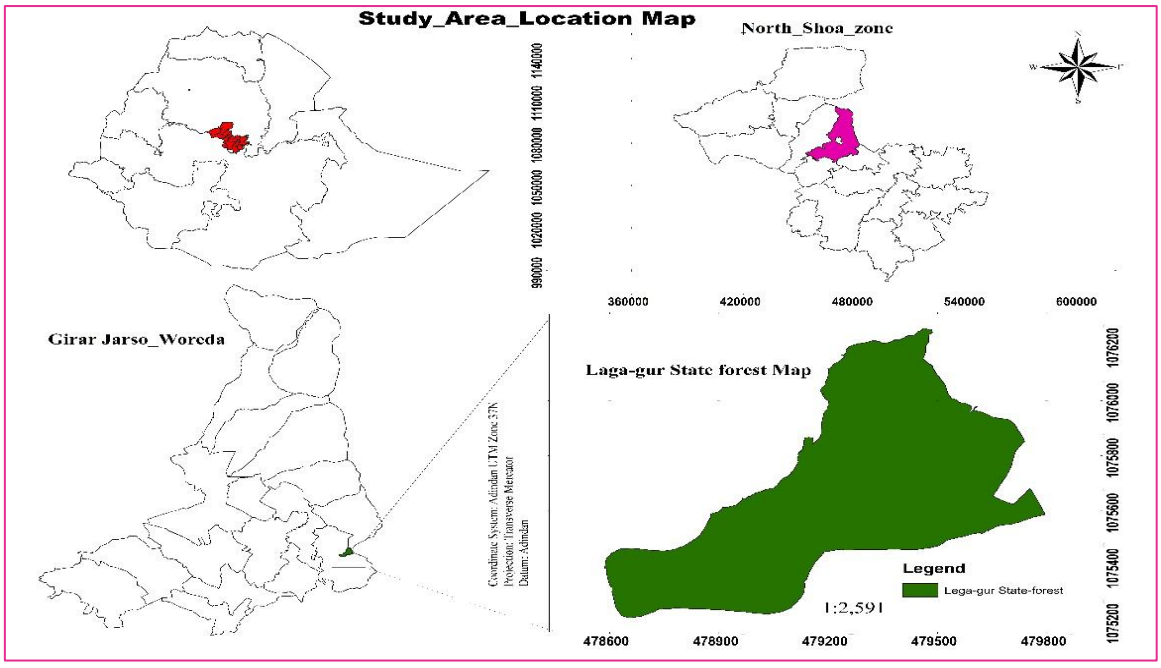

Figure 4. Laga Gur state Forest location map

A. Topography

The topography is characterized by mountainous, sloppy to steep sloppy, and gorges. Basic data obtained from Girar jarso woreda finance and development office (GWFEDO, 2023) indicate that about 36 % of the land cover is plain and about 33 % is sloppy. The remaining

31 % is classified as mountainous and gorges. The largest part of Girar Jarso woreda is part of the shoa plateaus. The topography of woreda is divided into three major altitudes: the highlands (*bada*) which contain 52%, the middle-highlands (*bada dare*) with 41%, and (*gamoji*) with 7% of the total land of the woreda's about 49,435 hectares (Girar Jarso Woreda Office for Agricultural Development and Natural Resources, 2023).

B. Climate

The climate is one of the elements of the physical environment that has a pronounced impact on settlement patterns, human life, soil type, flora, and fauna. According to the National Metrology Agency (2020), the mean annual temperature ranges from 15^{o}c to 18^{0}c, while the mean annual precipitation ranges between 1200-1400mm. According to the rainfall pattern of the study area, the mean annual rainfall is approximately 94.87 mm with irregular and scattered rainfall four or more times per year.

C. Vegetation

The study area's natural vegetation is DAF, with native trees such as*Juniperus procera, Acacia abyssinica, Ficussur, Hagenia abyssinica, Podocarpus falcatus, Cordia africana* and *Croton macrostachyus*as the dominant tree species. However, nowadays these three species are very rare and observed in town and small forest area like Laga Gur State forest. Thus, the vegetation cover of the study area includes scattered trees, shrubs, and eucalyptus trees. In addition, according to information obtained from the GJWAO (2023), there is a vegetation cover of dense plantations composed mainly of eucalyptus and junipers around the surrounding farms and churches.LGSF is located in Wertu Kebele.

Figure 5. Forest cover of LGSF

Source: photo by Ayanu Asefa (May, 2023)

D. Farming system

Agriculture is the back bone of the woreda's economy in the study area. More than 90% livelihood of the population earned from crop production and livestock rearing, and the rest 10% earn from petty trade and other livelihood activities (GJWAO, 2023). The area has two cropping seasons. The main rainy season, which represents the highest total precipitation of the year, takes place from June to August during the summer season, the other rainy season runs from February to April *(Belg*), and during this period the area receives a small amount of rain. Livestock rearing contributes a significant amount to the livelihood of the rural population for food and as a source of income. Out of the total livestock population existed in the woreda, cattle accounted for the largest share followed by sheep. In Girar Jarso the estimate of total livestock population of peasant holdings was 248,988 and 265,152 in the year of 2014 and 2015, respectively. Out of this livestock population, the cattle population covers 152,546 and 158,031 in the year of 2014 and 2015, respectively. Out of the available 158,031 cattle population in the year of 2016; 39,122 of them were beef cattle population in the woreda. This data show that there is an increasing trend in the number of cattle population in the Girar Jarso Agriculture Office (GJWAO, 2015).

3.2.Sampling techniques

Debre Libanos and Girar Jarso woredas were selected purposively by non-probability sampling method, because of the presence of considerable church and state forest coverage respectively and Addis Alem and Wertu Kebeles are selected because forest area covered by this study is located in both kebeles. Heterogeneous population in and around both study areas were divided into homogeneous strata by stratified random sampling. from those strata simple random sampling was done to select the representative sample.

3.3.Sample size determination

Hence, 1036 households in Addis Alem kebele (DLWOA, 2015) and 637 households in Wertu Kebele (GJWOA, 2015) were stratified by their category and sample size for the study was identified by Yaro Yamane (1967) Statistical Formula for finding sample size of a finite population.

$$\mathbf{n} = \frac{N}{1+N(e)^2} \quad \textbf{Equation 1}$$

By Yamane's (1967) formula $1673/1+ 1673(0.05)^2$ = **323**

Table 3. Sample size determination

NS	Type of Respondents	Sample size		
		Male	**Female**	**Total**
A	**FGD**	**16**	**10**	**26**
1	Model HH	6	4	**10**
2	Religious leaders	10	6	**14**
B	**Key Informants Interview (KII)**	**10**	**6**	**16**
1	Elders	7	3	**10**
2	DA	1	1	**2**
3	Woreda Experts	2	2	**4**
C	**House hold survey**	**181**	**100**	**281**
1	A/Alem kebele HH	107	60	**167**
2	Wertu kebele HH	74	40	**114**
	Grand Total A+B+C	**207**	**116**	**323**

3.4.Methods of Data collection

3.4.1. Vegetation Sampling and floristic data collection

The following materials were used while vegetation sampling was undergone in study areas.

Table 4. List of materials used

NS	List of materials/ equipement	Purpose
1	Hand held GPS-62sH	To record altitude, latitude and longitude
		To mark waypoints and tracks
		To calculate slope and spacing while aligning transect line
2	Silva compass	To measure Aspect (Direction
3	Suunto Clinometer	To measure tree and shrub height
4	Measuring tape	To measure circumference of trees and shrubs and cover abundance
5	Secauters	To cut plant specimen
6	Specimen collection box	To press specimen and hold them together
7	Sony Digital Camera	To take photos and videos

During February, 2023, reconnaissance survey was conducted to familiarize the researcher with the study area, to get an insight of the vegetation pattern, topography and other environmental conditions in order to locate sampling quadrats in the forest. Systematic sampling, in which plots are laid at regular intervals along transect lines, was used to collect vegetation data following a method described in Vegetation Ecology (Kuchler *et al.,* 1976).

This is followed by actual sampling and eight parallel transect lines in DLMCF and five in LGSF, each about 200 m apart from each other were laid out. In each transect, quadrats each with 20 m x 20 m were laid out at vertical spacing of 20 m elevation difference. Additionally in each quadrat, plots of 2m x 2m was laid four of them at each corner and one plot in the middle of quadrat for shrub diversity analysis located in both study areas. A total of 53 plots in DLMCF and 20 plots in LGSF were identified for tree and shrub data collection. All trees and shrubs inside the quadrats in both forest were counted to analyze the floristic composition of the forest. In each plot, all vascular plant species were listed by their local and/or scientific names, and their identities were recorded. The cover abundance of tree and shrubs was also measured and categorized by classes by Braun-Blanquet 1-9 scales as modified by (Maarel, 2005) by calculating the Ordinal Transformed Values (OTV).

Specimens of all woody plant species were collected, pressed and identified at the Salale University Mini- Herbarium (Fitche) using Flora of Ethiopia and Eritrea. Field assistants, forest guards and local people familiar with the flora helped in identifying local names of most plants. Plant nomenclature in this paper follows the Flora of Ethiopia and Eritrea (Hedberg and Edwards 1989, 1995; Edwards et al. 1995, 1997, 2000; Hedberg et al. 2003, 2004, 2006, 2009a, 2009b). Data collection was carried out from March to May 2023.

3.4.2. Primary and Secondary data collection (survey)

A general survey consisting of forest inventory, key-informant interviews and Focus Group Discussion (FGD) was carried out following (Martin, 2016). In D/Libanos woreda key informants, which have been suggested by the Monastery's administration (D/Libanos Woreda), forest guards (*Kantiba*) and representatives of the local communities (in both study areas), were selected and interviewed using the open-ended questionnaire prepared in advance for this purpose. For undertaking the FGD, a group consisting of the model households and religious leaders were interviewed. At the beginning of the discussion, the aim of the study was explained to the participants by the investigator to ensure openness in

the discussion. The actual FGD was carried out using relevant discussion points or questions, mainly the socio-economic importance of the forest, spiritual role of church forest and challenges/problems/constraints in the conservation and management of the forest, and the human activities affecting the forest. The ideas and suggestions forwarded by the group participants were recorded.

Forest inventory was undergone to collect data related tofloristic diversity and vegetation structure. Observations were made on the biophysical features of the study area, land use types, disturbances (extent of deforestation, livestock and human interferenceson the forest.

Published journals, articles, proceedings, books, annual plans and reports were used to as supporting documents in literature review and data analysis.

4. DATA ANALYSIS

4.1.Floristic diversity

The analysis was done by one of the most widely used approaches in measuring the diversity of species, Shannon and Wiener index of species diversity. The Shannon-Wiener index is relatively independent of sample size and has a tendency towards stressing rare species (Ghildiyal and Gairola, 2009). The Shannon diversity (H') and evenness (E') indices was calculated to incorporate both species richness and evenness. The following formula was used to calculate Shannon diversity.

$$\mathbf{H = -1\sum[(pi) * ln(pi)]} \quad \textbf{---------- Equation 2}$$

Where H' = Shannon diversity index, S = the number of species, Pi = the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of total cover and ln = log base n

Evenness was calculated as: $\mathbf{E = H'/H'max}$ **---------- Equation 3**

Where E = evenness. Statistical software R version 4.2.2.was used for the diversity indices analysis.both diversity and evennesss of study area forests was compared other forests.

Similarity of species composition among church and state forest plant community was assessed by Sorensen's similarity index. The similarity index (SI) between forests sites was calculated following Sorenson (1948), based on the existing species richness of all the sites as:

$$\mathbf{(Ss = 2a/2a + b + c)} \quad \textbf{---------- Equation 4}$$

Where Ss = Sorensen's coefficient (index), a = number of species shared between communities, b = number of species found in the first community and c = number of species found in the second community.

The floristic comparison of DLMCF and LGSF with other related DAF in Ethiopia was made using the Shannon – Wiener Diversity index.

4.2.Analyses of vegetation structure

For analyses of vegetation structure of the study area, all individuals of trees and shrubs with a diameter at breast height (DBH) greater than 1.5 cm, and height greater than 1.5 m were measured for DBH using Meter tape and Clinometer. Individuals with DBH less than 1.5 cm and height less than 1.5 m were counted.

The following analyses were done to describe the structure of the DLMCF and LGSF:

A. Density: - Tree density was computed by dividing total number of individuals to by number of quadrats in which the plant exits.

$$\textbf{i.e. } D = \frac{S}{Q} \quad \textbf{---------- Equation 5}$$

Where D is Density, S is total number of individuals in each quadrat and Q is total no. of quadrat in which species are found

B. Frequency:-frequency is the number of times a particular species is recorded in the sample area.

$$F = \frac{N}{Q} X\ 100 \quad \textbf{---------- Equation 6}$$

Where F is % of frequency, N is Number of quadrats in which the species is present and Q is Number of Quadrats employed in the study.

C. DBH (Diameter at Breast Height):-It is obtained by dividing the circumference of each tree recorded in the field by π or by equivalent value (3.14).

$$D = C/\pi \quad \textbf{---------- Equation 7}$$

Where D = Diameter, C = circumference and $\pi = 3.14$. It was categorized into five classes.

D. Basal Area: - Basal area calculations were made on the diameter measurements of the stem. It is expressed in square meter/hectare.

$$BA = \pi \times \frac{(DBH)^2}{2} \quad \textbf{---------- Equation 8}$$

For all individuals of tree having > 2.5 cm DBH, Relative density, Relative frequency, Relative Dominance and Importance Value Indices (IVI) were calculated for each tree species using the following formula.

i. Relative density (RD) $= \frac{\text{Total no.of species i}}{\text{Total sum of all individual species}} * 100$---------- **Equation 9**

ii. Relative frequency = **(RF)** $= \frac{\text{Frequency of species i}}{\text{Total sum of all individual species}} * 100$---------- **Equation 10**

iii. Relative Basal area = **(RBA)** $= \frac{\text{Total Basal Area of species i}}{\text{Total basal area of all species}} * 100$---------- **Equation 11**

iv. Importance Value Index (IVI) = RF + RD + RBA ---------- **Equation 12**

4.3.Cluster and Plant community analysis

Sites that were similar in their species composition were clustered by agglomerative hierarchical classification method following (Kindt R and Coe R, 2005) by R statistical Software. The plant community types were determined and named as 'type' by dominant characteristic species; mainly trees and shrubs with high cover abundance values were used. The community types distinguished were further refined in a synoptic table with a species having at least >1 synoptic value in at least one cluster.

4.3.1. Species Cover abundance

Species abundance first estimated visually, recorded and later was converted following the Braun-Blanquet 1-9 scales as modified by (Maarel, 2005) by calculating the Ordinal Transformed Values (OTV) as

$\mathbf{OTV = 1.415 \ln C + 2}$---------- **Equation 13**

Where, ln is the natural logarithm and C is the cover abundance value in percentage. the following table was used to select values.

Table 5.The Braun-Blanquat and Domain Cover Scales(Kent M. and Cocker P, 1992)

Value	Braun-Blanquet	Domain
+	Less than 1% cover	A single individual. No measurable cover
1	1-5% cover	1-2 individuals.No measurable cover. Individuals with normal vigor
2	6-25% cover	Several individuals but less than 1% cover
3	26-50% cover	1-4% cover
4	51-75% cover	4-10% cover
5	76-100% cover	11-25% cover
6		26-33% cover
7		34-50% cover
8		51-75% cover
9		76-90% cover
10		91-100% cover

Analysis of other primary data collected via Household survey, FGD and KII was manipulated by percentage and frequency and it is presented by tables and graphs.

5. RESULTS AND DISCUSSION

5.1.Species richness of study areas

70 plant species of 62 genera and 40 families were identified from the DLMCF. The family with the highest number of species was Fabaceae (7 species, 10% of all species), followed by Euphorbiaceae (5 species, 7.14%) and Myrtaceae and Oleaceae (both of them 4 species, 5.71%). See figure 6 for details.

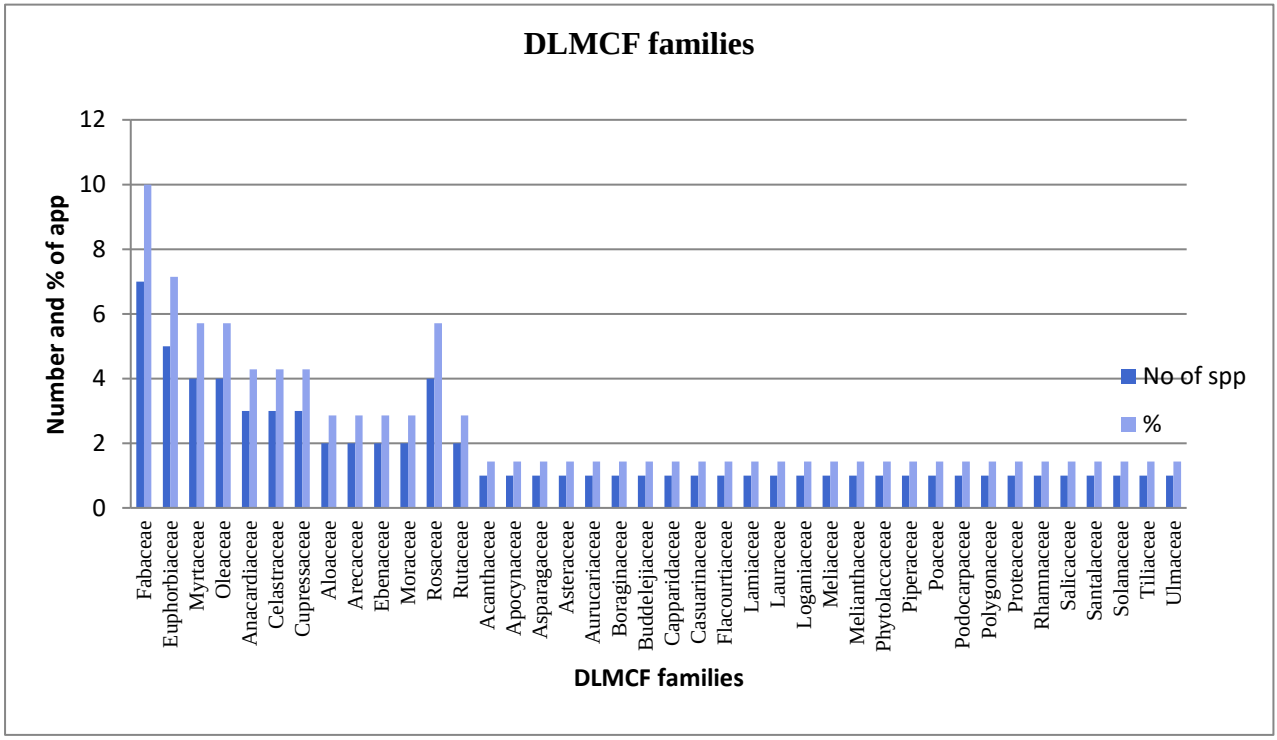

Figure 6. Plant Families found in DLMCF

DLMCF Species by Habit

There were about 40 (57 %) trees and 30 (43 %) shrubs in DLMCF. See figure 7 below.

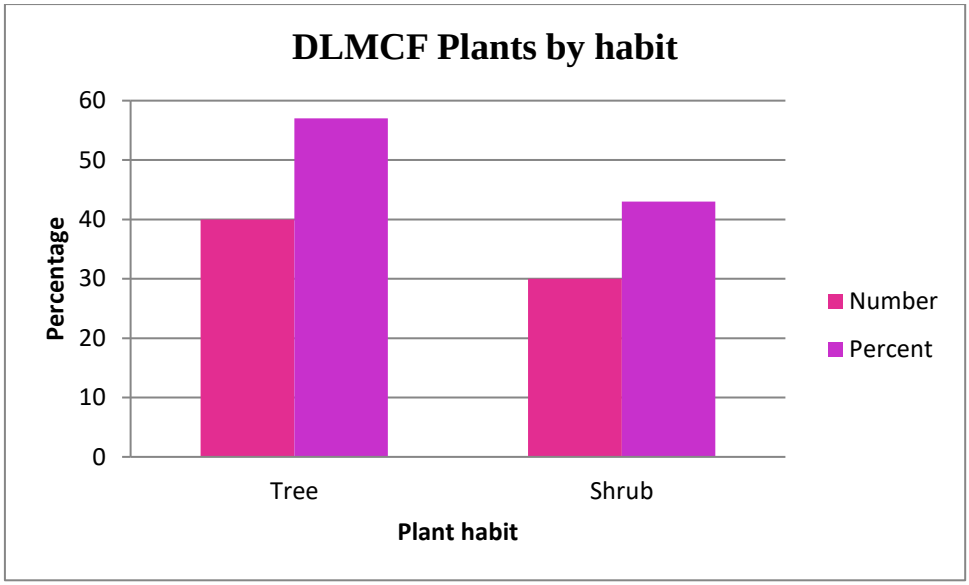

Figure 7. Number of species by habit in DLMCF

In case of LGSF 28 types of plant species out of which 16 (57.14%) are Trees and 12 (42.86%) are Shrubs. See figure 8 below for more details.

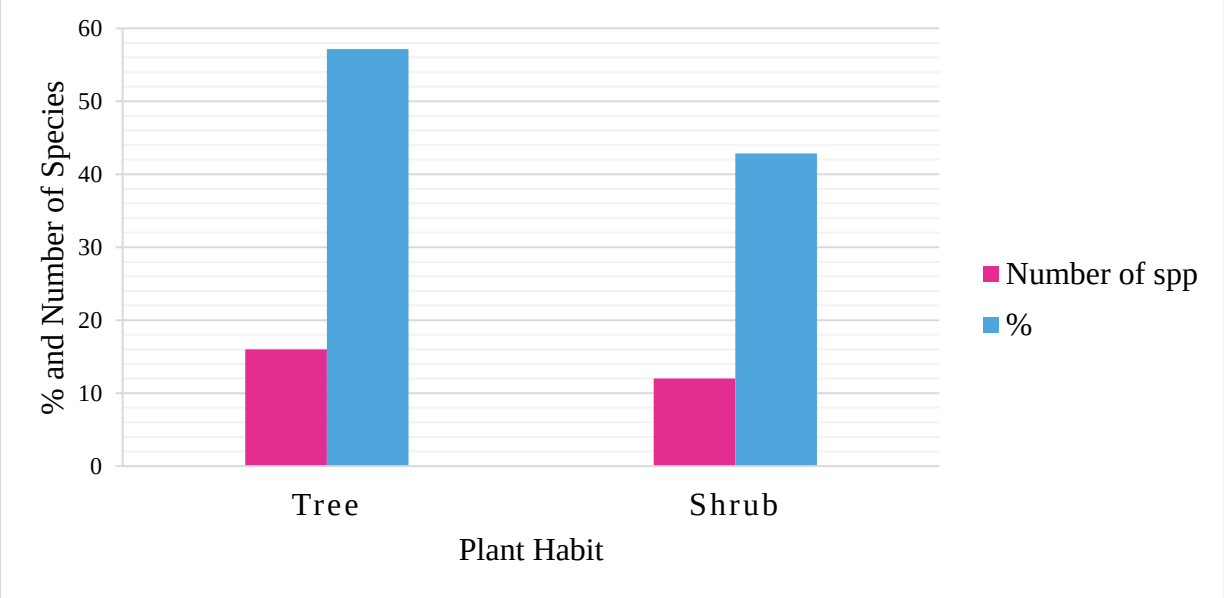

Figure 8. Laga Gur State Forest Species by Habit

28 plant species, **23** genera and **19** families were identified from Laga Gur State Forest. The family with the highest number of species was Euphorbiaceae, Fabaceae and Myrtaceae (3 species each, 10.71% of all species), followed by Aloaceae, Celastraceae and Rosaceae (2 species each, 7.14%). See figure 9.

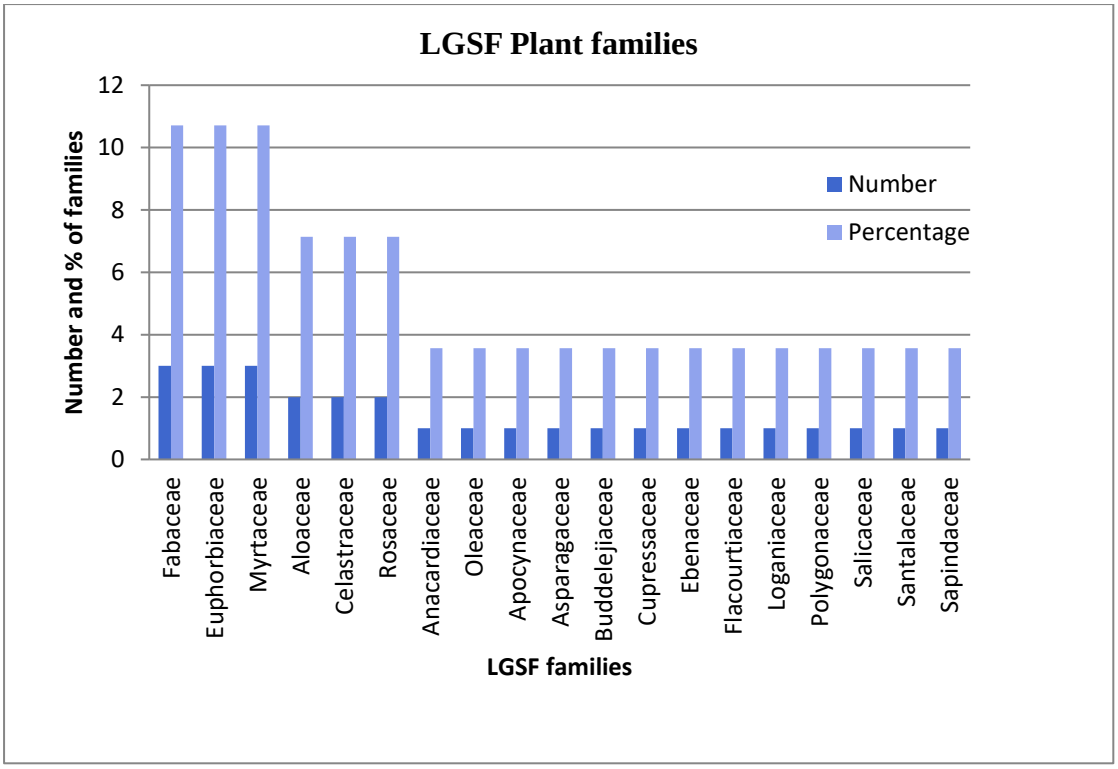

Figure 9. Plant families and number of species in LGSF

Overall number of individuals in DLMCF is 3502 while LGSF has 957 number of individuals. The overall family, genera and species of both study areas is shown below.

Table 6. Taxa (Family, genera and species of both study areas.

DLMCF			LGSF		
Family	**Genera**	**Species**	**Family**	**Genera**	**Species**
40	62	70	19	23	28

DLMCF Species Cover abundance

Regarding to abundance the following figure 10 shows abundance class of DLMCF is shown. DLMCF is classified into nineabundance classes.

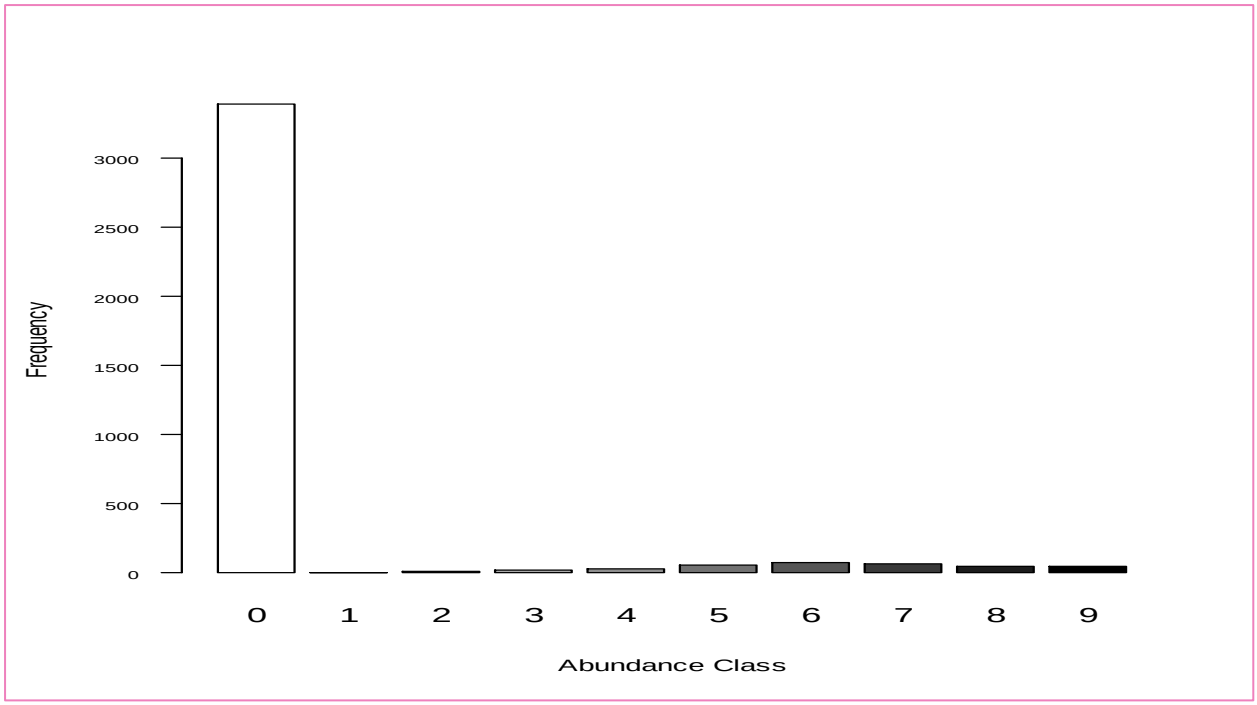

Figure 10. Abundance class of DLM Church Forest

Species occurrence and relative species frequency depending on number of occurences and frequency is plotted by R- software for DLMCF are shown below. (figure 11).

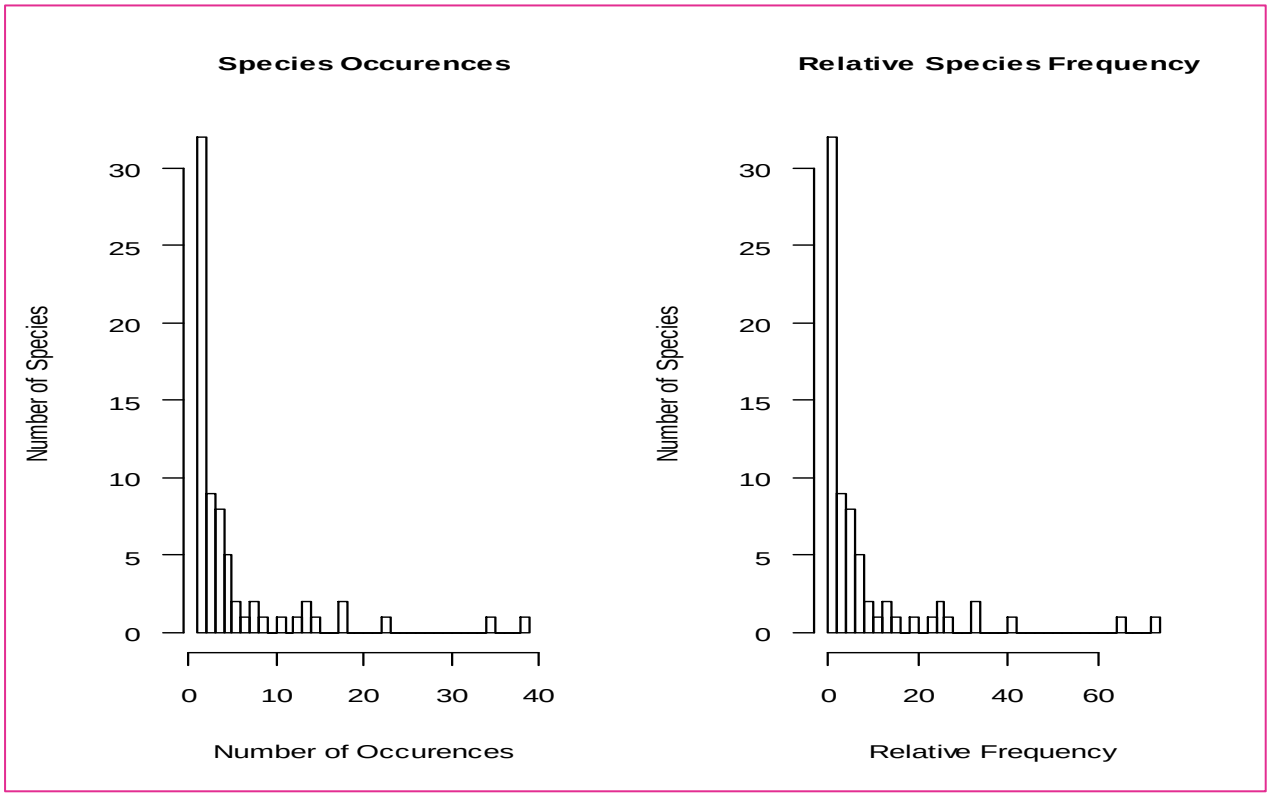

Figure 11. Species occurrence and relative frequency of DLMCF

Taxa (family, genera and species) and endemic richness of DLM Church forest (40 families, 62 genera and 70 species) were higher than or comparable to that of some other DAFof Ethiopia, for example, Zengena 31 families, 50 woody species (Desalegn Tadele, Ermias Lulekal, 2014), Belete forest 33 families, 64 species (Zerihun and Claire, 2022), Wof washa 40 families, 62 species (Gebremedhin, 2016) and less than Munessa forest 41 families, 61 species (Anissa and Elias, 2020), Yegof forest 43 families, 76 species(Mesfin, *et al.*, 2018), Dindin 43 families, 81 species(Simon Shibru and Gizachew Balcha, 2004).

Comparatively, Taxa (family and species) and endemic richness of LG state forest (19 families, 23 genera and 28 species and) was less than other DAFof Ethiopia, for example Zengena 31 families, 50 woody species (Desalegn *et al*., 2014) and Belete forest 33 families, 64 species (Zerihun and Claire, 2022), Wof washa 40 families, 62 species (Gebremedhin, 2016) and Munessa forest 41 families, 61 species (Anissa and Elias, 2020).

Variation in species composition among different forests is attributed to topographic, edaphic and climatic differences, as well as degree of human disturbance(Haileab, 2021).

5.2.Shannon -Wiener Diversity and evenness of DLMCF and LGSF woody species

The diversity (H') and evenness (E) values of tree species of DLMCF were 3.14 and 0.81respectively.The high diversity is attributed to habitat diversity and low human disturbances (as strict conservation and ***"gizit"*** withsloppy terrain limits human exploitation and livestock grazing/browsing). The high evenness showed that there is more or less balanced distribution of individuals among the different species. The diversity value implies the need to conserve the forest from floristic diversity perspective.The diversity and evenness of woody species in LGSF were 2.84 and 0.84 respectively and the comparison of both churches with others is presented as shown in table 7below.

Table 7. Comparative analysis of Diversity and Evenness of certain forests

NS	Name of forests	H (Diversity)	E (Evenness)	Source
1	**DLMCF**	**3.15**	**0.82**	**Present study**
2	Tara gedam	2.98	0.65	(Haileab *et al.*, 2011)
3	Kimphee	2.92	0.66	(Kedir *et al,*. 2019)
4	**LGSF**	**2.84**	**0.84**	**Present study**
5	Birhane Kontir	2.83	0.54	(Feyera et al., 2014)
6	Yayu forest	2.8	0.63	(Feyera et al., 2014)

NS	Name of forests	H (Diversity)	E (Evenness)	Source
7	Zengena	2.74	0.7	(Desalegn*et al.*, 2014)
8	Haranna forest	2.6	0.51	(Feyera et al., 2014)
9	Munessa	2.6	0.39	(Anissa and Elias, 2020),
10	Managesha Suba	2.57	0.92	(Dinkisa, 2021)
11	Kuandisha	2.5		(Abiyot *et al.*, 2017)
12	Yegof	2.26	0.57	(Mesfin, *et al.*, 2018)
13	Kahitassa	2.06	0.53	(Baymot *et al.*, 2022)
14	Maji forest	1.31	0.31	(Feyera et al., 2014)
15	Ababaye	1.31	0.31	(Haileab *et al.*, 2011)

5.3.Diameter class of both forest types

As shown in figure 15 below 39% of species fall in class 1, 27% in class 2, 13% falls in class3, 17% in class 4 and 4% of plant species falls in class 5. *Olea europaea*, *Grevillea robusta* and *Ficus sycomorus* are those three species having DBH > 25cm.

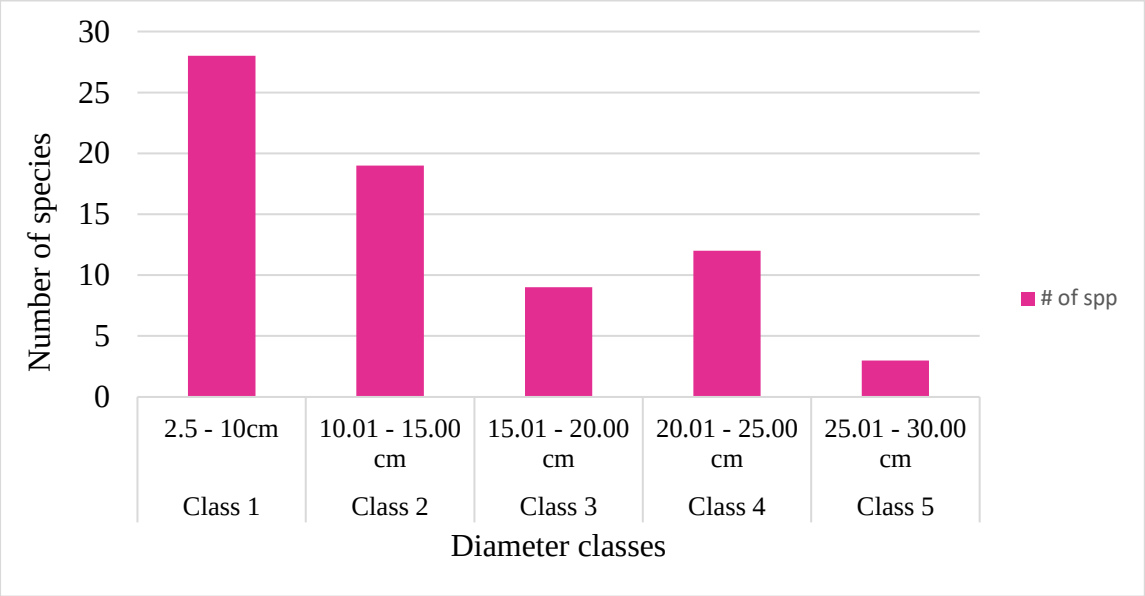

Figure 12. Diameter class of DLMCF

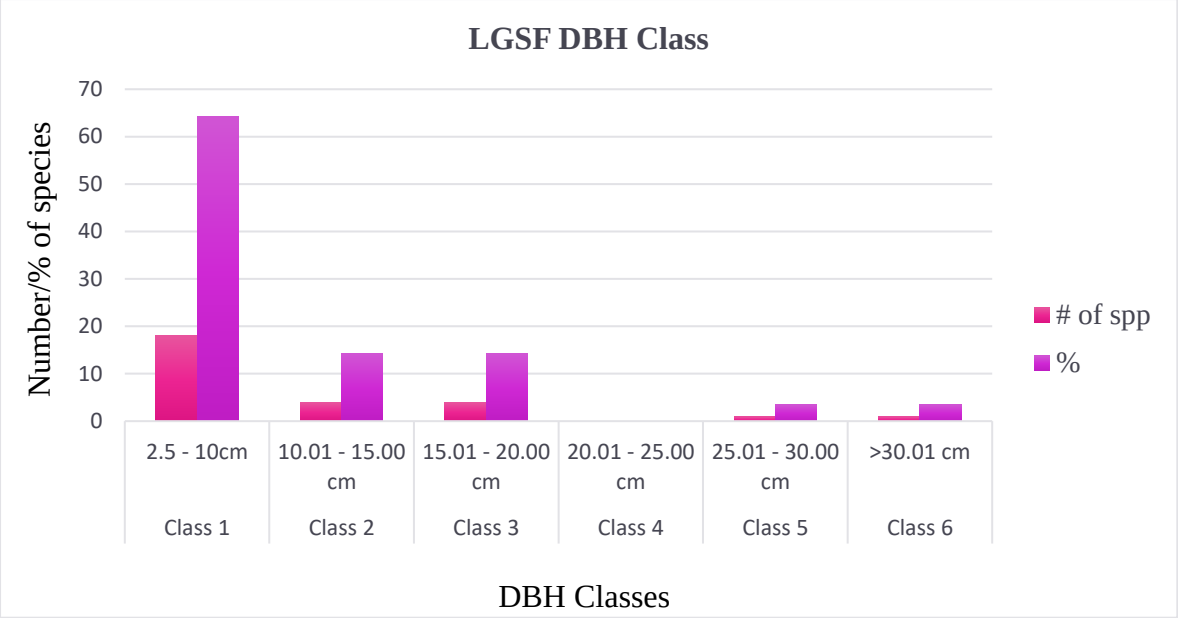

Figure 13. Diameter class of LGSF

Similarly, in LGSF 18 species (64.3%) fall in class 1, class 2 and 3 are represented by four species each (14.3% each), in class 5 and 6 there is one species each (3.6%). *Aloe debrana*falls in class 5 and *Olea europeae* is in class 6.

5.4.Similarity of Woody Species Composition across DLMCF and LGSF

The result showed that both forest shared 22species. Each forest type exclusively supported a number of species; 49 species in the DLMCF, 6 species in the LGSF (*Acacia decurrens, Acacia melanoxylon, Clutia abyssinica, Croton macrostachyus, Dodonaea angustifolia* and *Rosa abyssinica.*Sorensen's similarity index indicated the level of similarity among these two forest types. Both forests had 80% of woody species similarity. See table 9 below.

Table 8. Sorensen similarity index of woody species between DLMCF and LGSF

NS	Forest type	Total number of species recorded in DLMCF (A)	Total number of species recorded in LGSF (B)	Total Number of species common to both (C)	Sorenson's similarity IndexSI = $\frac{2C}{A+B}$
1	DLMCF	48		22	SI= 44/54 = 0.81 i.e. 81%
2	LGSF		6		

5.5.Density and frequency of DLMCF woody species

The total density of woody species of DLMCF was **643.15**individuals per plot (see Appendix 3). The species with the highest density in DLMCF was *Arundo donax* (**50** individuals per quadrat), followed by *Euphorbia candelabrum* (**30**), E*ucalyptus globulus* (**29.94**), R*hamnus prinoides* (**27.5**), *Ligustrum cafira* (**23.67**), *Carissa spinarum* (**21.91**) and *Senna siamea***21.67%.** These seven most abundant species contributed to about 29.24% of the total density. The high density of the species is attributed to suitable environmental conditions for regeneration, high reproductive capacity of the species, and the relatively better protection of the forest from human exploitation and livestock grazing/browsing as it is a protected area and the presence of sacred places within the forest area. Five species had the lowest density (1individuals.per quadrat each), and thus were poorly represented in the forest, namely *Vernonia amygdalina, Ficus sycomorus, Barsema abyssinica* and *Cupressus lusitanica*.

While considering frequency of species in DLMCF, *Olea europaea subsp.cuspidata* (41.5%), *Carissa spinarum* (41.5%), *Juniperus procera* (37.7%), *Eucalyptus globulus* (34%), *Acacia abyssinica* (34%), *Opuntia ficus-indica* (26.4%), *Pterolobium stellatum* (24.5%), *Calpurnia aurea* (24.5%), and *Maytenusarbutifolia* (22.6%) were those species with highest frequency, while 38 species had the lowest frequency (2% each), and thus were rare in the forest. (See Appendix 3). The high frequency indicates regular horizontal distribution of the species in the forest.

5.6.Cluster analysis

A cluster analysis arranges the sites into groups and they are formed of sites that are similar in species composition, as measured by a chosen ecological distance. Cluster analysis provides a summary of the similarity in species composition of various sites. Sites that are grouped into the same cluster are more similar in species composition than sites that are grouped into different cluster.

Hierarchical clustering methods do not only cluster sites, but also cluster the various clusters that were formed earlier in the clustering process. Hierarchical clustering methods thus provide a hierarchy for the similarity of sites (Kindt R and Coe R, 2005). The following figure shows agglomerative hierarchical classification of DLMCF.

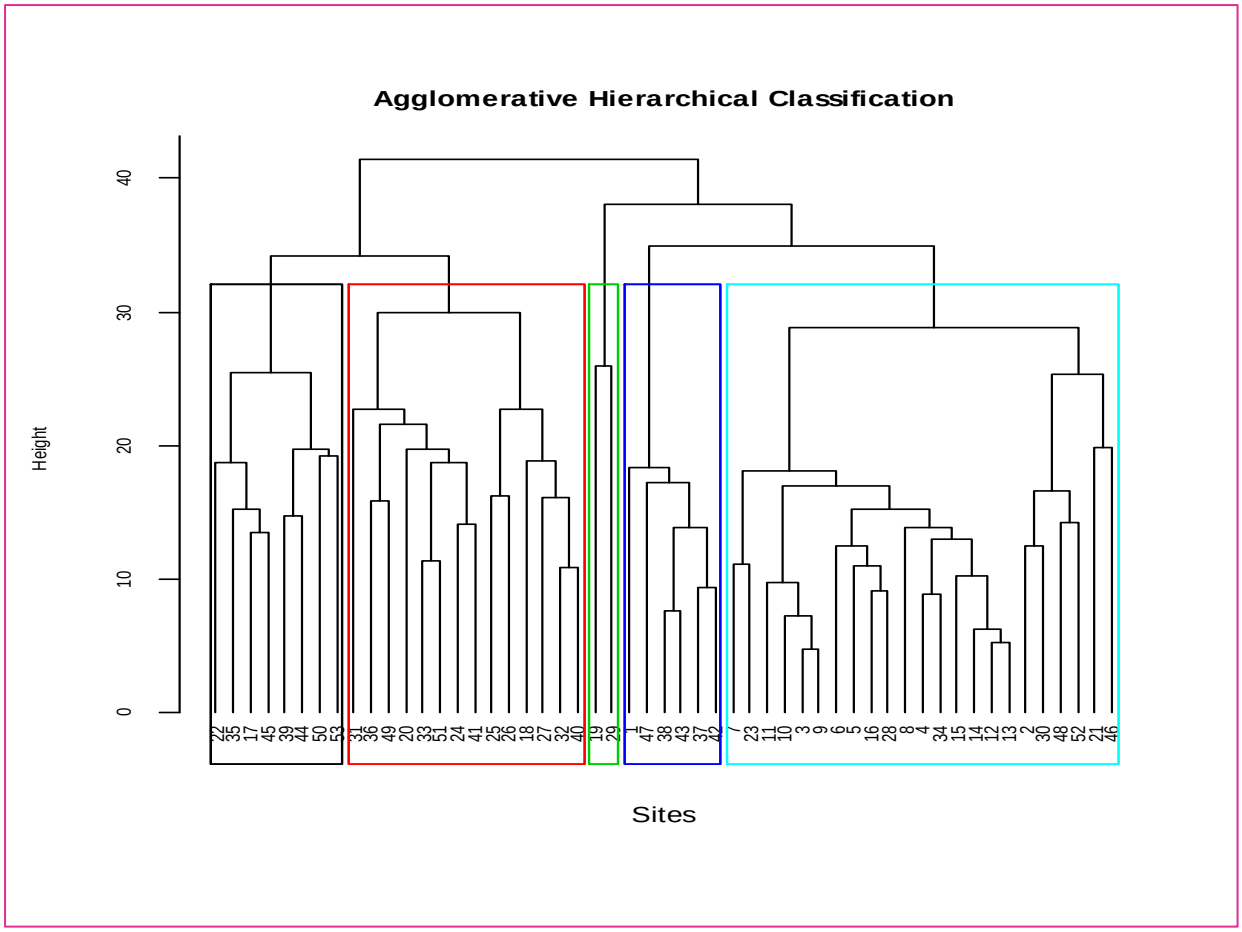

Figure 14. Agglomerative hierarchical classification of DLMCF

Table 19 shows synoptic table of species that have >1 synoptic value I at least one cluster that are found in DLMCF.

Table 9. Synoptic Table of species with synoptic values >1 in at least one cluster

Species	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Carissa spinarum	**6.9**	0.3	0.7	**6.4**	0.0
Olea africana	**4.2**	0.0	0.0	0.0	0.0
Pterolobium stellatum	**2.0**	0.6	**1.5**	**1.8**	0.0
Euclea divinorum	**1.7**	0.3	0.8	**1.4**	0.0
Buddleia polystachya	**1.1**	0.2	0.0	0.0	0.0
Senna siamea	**1.0**	0.0	0.5	0.4	0.0
Olea europea	0.2	**7.7**	**7.1**	**7.4**	0.0
Juniperus procera	**5.9**	**6.7**	**1.0**	**3.8**	**1.8**
Calpurnia aurea	**1.7**	**2.3**	0.6	**2.0**	0.0
Clutia abyssinica	0.0	0.0	0.6	**1.3**	0.0
Euphorbia abyssinica	0.7	**1.5**	0.6	**1.0**	0.0
Cordia.africana	0.7	0.5	**1.5**	0.0	0.0
Gravelia robusta	**1.1**	0.0	**1.2**	0.0	0.0
Borassus ethiopium	0.0	0.0	**1.2**	0.0	0.0
Jacaranda memosifolia	0.0	0.0	**1.2**	0.0	0.0
Ligustrum cafira	0.7	0.0	**1.2**	0.0	0.0
Phoenix reclinata	0.0	0.3	**1.2**	0.0	0.0
Juniperus procera.	0.0	0.0	**1.1**	0.0	0.0
Maytenus arbutifolia	**2.0**	0.8	0.0	**4.5**	0.0
Acacia abyssinica	0.7	0.7	**2.7**	**3.7**	0.0
Opuntia ficus indica	**1.6**	**1.1**	0.0	**3.1**	**1.3**
Rhus gilutinosa	0.0	0.0	0.0	**1.4**	0.0
Euclea divinorum	0.7	0.0	0.0	**1.1**	0.0
Justicia schimperiana	0.0	0.0	0.0	0.0	**1.0**
Eucalyptus globulus	**2.3**	**2.5**	0.0	**1.2**	**8.8**
Eucalyptus camaldulensis	**2.1**	0.7	0.5	0.4	**3.3**
Justicia schimperiana	0.6	0.7	0.0	0.8	**2.8**
Croton macrostachyus	0.0	0.6	0.0	0.8	**2.5**

Based on the above synoptic table DLMCF is classified into five community clusters, which are discussed in detail below.

A. Carissa spinarum - Olea europaea subsp.cuspidata type

This community type is found between elevation ranges of 2354–2529 m and dominated by ***Eucalyptus globulus****and Olea europaea subsp.cuspidata* plant species. *Juniperus procera, Buddleia polystachya,Carissa spinarum* and *Calpurnia aurea*are also common species on this community type. Similarly, *Rumex nervosus, Opuntia ficus-indica, Pterolobium stellatum* were relatively rare species in this community type (Figure 15).

Figure 15.*Carissa spinarum - Olea europaea subsp.cuspidata* community type

B. Olea europaea subsp.cuspidata – Juniperus procera Community type

This community type is found between elevation ranges of 2361–2495 m and dominated by ***Olea europaea subsp.cuspidata*** and ***Juniperus procera*** plant species. *Euclea divinorum,Carissa spinarum, Calpurnia aurea and Eucalyptus camaldulensis* are also common species on this community type. Likewise, *Pterolobium stellatum, Justicia schimperiana, Opuntia ficus-indica* and *Nuxia congesta* were relatively rare species in this community type (see Figure 16 below).

Figure 16.*Olea europaea- Juniperus procera* community type

C. Cordia africana -Grevillea robusta Community type

This community type is found between elevation ranges of 2342 - 2472 m. *Cordia africana and Grevillea robusta with Olea europaea, Acacia abyssinica* and *Jasminum grandiflorum* are common species in this community while *Salix mucronata, Aurucaria aurucariana, Persea Americana, Phytolecca deodecandra* and *Acacia abyssinic* were rare species.

Figure 17.*Cordia africana – Gravelia robusta* community

D. Maytenus arbutifolia- Acacia abyssinica community

This community type is found between elevation ranges of 2337 - 2480 m asl. *Maytenus arbutifolia* and *Acacia abyssinica* are dominant species with *Juniperus procera, Olea europaea, Calpurnia aurea,Carissa spinarum and Opuntia ficus-indica. Vernonia amygdalina, Eucalyptus globulus, Euclea divinorum* and *Sesbania sesbun* are rare species. See figure 18.

Figure 18.*Maytenus arbutifolia- Acacia abyssinica*

E. Eucalyptus globulus - Eucalyptus camaldulensis Community type

This community type is found between elevation ranges of 2402–2446 m and dominated by ***Eucalyptus globulus*** *and* ***Eucalyptus camaldulensis*** plant species. *Carissa spinarum*and *Olea europaea subsp.cuspidata* were also common species on this community type. Similarly, *Justicia schimperiana, Euclea divinorum, Acacia abyssinica* and *Croton macrostachyus* are relatively rare species in this community type (Figure 19).

Figure 19.*Eucalyptus globulus – Eucalyptus camaldulensis* community type

5.7.Dominance / basal area of woody species

A. Dominance/ Basal area of woody species in DLMCF

The relative ecological importance and/or dominance of tree species in a forest ecosystem can better be depicted from measurements of basal area than stem counts (Cain and Castro 1959). The total BA of woody species of DLMCF was 122.78 m^2/ha (Appendix 3). The species with the highest BAincludes *Olea europaea subsp.cuspidata* (6.31m^2/ha), followed by*Ficus sycomorus* (5.72 m^2/ha) and *Grevillea robusta* (5.72 m^2/ha). These species have greater DBH and hence BA. The reason for the variation in the basal areas of the species might be due to size and number of individual species in the forest (Wakshum *et al*., 2019). Other 27 species have lower BA including *Ligustrum cafira (0.04 m^2/ha), Asparagus seatacesus (0.04 m^2/ha)* and *Leonotis ocymifolia* (0.03m^2/ha) due to their smaller diameters. Comparatively, the basal area of DLMCF in this study (122.78m^2/ha) was greater than what was studied by (Wakshum *et al*., 2019)i.e. 33.5 m^2/ha. The reason could be the forest area

from which samples were taken and DBH of individual trees that may increase from that time to now.

B. Dominance/ Basal area of woody species of LGSF

The total basal area of woody species of LGSF was 146.14 m^2/ha(Appedix 4). The species with the highest basal area includes *Olea europaea subsp.cuspidata* 43.26 m^2/ha, *Aloedebrana*19.87 m^2/ha and *Juniperus procera* 11.78 m^2/ha, *Croton macrostachyus*10.82m^2/ha, *Aloe macrocarpa* 8.11m^2/ha and *Acacia abyssinica* 8.02 m^2/ha.These six most dominant woody species accounted for about 69.7% of the total basal area. Woody species with the largest contribution in basal area can be considered as the most important species in a forest. *Psidium guajava, Rhus vulgaris, Euclea divinorum, Maytenus arbutifolia, Nuxia congesta, Acacia decurrens* and *Asparagus seatacesus* have basal area <1 m^2/ha because of their smaller diameter.

5.8.Density and frequency of LGSF woody species

For LGSF, the total density of woody species was **235.38** individuals per quadrat. The species with the highest density in in this state forest was *Dodonaea angustifolia* (**20.50** individuals per quadrat), followed by *eucalyptus species* (**15.5**), *Osyris quadripartita Decn*, *Rumex nervosus vahl* and *psidium guajava* **15** individuals each, *eucalyptus globulus* **(12.33)**, *Aloe debrana* (**10.67**), *Carissa spinarum (C. edulis* **(10.59),***Nuxia congesta* **(10.00)**, *Doviyalis abyssinica* **(10)**. These ten most abundant species contributed about 13.5% of the total density. The high density of the species is attributed to suitable environmental conditions for regeneration, high reproductive capacity of the species. Three species had the lowest density i.e. *Asparagus seatacesus, Croton macrostachyus and Acacia melanoxylon.* Thus were poorly represented in the forest. See Appendix 4.

In case of LGSF, the species with the highest frequency was *Carissa spinarum* (85%), followed by *Juniperus procera* (65%) and *Acacia abyssinica* (60%). The high frequency indicates regular horizontal distribution of the species in the forest. On the other hand, nine species had the lowest frequency (5% each), and thus were rare in the forest. See appendix 6. Density and frequency of the woody species varied considerably among the species. The variation in density and frequency between species is attributed to habitat differences, habitat preferences among the species, species characteristics for adaptation, conditions for regeneration, and degree of human disturbance (Teketay, 2005).

5.9.Importance Value Index (IVI) of woody species

The IVI is an important parameter that reveals the ecological importance and/or dominance of species in a given ecosystem (Cain and Castro 1959; Lamprecht 1989). Species with high IVI values are considered more important than those with low IVI values. According to Curtis and McIntosh (1951), a given species is said to be dominant if it had the highest IVI value compared to other plant species within an area. In a very general sense, the higher the IVI value of a species, the more successful it is in that particular habitat. Accordingly, *Olea europaea, Eucalyptus globulus, Juniperus procera, Carissa spinarum, Acacia abyssinica, Arundo donax* and *Euphorbia candelabrum* (In DLMCF) and *Dodoneae angustifolia, Aloe macrocarpa, Eucalyptus camaldulensis and Rosa abyssinica (*LGSF*)* were ecologically the most important species. In other words, these species were more abundant, frequent and dominant in both forests.

In DLMCF, the dominant species are shown in the following tablewhile *Rhus vulgaris*, *Citrus aurantifolia* and *Hagenia abyssinica* has the least IVI <1.15%.

Table 10.IVI of dominant 10 species in DLMCF

NS	Species Name	F	BA	D	RBA	RD	RF	IVI	Rank
1	*Olea europaea subsp. cuspidata*	41.5	6.31	16.95	5.14	2.64	7.74	15.51	1
2	*Eucalyptus globulus*	34	1.31	29.94	1.07	4.66	6.34	12.06	2
3	*Juniperus procera*	37.7	4.72	7.1	3.84	1.10	7.03	11.98	3
4	*Carissa spinarum*	41.5	0.63	21.91	0.51	3.41	7.74	11.66	4
5	*Acacia abyssinica*	34	3.07	4.28	2.50	0.67	6.34	9.50	5
6	*Arundo donax*	1.9	1.1	50	0.90	7.77	0.35	9.02	6
7	*Euphorbia candelabrum*	1.9	3.78	30	3.08	4.66	0.35	8.10	7
8	*Pterolobium stellatum*	24.5	0.51	19	0.42	2.95	4.57	7.94	8
9	*Opuntia ficus-indica*	26.4	1.6	9.57	1.30	1.49	4.92	7.71	9
10	*Eucalyptus camaldulensis*	15.1	2.96	11.38	2.41	1.77	2.82	7.00	10

Dominant species of LGSF with great IVI of plant species is shownin the following table.

Table 11.IVI of most dominant tree species of LGSF

NS	Spp Name	BA	RBA	D	RD	F	RF	IVI
1	*Olea europaea subsp. cuspidata*	43.26	29.60	5	2.12	5	0.92	32.64
2	*Juniperus procera*	11.78	8.06	7.46	3.17	65	11.93	23.16
3	*Carissa spinarum (C. edulis)*	2.83	1.94	10.59	4.50	85	15.60	22.03
4	***Aloe debrana***	19.87	13.60	10.67	4.53	15	2.75	20.88
5	*Acacia abyssinica*	8.02	5.49	7.75	3.29	60	11.01	19.79
6	*Dodonaea angustifolia*	5.09	3.48	20.5	8.71	20	3.67	15.86
7	*Aloe macrocarpa*	8.11	5.55	8.75	3.72	20	3.67	12.94
8	*Eucalyptus camaldulensis*	2.85	1.95	15.5	6.59	20	3.67	12.21
9	*Rosa abyssinica*	5.23	3.58	6.17	2.62	30	5.50	11.70
10	*Rumex nervosus vahl*	2.08	1.42	15	6.37	20	3.67	11.47

IVI values can also be used to prioritize species for conservation: species with high IVI values need less conservation efforts whereas those with low IVI values need high conservation efforts (Simon Shibru and Gizachew Balcha, 2004). The results suggest that species with low IVI values such as *Jasminum grandiflorum, Buddleia polystachya, Leonotis ocymifolia, Milletia ferruginea, Ocyris quadripartita, Maytenus undata, Rhus vulgaris, Citrus aurantifolia, Hagenia abyssinica, Croton macrostachyus, Asparagus seatacesus, Nuxia congesta, AA035 (Tikure)* and*Acacia melanoxylon* should be given high priority for conservation.

5.10. Vegetation structure of Study area forests

The vegetation structure of trees in DLMCF and LGSF was described following the International Union for Foreestry Research Organization (IUFRO) classification schemeused by (Birhanu *et al.*,2014). According to the scheme three vertical structures were identified which are upper storey(tree height >2/3 of top height), middle storey (tree height between 1/3 and 2/3 of top height) and lower storey (<1/3 of top height). The tallest tree in DLMCF was *Podocarpus falcatus* (23 m) and *Eucalyptus globulus* (31.25m) in LGSF. The height range and number of species in those range is shown below (Table 19). Accordingly, the most woody species were found in the lower storey 73.24% and 75% , showing that the forests are in good condition.

Table 12. Vegetation structure of study areas by storey

Storey	DLMCF		LGSF	
	Height (m)	No of spp and %	Height (m)	No of spp and %
Upper	>15.33	**6** (8.57)	>20.83	**5** (17.85)
Middle	7.67-15.33	**13**(18.57)	10.42-20.83	**2** (7.14)
Lower	<7.67	**51** (72.85)	<10.42	**22** (78.57)
Total		**70 (100)**		**28 (100)**

5.11. Socio-economic and spiritual importance of the forest to the local communities

The responses from the key informants indicated that DLMC forest is the major source of fuel wood (most of the woody species), construction material (several woody and some shrub species, e.g. especially in the place where food and drinks are prepared.

Table 13. Assessment of Socio economic roles of church forest for the community

NS	Socio economic roles of Church Forests	Strongly agree	Agree	Disagree	Strongly disagree
1	Important for the survival of all living things	89	11		
2	Vital for life as they provide oxygen, food, shelter, fuelwood	100			
3	Home to prayers who lives in caves/***menagn***/	62	38		
4	Critical sources of water	96	4		
5	Source of seed	65	20	15	
6	Source of food-plants for food security e.g. vegetables and fruits	75	10	5	
7	We can get medicinal plants for health care	87	13		
9	It provides recreational grounds	90	10		
10	Raw materials for wood based construction (wood, timber)	94	6		
11	Collecting fuel wood for energy	100			
12	Creation of job opportunity in Nursery	65		35	
13	Revenue from Tourism - Contribution of forests to National income	70	20	10	
14	Source of NTFP (gum, incense, Honey etc.)	67	15	18	
15	Protective role (Soil erosion, wind break, violent flood)	94	6		

In case of LGSF, major socio economic roles of state forest for the local community is shown below.

Table 14. Socio economic roles of state forest

NS	Socio economic roles of State Forest	Strongly agree	Agree	Disagree	Strongly disagree
1	Important for the survival of all living things	86	14		
2	Vital for life as they provide oxygen, food, shelter, fuelwood	100			
3	Source of seed	45	30	25	
4	It provides recreational grounds	88	12		
5	Raw materials for wood based construction (wood, timber)	77	15	8	
6	Collecting fuel wood for energy	84	10	6	
7	Creation of job opportunity as tourist guides and guards	90	10		
8	Revenue from Tourism	65	35		
9	Protective role (Soil erosion, wind break, violent flood)	88	12		

Concerning spiritual values of church forest, the FGD undertaken with religious leaders of DLM indicated that communities living in and around DLM are highly commited to conserving forests. This is similar to finding of Menbere (2011). Such commitment came from theological and biblical thoughts that churches were holy places and houses of God, where cutting of trees is considered an immoral deed.

Many visitors and church communities get spiritual healing because of the presence of Holy waterthat is believed to cure from illness. Additionally smoke and dust of ***'tegbar bet'***is believed to cure the sin of human being. To get emotional feeling and vital energy, these church forests were considered best place. Burial services that serves not only people of the surrounding but from different parts of the country, as religiously people believe that if their dead body is buried in this monastery they will get salivation. The beauty of the forest/ landscape, species in the forest and waterfalls provide invaluable social benefit to many people. The sector is also crucial for educational purpose, as it attracts local students and University researchers to conduct their forestry research around this area.

Incase of LGSF,the forest helps as home to wild life like Chilada baboon, wolf, antelope, and hyena. The presence of Portuguese Bridge and beautiful landscape located below forest attracts both domestic and international tourists.

Figure 20. Portuguese Bridge located at the foot of Laga Gur Forest

5.12. Conservation and management of the forest

The conservation and management of DLMCF is a tripartite venture: the conservation efforts of local communities, religious institutions (churches and monasteries), and governmental institutions. Moreover, presence of indigenous (sacred grove) conservation methods have been (***"gizit"***) helped to conserve and manage the forest. The integration of the conservation methods and the integration of the relevant stakeholders are crucial for conserving the biodiversity.

In case of LGSF, the forest is protected under Salale University. During data collection it was observed that currently the forest was under problems like cutting (even natural forest), grazing by livestock and interference by man that causes wild life to disappear from the area. More over guards that were hired to protect the forest were not protecting it.

A. Role of local communities

From FGD, it is identified that in case of DLMCF, local communities with the help of Monastery protect the forest from cutting and exploiting it. Local communities consider forest as cloth (blanket) of monastery and helps as beauty for church. So cutting trees is not allowed (***"gizit"***) rather than branches of selected trees for fuel wood and construction purpose.

Additionally, local people participate in reforesting by planting trees that help to replace old trees that fell down. The maintenance of the sacred groves in the study area is attributed to the strong religious belief and respect of the followers to the church, which is considered the house of God. Cutting trees from the sacred groves is taboo and it is considered as denying the presence of God unless it is for the special purpose of the church. If a person cuts trees from the sacred sites, the followers of the church inform the case to the religious fathers, forest guards (*Kantiba*) and the doer is condemned. The followers of the church actively participate in the religious, conservation (e.g., tree planting in church/monastery yards) and development activities of the churches and monasteries. The majority of the Ethiopian people have respect and trust for the EOTCand it is this spirit that supported the church to maintain forest resources until this generation as Orthodox Christians fear ***'gizit'***, they do not dare cut trees in church forests (Alemayehu, 2020).

B. Role of religious institutions (churches and monasteries) in forest conservation

Although the main role of the churches and monasteries is to give religious service to the followers of the church, they are also involved in protecting the sacred groves, planting trees in church/monastery yards, and giving advice to the followers about the importance of conserving the sacred groves. The EOTC has a long history of conserving sacred groves, i.e. patches of natural vegetation conserved on sacred sites.

The EOTC has over 30 million followers, 400,000 clergies and 35,000 churches in Ethiopia (Alemneh, 2020). Churches and monasteries have played a great role in the conservation of sacred groves in particular and forest resources of the country in general.

In case of DLMCF there is religious structure that takes care of church forest from danger. Information obtained from *Aba G/Medhin Kasahun* (Reource Contoliing Team Chair person)፡Monastery Administrator arranges meeting on agenda like forest protection, monastery security issues, and Religious services with 12 members (which are considered as Parlama). *Ri'isa Abaw* discusses on issues raised during meeting and they will give additional comments and suggestions related to monasteries services and resource. The Monasteries Resource Controlling team (*nibrat kutitir**)*** is highly responsible in protecting forest resource. See figure 23. They have 3 members (Team Leader, Seretary and Cashier). Without their permission, a single tree will not cut for any purposes. The so-called*Kantiba*controls the security and protection of church surrounding and its forest by dividing the whole area into

2.Two of Kantiba's are responsible to area from Amanuel Church toWusha Gedel town while others responsibility is from *Set debir* to *Tagbar Bet*. Under these *Kantiba* there are around 18 Forest Guards who daily keep forest and church community from danger.

Figure 21. Interview held with religious leaders (Aba G/Medhin Kasahun)

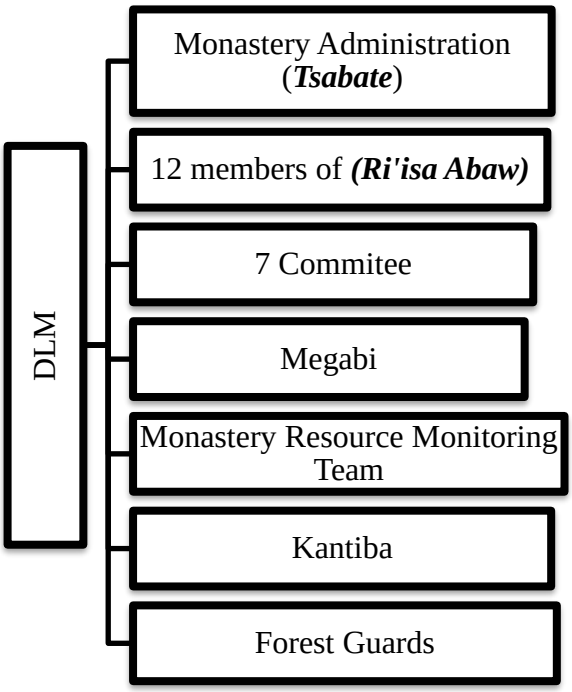

Figure 22. Religious structure of DLM

C. Role of governmental institutions

In case of LGSF, Salale University employed 6 guards to protect the forest from human and livestock interference. Girar Jarso woreda hired 4 guards to protect the forest which is located beside Lag Gur river. The guards are trying to protect forest nearby that was planted recently, but Laga Gur forest is currently not under protection and one can see cutting of trees and livestock interference (free grazing).

5.13. Threats to the forest

The major threats to DLMC forest is cattle interference, which damages seedlings by browsing and trampling, while in case of LGSF the damage exceeds because there is cutting of trees like *Juniperus procera* and *Eucalyptus globulus*, grazing and felling of tree stands. See figure 25 below.

Figure 23.Different damages (livestock interference, tree cutting, etc.) in LGSF

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6. CONCLUSIONS AND RECOMMENDATIONS

DLMCF and LGSF possesses high plant diversity 3.15 and 2.84 respectively, which is attributed to habitat heterogeneity as well as conservation efforts. The high diversity is attributed to habitat diversity and low human disturbances (as strict conservation and ***"gizit"*** withsloppy terrain limits human exploitation and livestock grazing/browsing) in the case of DLMCF. Evenness of respective forests which is 0.82 and 0.84 indicates that there is more or less balanced distribution of individuals among the different species. The diversity value implies the need to conserve the forest from floristic diversity perspective.

As revealed by their Basal area *Olea europaea, Ficus sycomorus, Grevillea robusta*), *Podocarpus falcatus*, *Ficus sur*, *Juniperus procera*, *Cordia Africana* and *Croton macrostachyus* (DLMCF) and *Aloe debrana, Aloe macrocarpa and Acacia abyssinica* in (LGSF)have greater basal area that indicated greater volume of these species and their ecological preference.

Olea europaea, Eucalyptus globulus, Juniperus procera and *Carissa spinarum in DLMCF and Acacia abyssinica, Dodonaea angustifolia, Rumex nervosus and Doviyalis abyssinica* in LGSF have greater IVI values which means these species are ecologically the most important species in the forest, while Woody species having low IVI values (such as *Hagenia abyssinica* and *Acacia melanoxylon*) need high priority for conservation.

The DBH class distributions indicated that most woody species have good regeneration potential, but some are in poor regeneration status.

The local communities were highly dependent on the forest for fuel wood, construction material, charcoal, timber and farm implements, as well as food (edible fruits), medicines, fodder, and bee forage. The forest has been maintained to the present-day through the combined indigenous (sacred grove) and modern (protected area system) conservation methods. At present, especially LGSF is declining due to livestock grazing/browsing, deliberate tree cutting for various purposes, farmland expansion, road construction and exotic species (Eucalyptus plantations) nearby the natural forest. Therefore, effective conservation and management interventions are urgently needed to ensure the long-term maintenance of the forest ecosystem, and benefit the local communities and monastery through sustainable utilization of the forest.

Therefore, in order to ensure the long-term maintenance of the forest, the following recommendations are forwarded:

- ✓ Employ in situ and ex situ conservation methods for the conservation of woody species having low IVI values and poor regeneration status
- ✓ Develop appropriate forest management plan to enhance the conservation,
- ✓ strengthen the role of churches and monasteries in forest conservation and protection, development and sustainable utilization of the forest;
- ✓ Promote tree planting (reforestation, afforestation, agroforestry) in the area with emphasis on multipurpose indigenous and suitable exotic tree species to reduce the pressure on the natural forest,
- ✓ Provide the local communities with alternative sources of energy (solar, biogas) and locally-made energy-saving stoves (*mirt*, *gonzie*, *tikikil*, *lakech*) to reduce the dependency on the forest for fuel wood and charcoal;
- ✓ Promote agricultural and forestry extension services in the area and Carry out further research on the forest.

LGSF may shrink in the near future unless appropriate and immediate measures are taken. The loss of the forest will lead to loss of biodiversity, particularly the endemic plant species. This calls for strengthening the conservation and management of the forest, as it harbors high number of plant species including endemics, and is a refuge for different plants and animals that are endemic to the country like Chilada Baboon. A proper forest management plan should be developed and implemented to reverse or at least stabilize the present trend in the forest

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8. APPENDICES

Appendix 1.List of families and genera (DLMCF)

Table 15. Families and genera list in DLMCF

List of families				List of genera			
NS	**Family**	**No of spp**	**Percentage**	**NS**	**Genera**	**Number**	**Percentage**
1	Fabaceae	7	10.00	1	Aloe	2	2.86
2	Euphorbiaceae	5	7.14	2	Cupressus	2	2.86
3	Myrtaceae	4	5.71	3	Eucalyptus	2	2.86
4	Oleaceae	4	5.71	4	Euphorbia	2	2.86
5	Anacardiaceae	3	4.29	5	Ficus	2	2.86
6	Celastraceae	3	4.29	6	Maytenus	2	2.86
7	Cupressaceae	3	4.29	7	Olea	2	2.86
8	Aloaceae	2	2.86	8	Rhus	2	2.86
9	Arecaceae	2	2.86	9	Acacia	1	1.43
10	Ebenaceae	2	2.86	10	Arundo	1	1.43
11	Moraceae	2	2.86	11	Asparagus	1	1.43
12	Rosaceae	4	5.71	12	Aurucaria	1	1.43
13	Rutaceae	2	2.86	13	Barsema	1	1.43
14	Acanthaceae	1	1.43	14	Borassus	1	1.43
15	Apocynaceae	1	1.43	15	Buddleia	1	1.43
16	Asparagaceae	1	1.43	16	Calistemone	1	1.43
17	Asteraceae	1	1.43	17	Calpurnia	1	1.43
18	Aurucariaceae	1	1.43	18	Capparis	1	1.43
19	Boraginaceae	1	1.43	19	Carissa	1	1.43
20	Buddelejiaceae	1	1.43	20	Casimiroa	1	1.43
21	Capparidaceae	1	1.43	21	Casuarina	1	1.43
22	Casuarinaceae	1	1.43	22	Catha	1	1.43
23	Flacourtiaceae	1	1.43	23	Celtis	1	1.43
24	Lamiaceae	1	1.43	24	Cesalpina	1	1.43
25	Lauraceae	1	1.43	25	Citrus	1	1.43
26	Loganiaceae	1	1.43	26	Clutia	1	1.43
27	Meliaceae	1	1.43	27	Cordia	1	1.43
28	Melianthaceae	1	1.43	28	Croton	1	1.43
29	Phytolaccaceae	1	1.43	29	Diospyrus	1	1.43
30	Piperaceae	1	1.43	30	Doviyalis	1	1.43
31	Poaceae	1	1.43	31	Euclea	1	1.43
32	Podocarpaceae	1	1.43	32	Grevillea	1	1.43
33	Polygonaceae	1	1.43	33	Grewia	1	1.43
34	Proteaceae	1	1.43	34	Hagenia	1	1.43
35	Rhamnaceae	1	1.43	35	Jacaranda	1	1.43
36	Salicaceae	1	1.43	36	Jasminum	1	1.43

NS	Family	No of spp	Percentage
37	Santalaceae	1	1.43
38	Solanaceae	1	1.43
39	Tiliaceae	1	1.43
40	Ulmaceae	1	1.43
	Total	**70**	**100**

NS	Genera	Number	Percentage
37	Juniperus	1	1.43
38	Justicia	1	1.43
39	Leonotis	1	1.43
40	Ligustrum	1	1.43
41	Melia	1	1.43
42	Milletia	1	1.43
43	Nuxia	1	1.43
44	Ocyris	1	1.43
45	Opuntia	1	1.43
46	Persea	1	1.43
47	Phoenix	1	1.43
48	Phytolecca	1	1.43
49	Podocarpus	1	1.43
50	Prunus	1	1.43
51	Psidium	1	1.43
52	Pterolobium	1	1.43
53	Rhamnus	1	1.43
54	Ricinus	1	1.43
55	Rosa	1	1.43
56	Rumex	1	1.43
57	Salix	1	1.43
58	Senna	1	1.43
59	Sesbania	1	1.43
60	Shinus	1	1.43
61	Solanum	1	1.43
62	Vernonia	1	1.43
	Total	**70**	**100**

Appendix 2.List of families and genera (LGSF)

Table 16.LG State Forest families and genera

NS	Family	Number	Percentage
1	Fabaceae	3	10.71
2	Euphorbiaceae	3	10.71
3	Myrtaceae	3	10.71
4	Aloaceae	2	7.14
5	Celastraceae	2	7.14
6	Rosaceae	2	7.14
7	Anacardiaceae	1	3.57
8	Oleaceae	1	3.57
9	Apocynaceae	1	3.57
10	Asparagaceae	1	3.57
11	Buddelejiaceae	1	3.57
12	Cupressaceae	1	3.57
13	Ebenaceae	1	3.57
14	Flacourtiaceae	1	3.57
15	Loganiaceae	1	3.57
16	Polygonaceae	1	3.57
17	Salicaceae	1	3.57
18	Santalaceae	1	3.57
19	Sapindaceae	1	3.57
	Total	**28**	**100**

NS	Genera	Number	Percentage
1	Acacia	3	10.71
2	Eucalyptus	2	7.14
3	Aloe	2	7.14
4	Maytenus	2	7.14
5	Rosa	1	3.57
6	Doviyalis	1	3.57
7	Juniperus	1	3.57
8	Clutia	1	3.57
9	Olea	1	3.57
10	Asparagus	1	3.57
11	Buddleia	1	3.57
12	Carissa	1	3.57
13	Croton	1	3.57
14	Dodonaea	1	3.57
15	Euclea	1	3.57
16	Euphorbia	1	3.57
17	Nuxia	1	3.57
18	Osyris	1	3.57
19	Psidium	1	3.57
20	Rhus	1	3.57
21	Rumex	1	3.57
22	Salix	1	3.57
23	Prunus	1	3.57
	Total	**28**	**100**

Appendix 3.Frequency, Density, Relative Basal area and IVI of DLMCF

Table 17.IVI of DLMCF

NS	Species Name	F	BA	D	RBA	RD	RF	IVI	Rank
1	*Olea europaea subsp. cuspidata*	41.5	6.31	16.95	5.14	2.64	7.74	15.51	1
2	*Eucalyptus globulus*	34	1.31	29.94	1.07	4.66	6.34	12.06	2
3	*Juniperus procera*	37.7	4.72	7.1	3.84	1.10	7.03	11.98	3
4	*Carissa spinarum*	41.5	0.63	21.91	0.51	3.41	7.74	11.66	4
5	*Acacia abyssinica*	34	3.07	4.28	2.50	0.67	6.34	9.50	5
6	*Arundo donax*	1.9	1.1	50	0.90	7.77	0.35	9.02	6
7	*Euphorbia candelabrum*	1.9	3.78	30	3.08	4.66	0.35	8.10	7
8	*Pterolobium stellatum*	24.5	0.51	19	0.42	2.95	4.57	7.94	8
9	*Opuntia ficus-indica*	26.4	1.6	9.57	1.30	1.49	4.92	7.71	9
10	*Eucalyptus camaldulensis*	15.1	2.96	11.38	2.41	1.77	2.82	7.00	10
11	*Grevillea robusta*	7.5	5.72	4.25	4.66	0.66	1.40	6.72	11
12	*Calpurnia aurea*	24.5	0.25	12.15	0.20	1.89	4.57	6.66	12
13	*Croton macrostachyus*	11.3	4.7	2.33	3.83	0.36	2.11	6.30	13
14	*Maytenus arbutifolia*	22.6	0.62	9.33	0.50	1.45	4.21	6.17	14
15	*Euphorbia abyssinica*	15.1	1.02	15.13	0.83	2.35	2.82	6.00	15
16	*Cordia africana*	7.5	4.7	4	3.83	0.62	1.40	5.85	16
17	*Rhamnus prinoides*	3.8	0.8	27.5	0.65	4.28	0.71	5.64	17
18	*Phoenix reclinata*	1.9	2.87	18	2.34	2.80	0.35	5.49	18
19	*Euclea divinorum*	18.9	0.07	11.2	0.06	1.74	3.52	5.32	19
20	*Justicia schimperiana*	15.1	0.13	14.88	0.11	2.31	2.82	5.23	20
21	*Ficus sycomorus*	1.9	5.72	1	4.66	0.16	0.35	5.17	21
22	*Doviyalis abyssinica*	1.9	3.44	12	2.80	1.87	0.35	5.02	22
23	*Diospyrus mespiliformis*	1.9	3.22	12	2.62	1.87	0.35	4.84	23
24	*Ligustrum cafira*	5.7	0.04	23.67	0.03	3.68	1.06	4.78	24
25	*Senna siamea*	5.7	0.42	21.67	0.34	3.37	1.06	4.77	25
26	*Podocarpus falcatus*	1.9	5.03	2	4.10	0.31	0.35	4.76	26
27	*Ficus sur*	1.9	4.77	2	3.88	0.31	0.35	4.55	27
28	*Psidium guajava*	3.8	1.43	17	1.16	2.64	0.71	4.52	28
29	*Borassus aethiopium*	3.8	3.78	3	3.08	0.47	0.71	4.25	29
30	*Persea Americana*	1.9	4.38	2	3.57	0.31	0.35	4.23	30
31	*Grewia villosa*	1.9	1.43	15	1.16	2.33	0.35	3.85	31
32	*Vernonia amygdalina*	1.9	3.78	1	3.08	0.16	0.35	3.59	32
33	*Casimiroa edulis*	3.8	3.22	1.5	2.62	0.23	0.71	3.56	34
34	*Rumex nervosus*	7.5	0.06	13.5	0.05	2.10	1.40	3.55	33
35	*Casuarina equisetifolia*	5.7	2.21	3.33	1.80	0.52	1.06	3.38	35
36	*Clutia abyssinica*	7.5	0.68	8.75	0.55	1.36	1.40	3.31	37
37	*Prunus africana*	7.5	0.39	10.25	0.32	1.59	1.40	3.31	36

NS	Species Name	F	BA	D	RBA	RD	RF	IVI	Rank
38	*Solanum species*	1.9	2.42	6	1.97	0.93	0.35	3.26	38
39	*Jacaranda memosifolia*	1.9	1.2	12	0.98	1.87	0.35	3.20	39
40	*Nuxia congesta*	1.9	1.81	8	1.47	1.24	0.35	3.07	40
41	*Cesalpina species*	1.9	1.22	10	0.99	1.55	0.35	2.90	41
42	*Salix mucronata*	3.8	0.2	13	0.16	2.02	0.71	2.89	42
43	*Olea capensis*	1.9	2.71	2	2.21	0.31	0.35	2.87	43
44	*Rhus retinorrhoea*	7.5	0.45	6.75	0.37	1.05	1.40	2.81	44
45	*Ricinus communis*	5.7	1.54	2.33	1.25	0.36	1.06	2.68	45
46	*Phytolecca deodecandra*	1.9	0.8	10	0.65	1.55	0.35	2.56	47
47	*Shinus mole*	1.9	1.16	8	0.94	1.24	0.35	2.54	48
48	*Rosa xrichardii*	1.9	1.1	8	0.90	1.24	0.35	2.49	49
49	*Catha edulis*	1.9	1.43	6	1.16	0.93	0.35	2.45	50
50	*Celtis africana*	1.9	1.43	6	1.16	0.93	0.35	2.45	50
51	*Melia azedarach*	1.9	1.43	4	1.16	0.62	0.35	2.14	52
52	*Aurucaria aurucariana*	1.9	1.22	5	0.99	0.78	0.35	2.13	53
53	*Asparagus seatacesus*	3.8	0.04	8.5	0.03	1.32	0.71	2.06	54
54	*Cupressus pyramidalis*	1.9	1.43	3	1.16	0.47	0.35	1.99	55
55	*Calistemone citrinus*	1.9	1.1	4	0.90	0.62	0.35	1.87	57
56	*Capparis tomentosa*	1.9	0.49	7	0.40	1.09	0.35	1.84	58
57	*Aloe macrocarpa*	1.9	1.43	2	1.16	0.31	0.35	1.83	55
58	*Barsema abyssinica*	1.9	1.6	1	1.30	0.16	0.35	1.81	59
59	*Aloe debrana*	1.9	1.16	3	0.94	0.47	0.35	1.77	62
60	*Cupressus lusitanica*	1.9	1.43	1	1.16	0.16	0.35	1.67	60
61	*Sesbania sesbun*	1.9	0.8	4	0.65	0.62	0.35	1.63	61
62	***Jasminum grandiflorum***	1.9	0.56	5	0.46	0.78	0.35	1.59	63
63	*Buddleia polystachya*	5.7	0.06	2.33	0.05	0.36	1.06	1.47	64
64	*Leonotis ocymifolia*	1.9	0.03	7	0.02	1.09	0.35	1.47	65
65	***Milletia ferruginea***	1.9	0.75	3	0.61	0.47	0.35	1.43	66
66	*Ocyris quadripartite*	5.7	0.07	1.67	0.06	0.26	1.06	1.38	67
67	*Maytenus undata*	1.9	0.09	5	0.07	0.78	0.35	1.20	68
68	*Rhus vulgaris*	1.9	0.23	4	0.19	0.62	0.35	1.16	69
69	*Citrus aurantifolia*	1.9	0.13	4	0.11	0.62	0.35	1.08	70
70	*Hagenia abyssinica*	1.9	0.39	2	0.32	0.31	0.35	0.98	71
		536.4	**122.78**	**643.15**	**100**	**100**	**100**	**300**	

Appendix 4.Frequency, Density, Relative Basal area and IVI of LGSF

Table 18.BA and IVI of LGSF

NS	Spp Name	BA	RBA	D	RD	F	RF	IVI
1	*Olea europaea subsp. cuspidata*	43.26	29.60	5	2.12	5	0.92	32.64
2	*Juniperus procera*	11.78	8.06	7.46	3.17	65	11.93	23.16
3	*Carissa spinarum (C. edulis)*	2.83	1.94	10.59	4.50	85	15.60	22.03
4	***Aloe debrana***	19.87	13.60	10.67	4.53	15	2.75	20.88
5	*Acacia abyssinica*	8.02	5.49	7.75	3.29	60	11.01	19.79
6	*Dodonaea angustifolia*	5.09	3.48	20.5	8.71	20	3.67	15.86
7	*Aloe macrocarpa*	8.11	5.55	8.75	3.72	20	3.67	12.94
8	*Eucalyptus camaldulensis*	2.85	1.95	15.5	6.59	20	3.67	12.21
9	*Rosa abyssinica*	5.23	3.58	6.17	2.62	30	5.50	11.70
10	*Rumex nervosus vahl*	2.08	1.42	15	6.37	20	3.67	11.47
11	*Croton macrostachyus*	10.82	7.40	2	0.85	10	1.83	10.09
12	*Eucalyptus globulus*	2.3	1.57	12.33	5.24	15	2.75	9.56
13	*Maytenus arbutifolia*	0.72	0.49	6.33	2.69	30	5.50	8.69
14	*Maytenus undata*	1.2	0.82	7	2.97	25	4.59	8.38
15	*Osyris quadripartita Decn*	1.2	0.82	15	6.37	5	0.92	8.11
16	*Psidium guajava*	0.97	0.66	15	6.37	5	0.92	7.95
17	*Doviyalis abyssinica*	3.08	2.11	10	4.25	5	0.92	7.27
18	*Euphorbia abyssinica*	1.17	0.80	5.75	2.44	20	3.67	6.91
19	*Euclea divinorum*	0.75	0.51	5.25	2.23	20	3.67	6.41
20	*Salix mucronata*	1.45	0.99	5.33	2.26	15	2.75	6.01
21	*Nuxia congesta*	0.59	0.40	10	4.25	5	0.92	5.57
22	*Acacia melanoxylon*	5.3	3.63	2	0.85	5	0.92	5.39
23	*Clutia abyssinica*	2.27	1.55	4.5	1.91	10	1.83	5.30
24	*Rhus vulgaris*	0.82	0.56	6	2.55	10	1.83	4.95
25	*Prunus africana*	1.08	0.74	5.5	2.34	10	1.83	4.91
26	*Buddleia polystachya*	2.7	1.85	5	2.12	5	0.92	4.89
27	*Acacia decurrens*	0.3	0.21	8	3.40	5	0.92	4.52
28	*Asparagus seatacesus*	0.3	0.21	3	1.27	5	0.92	2.40
		146.14	**100**	**235.38**	**100**	**545**	**100**	**300**

D- Density, F- Frequency, BA- Basal area, RBA- Relative Basal area, RD- Relative density, RF- Relative frequency, IVI- Importance value Index

Appendix 5.List of plant species collected from the study area

Table 19. List of plant species collected from both study areas

SN	Species	Family	Habit	Local name
1	*Acacia abyssinica Hochst. e*x Benth	Fabaceaeae	T	Girar/ laaftoo
2	*Acacia decurrens* Willd	Fabaceae	T	Shafare
3	*Acacia melanoxylon* R.Br	Fabaceae	T	Omedla
4	***Aloe debrana* Christian**	Aloeaceae	S	Eret/ argiisa
5	*Aloe macrocarpa* Tod	Aloeaceae	S	Eret/ argiisa
6	*Arundo donax* L	Poaceae	T	Shambooqqoo
7	*Asparagus seatacesus* (Kunth) Jessop	Asparagaceae	S	Sariitii
8	*Aurucaria aurucariana*	Aurucariaceae	T	
9	*Barsema abyssinica* Fresen	Melianthaceae	T	Azamir/ Lolchiisa
10	*Borassus aethiopium* Mart	Arecaceae	T	Zambaabaa
11	*Buddleia polystachya* Fresen	Loganiaceae	T	Anfar Adaaddii
12	*Calistemone citrinus (Curtis) Skeels*	Myrtaceae	S	Bottle brush
13	*Calpurnia aurea* (Ait) Benth	Fabaceae	S	Ceekaa
14	*Capparis tomentosa* Lam	Capparidaceae	S	Gumarroo
15	*Carissa spinarum* (C. Edulis) L.	Apocynaceae	T	Agam/ Agamsa
16	*Casimiroa edulis* La Llave	Rutaceae	T	Kazmir/ Kuukoo
17	*Casuarina equisetifolia* L	Casuarinaceae	T	Shawshawwee
18	*Catha edulis* (Vahl) Forssk	Celastraceae	S	Chat/ Caatii
19	*Celtis Africana* Burm. f	Ulmaceae	T	Qawut
20	*Cesalpina species*	Fabaceae	S	Harangamaa diimaa
21	*Citrus aurantifolia* (Christm)	Rutaceae	T	Loomii
22	*Clutia abyssinica* Jaub and Spach	Euphorbiaceae	S	Fiyala faj
23	*Cordia africana* Lam	Boraginaceae	T	Wanza/ Waddeessa
24	*Croton macrostachyus* Del	Euphorbiaceae	T	Bisana/ Bakkanniisa
25	*Cupressus lusitanica* Mill	Cupressaceae	T	Gaattiraa faranjii

SN	Species	Family	Habit	Local name
26	*Cupressus sempervirens* L	Cupressaceae	T	Gaattiraa
27	*Diospyrus mespiliformis* Hochst.	Ebenaceae	S	Ayay/ African ebony
28	*Dodonaea angustifolia* L.f	Sapindaceae	T	Kitkittaa
29	*Doviyalis abyssinica* (A.Rich) Warb	Flacourtaceae	S	Koshommii/Kuraawaa
30	*Eucalyptus camaldulensis* Dehn	Myrtaceae	T	Baargamoo diimaa
31	*Eucalyptus globules* Labill	Myrtaceae	T	Baargamoo adii
32	*Euclea divinorum* Hiern	Ebenaceae	S	Didihoo
33	*Euphorbia abyssinica* Gmel	Euphorbiaceae	T	Adaamii
34	*Euphorbia candelabrum* Kotschy	Euphorbiaceae	T	Adaamii Oromoo
35	*Ficus sur* Forssk	Moraceae	T	Shoolaa/ Harbuu
36	*Ficus sycomorus* L.	Moraceae	T	Waarkaa/ Odaa
37	*Grevillea robusta* R.Br	Proteaceae	T	Giraaviiliyaa
38	*Grewia villosa* Willd	Tiliaceae	S	Lanqowaata/ Ogomdi
39	*Hagenia abyssinica* (Brace) J.F. Gmel	Rosaceae	T	Koosoo/ Heexoo
40	*Jacaranda mimosifolia* D.Don	Bignoniaceae	T	Yetemenja zaf
41	***Jasminum grandiflorum L***	Oleaceae	S	Tembelel
42	*Juniperus procera* Hochst. Ex Endl	Cupressaceaea	T	Yehabesha tsid
43	*Justicia schimperiana* Hochst. Ex Nees	Acanthaceae	S	Sensel/ dhummuugaa
44	*Leonotis ocymifolia* (Burm. F.)	Lamiaceae	S	Bokkolluu
45	*Ligustrum cafira*	Oleaceae	S	Duranta
46	*Maytenus arbutifolia* A. Rich.) Wilczek	Celastraceae	S	Atat/ Kombolcha
47	*Maytenus undata* (Thunb.)	Celastraceae	S	Geram atat/ Kombolcha
48	*Melia azaderach* L	Meliaceae	T	Kiniin Neem tree
49	***Millettia ferruginea*** (Hochst.)Bak.	Fabaceae	T	Birbirraa/ Sootelluu
50	*Nuxia congesta* R.Br. Ex Fresen	Buddelejiaceae	S	አትኪር/ qawwisa
51	*Ocyris quadripartita* decn	Santalaceae	S	Waatoo
52	*Olea capensis* L. subsp. capensis	Oleaceae	S	Mirez

SN	Species	Family	Habit	Local name
53	*Olea europaea subsp. Cuspidate*	Oleaceae	T	Wayiraa/ ejersa
54	*Opuntia ficus-indica* L (Miller)	Euphorbiaceae	S	Adaamii
55	*Persea Americana*	Lauraceae	T	Avokaadoo
56	*Phoenix reclinata* Jacq	Arecaceae	T	Selen, zembaba, meexxii
57	*Phytolecca deodecandra* L 'Herit'	Phytolaccaceae	S	Indod/ andoodee
58	*Podocarpus falcatus* (Thunb.) R.B. ex. mirb	Podocarpaceae	T	Zigba/ birbirsa
59	*Prunus Africana* (Hook. F.) Kalkm		T	Tikur inchet
60	*Psidium guajava L.*	Myrtaceae	T	Zeituna
61	*Pterolobium stellatum* (Forssk.) Brenan	Fabaceae	S	Kentefa/ arangama diimaa
62	*Rhamnus prinoides* L 'Herit'	Rhamnaceae	T	Geeshoo
63	*Rhus retinorrhoea* Oliv	Anacardiaceae	T	Tilem/ xaddeessa
64	*Rhus vulgaris* Meikle	Anacardiaceae	S	Yeiragna kolo, Xaaxessa
65	*Ricinus communis* L. var communis	Euphorbiaceae	S	Guloo/ Qobboo
66	*Rosa abyssinica* Lindley	Rosaceae	S	Qaga/ goraa
67	*Rosa xrichardii* Rehd	Rosaceae	S	Tsiggeeradaa
68	*Rumex nervosus* vahl	Polygonaceae	S	Dhangaggoo
69	*Salix subserrata* Willd	Salicaceae	T	Akiyaa/ Alaltuu
70	*Senna siamea* (Lam)	Fabaceae	S	Yeferenj digita
71	*Sesbania sesbun* (Merr)	Fabaceae	T	Sasbaaniyaa
72	*Shinus molle*	Anacardiaceae	T	Qundoo barbaree
73	*Solanum marginatum* L.f	Solanaceae	S	Hiddii
74	*Vernonia amygdalina*	Asteraceae	T	Giraawwaa

Appendix 6. Different images related to thesis work


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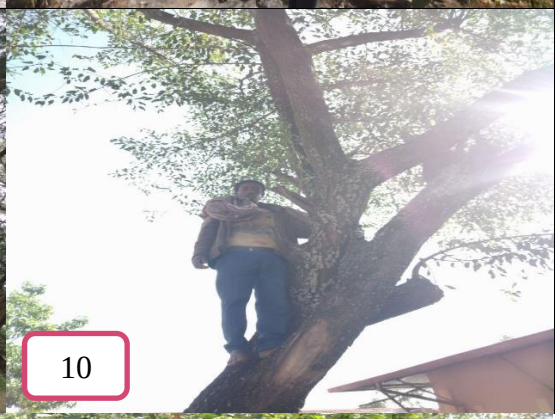
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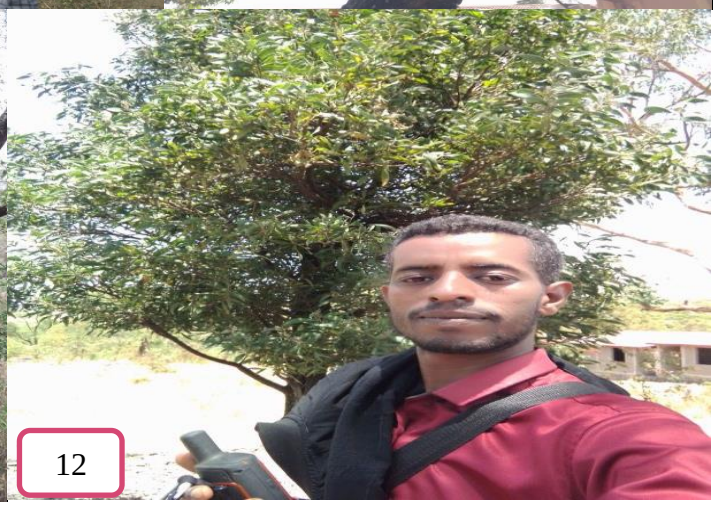
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Description of Images

1. Salale University Mini Herbarium
2. Dr Zewdie Kassa Tessema, showing the researcher how to collect and record plant specimen
3. Different volumes of Flora of Ethiopia and Eritrea used to identify plant specimen
4. Debre Libanos Monastery's landscape from different views
5. " " " " "
6. Portuguese Bridge at the foot of LGSF
7. Sahle Mariam (Excellentboy) participated during the whole plant specimen collection
8. Individuals who assisted the researcher during forest inventory and data collection
9. " " " " " " " "
10. " " " " " " " "
11. The researcher collecting data by Clinometer, Compass, GPS and meter (DLMCF)
12. " " " " " " " (LGSF)

13 - 16 FGD and KII held at both study areas

17 – Interview held with Guards at LGSF

18. Interview with religious leaders (Aba G/Medhin Kasahun