



SEEK WISDOM, ELEVATE YOUR INTELLECT AND SERVE HUMANITY!

Addis Ababa University  
አዲስ አበባ ዩኒቨርሲቲ



**COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES CENTER**

**FOR ENVIRONMENTAL SCIENCE**

**COMPOSITION AND STRUCTURE OF WOODY SPECIES OF LEGAY FOREST IN  
SEDEN SODO WOREDA, SOUTH WEST SHOA, ETHIOPIA**

**BY: ABDUDIN CHIBSA**

**A THESIS SUBMITTED TO CENTER FOR ENVIRONMENTAL SCIENCE PRESENT  
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF  
MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE**

**ADVISORS: Dr. GEMEDO DALLE**

**Dr. BIKILA WARKINEH**

**JULY, 2024**

**ADDIS ABABA, ETHIOPIA**

**COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES CENTER FOR ENVIRONMENTAL SCIENCE**

**COMPOSITION AND STRUCTURE OF WOODY SPECIES OF LEGAY FOREST IN SEDEN SODO WOREDA, SOUTH WEST SHOA, ETHIOPIA**

**BY: ABDUDIN CHIBSA**

**APPROVED BY THE EXAMINING BOARD:**

**EXTERNAL EXAMINER**

**SIGNATURE**

\_\_\_\_\_

\_\_\_\_\_

**INTERNAL EXAMINER**

\_\_\_\_\_

\_\_\_\_\_

**ADVISORS:**

**Dr. GEMEDO DALLE (PhD)**

\_\_\_\_\_

**Dr. BIKILA WARKINEH (PhD)**

\_\_\_\_\_

**JULY, 2024**

**ADDIS ABABA, ETHIOPIA**

## **DECLARATION**

I hereby declare that this thesis, entitled: Composition and structure of woody species of legay forest in seden sodo woreda, south west shoa, Oromia regional state, Ethiopia has been composed entirely by myself and has not been submitted for any other degree or qualification. The work complies with the regulations of the University and meets the accepted standards with respect to originality and quality and all sources of information have been specifically acknowledged.

Abdudin Chibsa: Signature \_\_\_\_\_ Date \_\_\_\_\_

## **ADVISORS:**

Dr. GEMEDO DALLE (PhD) \_\_\_\_\_

Dr. BIKILA WARKINEH (PhD) \_\_\_\_\_

## ABSTRACT

This study was conducted in Legay forest to determine the woody composition, structure and regeneration status of the Legay forest. Systematic sampling method was used to collect vegetation data from fifty-two plots of 20 m x 20 m for woody plant species, and 5 m × 5 m was used for sampling of seedlings and saplings plants. The sampling plots were placed at every 200 m intervals on flat and 50 m altitudinal difference on sloppy areas and the parallel transect lines laid at 500 m apart. Diameter at breast height (DBH) of all woody species was measured by using a meter tape. Data was analyzed using descriptive statistics and R software. A total of 57 woody species belonging to 54 genera and 46 families were identified. Fabaceae was the most dominant family represented by four species followed by Asteraceae, Lamiaceae, Myrtaceae, Oleaceae, and Rosaceae, which shared three species each. The main five plant communities identified from the study sites were *Olea europaea*-*Rytigynia neglecta*, *Rhus glutinosa* - *Rosa abyssinica*, *Dodonaea angustifolia* -*Quercus sp.*, *Maytenus undata*- *Carissa edulis* and *Polyscias fulva*- *Euclea divinorum*. The density for mature woody species, seedlings and saplings were 157, 475.8 and 310 individuals ha<sup>-1</sup>, respectively. The basal area of the forest was 69.22 m<sup>2</sup> ha<sup>-1</sup>. Plant species with greater IVI in Legay forest were *Carissa edulis*, *Rytigynia neglecta* and *Euclea divinorum*. The plant species that had lowest IVI and calling for conservation priority were, *Cupressus lusitanica*, *Dovyalis abyssinica*, *Solanum incanum*, *Asparagus acutifolias* and *Salvia officinalis*. The population structure of the forest indicated that the lower storey (57.25%) dominant than the middle (27.72%) and upper storey (15.02%). Regeneration status of the forest indicated that the total density of seedlings and saplings of woody plants species of the forest were 570.29 and 407.77 ha<sup>-1</sup>, respectively and that of mature individuals was 261.81 ha<sup>-1</sup>, indicating that mature plant species were selectively cut. To minimize negative effects on the forest and make sustainable use of it, this study suggests implementing community-based participatory forest management in the area.

**Keywords/phrases:** *Dry evergreen montane forest, floristic composition, Legay forest, plant community, regeneration, Vegetation structure*

## **ACKNOWLEDGEMENTS**

First and foremost, I am grateful to my Advisors Dr. Gemedo Dalle and Dr. Bikila Warkineh, for their valuable guidance, scholarly inputs and consistent encouragement. They are persons with an amicable and positive disposition, availing themselves to clarify my doubts, despite their busy schedules. This made my stay at the university smoother and easier. Thank you my advisors for all your help and support.

My special thanks also go to Dr. Ahmed Hussein, for his positive responses, coordination during my study and for making my stay in the department smooth.

Finally, I owe a debt of gratitude to the local people who generously provided me their time and shared the necessary information and guide in showing the direction during the data collection.

Last but not least, special thanks to my family and friends for their support and encouragement throughout the study period.

## Table of Contents

DECLARATION .....	ii
ABSTRACT .....	iii
ACKNOWLEDGEMENTS.....	iv
LIST OF TABLES.....	viii
LIST OF FIGURES .....	ix
LIST OF PLATES .....	x
LIST OF ACRONYMS .....	xi
1. INTRODUCTION.....	1
1.1. Background of the study .....	1
1.2. Statement of the problem .....	3
1.3. Objective of the study .....	4
1.3.1. General objective .....	4
1.3.2. Specific objectives .....	4
1.4. Research questions .....	4
1.5. Significance of the Study .....	5
2. LITERATURE REVIEW .....	6
2.1. Forest and biodiversity .....	6
2.2. Vegetation of Ethiopia .....	6
2.3. The vegetation type of Ethiopia .....	7
2.3.1. Dry evergreen montane forest vegetation .....	7
2.4. Threats on biodiversity in Ethiopia.....	8
2.5. The role of forest resources of Ethiopia.....	9
2.6. Regeneration of Woody Species .....	9
2.7. The Plant Community .....	10
2.8. Natural forest conservation and utilizations in Ethiopia.....	10
2.9. Species diversity, evenness and richness .....	11
3. MATERIALS AND METHODS .....	12
3.1. Description of the study area .....	12
3.1.1. Climate.....	12
3.1.2. Topography.....	13
3.1.3. Land use.....	13
3.1.4. Vegetation.....	13
3.2. Data collection .....	14

3.2.1.	Reconnaissance Survey .....	14
3.2.2.	Sampling technique .....	14
3.3.	Data collection methods.....	14
3.3.1.	Floristic data collection.....	14
3.3.2.	Structural data collection .....	15
3.4.	Data analysis .....	15
3.4.1.	Structural data analysis .....	15
3.4.2.	Plant community analysis .....	17
3.4.3.	Diversity analysis.....	17
3.5.	Regeneration of woody species in the Forest.....	18
3.6.	Ecological disturbances of the forest .....	19
4.	RESULTS AND DISCUSSION.....	20
4.1.	Floristic composition.....	20
4.2.	Vegetation community classification.....	21
4.3.	Distribution of community types in the Legay forest .....	23
4.3.1.	<i>Olea europaea</i> - <i>Rytigynia neglecta</i> community .....	23
4.3.2.	<i>Rhus glotinosa</i> - <i>Rosa abyssinica</i> community .....	23
4.3.3.	<i>Dodenea agustifolia</i> - <i>Quercus sp.</i> Community .....	23
4.3.4.	<i>Maytenus Undata</i> - <i>Carissa edulis</i> community .....	24
4.3.5.	<i>Polyscias fulva</i> - <i>Euclea divinorum</i> community.....	24
4.4.	Species richness, evenness and diversity of the five plant community types .....	27
4.5.	Vegetation structure analysis .....	28
4.5.1.	Frequency .....	28
4.5.2.	Tree density .....	31
4.5.3.	Diameter at breast height (DBH).....	34
4.5.4.	Height distribution of woody plant species in Legay forest .....	36
4.5.5.	Basal area and dominance .....	37
4.5.6.	Important value index (IVI).....	39
4.5.7.	Vertical structure of the forest .....	42
4.6.	Regeneration status of Legay forest.....	43
4.6.1.	Regeneration patterns of some selected woody plant species in Legay forest.....	46
4.7.	Phytogeographical Comparison with similar forests .....	47
4.8.	Some indicators of forest disturbances in Legay forest .....	51
5.	CONCLUSIONS AND RECOMMENDATIONS.....	53

5.1. Conclusions.....	53
5.2. Recommendations.....	54
6. REFERENCES .....	55
APPENDICES .....	65

## LIST OF TABLES

Table 1. The most dominant families and plant species in Legay forest.....	21
Table 2. Indicator values of each species for each community with their P-value. ....	25
Table 3. Shannon-Weiner Diversity Index ( $H'$ ) and evenness ( $J$ ) for the five community types of Legay forest .....	28
Table 4. List of most frequent trees and shrubs in Legay forest.....	29
Table 5. Density of individual tree and shrub species with DBH < 10 cm, between $\geq 10$ and $\leq 20$ cm, and > 20 cm and their percentage coverage in the Legay forest.....	32
Table 6. Comparison of tree/shrub densities with DBH between 10 and 20 cm and > 20 cm of Legay with other fifteen (15) forests in Ethiopia.....	33
Table 7. Distribution of DBH classes, density $ha^{-1}$ and percentage of tree and shrub species in Legay .....	34
Table 8. Basal area and relative basal area of top ten plant species in Legay forest.....	38
Table 9. Comparison of the basal area of Legay forest with basal areas of other forests in Ethiopia in $m^2 ha^{-1}$ .....	39
Table 10. The IVI for all species of the forest with their corresponding relative frequency, relative density and relative dominance in Legay forest .....	40
Table 11. Density, number of individual plants and percentage of Legay forest Storeys .....	42
Table 12. Sorensen's coefficient of plant species between Legay and other six montane forests of Ethiopia. ....	50

## LIST OF FIGURES

Figure 1. Map of the study area .....	12
Figure 2. Growth forms and number of plants species in Legay forest.....	20
Figure 3. Dendrogram of hierarchical clustering using similarity ratio showing five community types of the Legay forest (Ward’s method, similarity ratio). .....	22
Figure 4. Frequency distribution of woody species in Legay forest.....	31
Figure 5. Distribution of DBH (cm) class and density of woody plant species .....	35
Figure 6. Percentage distribution of height classes of woody plant species.....	36
Figure 7. Percentage distribution of trees and shrubs in the three storey in Legay forest. ....	43
Figure 8. Density ha <sup>-1</sup> of seedlings, saplings and mature trees of Legay forest .....	44
Figure 9. Mature individuals, seedling and sapling distribution of woody species.....	44
Figure 10. Percentage distribution of seedlings and saplings of woody plant species .....	45
Figure 11. Regeneration patterns of some selected woody plant species.....	47

## LIST OF PLATES

Plate 1. The stump of <i>juniperous procera</i> inthe legay forest .....	51
Plate 2. Regrowing spp. ( <i>Syzygium guineense</i> and <i>Podocarpus falcatus</i> ) in the Legay .....	51
Plate 3. Location of charcoal production and collection of wood for charcoal production.....	52
Plate 4. Wood extraction for different purpose .....	52
Plate 5. The burning the forest and some of the burned plant species in the forest .....	52

## **LIST OF ACRONYMS**

<b>CBD:</b>	Convention on Biological Diversity
<b>CRGE:</b>	Climate Resilient Green Economy
<b>CSA:</b>	Central Statistical Agency
<b>DBH:</b>	Diameter at Breast Height
<b>EFAP:</b>	Ethiopia Forestry Action Plan
<b>FAO:</b>	Food and Agriculture Organization
<b>FDRE:</b>	Federal Democratic Republic of Ethiopia
<b>FRA:</b>	Forest Rights Act
<b>GPS:</b>	Geographical Positioning System
<b>IBC:</b>	Institute of Biodiversity Conservation
<b>IUCN:</b>	International Union for Conservation of Nature
<b>IUFRO:</b>	International Union for Forestry Research Organization
<b>IVI:</b>	Important Value Index
<b>MoA:</b>	Ministry of Agriculture
<b>RD:</b>	Relative Density
<b>RDo:</b>	Relative Dominance
<b>REDD<sup>+</sup>:</b>	Reducing Emissions from Deforestation and Forest Degradation
<b>RF:</b>	Relative Frequency
<b>Ss:</b>	Sorensen`s similarity coefficient
<b>UNEP:</b>	United Nations Environmental Programme
<b>UNESCO:</b>	United Nations Education,Scientific and Cultural Organization
<b>USAID:</b>	The United States Agency for International Development
<b>WWF:</b>	World Wide Fund

# 1. INTRODUCTION

## 1.1. Background of the study

Forests provide many benefits including being home to biodiversity as they are habitats for 80 percent of amphibian species, 75 percent of bird species, 68 percent of mammal species and 60 percent of all vascular plants in tropical forests. Forests are also sources of wood used for construction, furniture and firewood. Furthermore, forests are useful for both mitigation and adaptation to climate change (Stevenson *et al.*, 2020).

Globally, about 30 percent of the land is covered by forests. However, due to conversion of forests to agricultural land, expansion of human settlements, utilization of forests for infrastructure and unwise logging practices the world forest exposed for deforestation (FAO, 2007). Despite their unparalleled importances, deforestation continued over years. For example, during the year of 2010–2020 the net loss of forest area was 4.7 million hectares per year and the main drivers for the declining of the global forest coverage (forest disturbances) were identified to be population growth (the need to provide food and energy), climate change and fluctuation, unsustainable agricultural practices (conversion of forests for agriculture); invasive species; low resource-use efficiency (wood-fuel from forest), over-exploitation of forest resources, expansion of human settlements, utilization of forests for infrastructure (Stevenson *et al.*, 2020). The most prevalent driver of deforestation in tropical and subtropical countries and that accounted for about 40 percent was large-scale commercial agriculture such as cattle ranching, cultivation of soya bean and oil palm (McFarland *et al.*, 2018). In addition to large scale commercial agriculture, local subsistence agriculture accounts for an estimated 33 percent of deforestation, urban expansion for 10 percent, and infrastructure for 10 percent and mining for 7 percent (Hosonuma *et al.*, 2012).

Africa is one of rich continent in forests and woodlands, shrubs, as well as trees outside forests. The continent is also characterized by extremely diverse ecological or ecosystem conditions that range from extreme deserts to humid forests and from coastal mangrove swamps to mountain temperate forests. Around 624 million hectares (ha) land is covered with forests, which comprise 20.6 percent of the continent's land area and 15.6 percent of

the world's forest cover. But, when compared with other region, forests area of Africa shows higher rate of reduction. The two main global forest challenges such as deforestation and degradation mainly occurred in Africa than in other regions. Between the year 2010 and 2015, Africa's forest area has declined by about 2.8 million ha due to anthropogenic activities. When it compared with other continent its rate of reduction is a much higher rate than in any other region in the world, and this has been mainly due to deforestation and forest degradation (Payn *et al.*, 2015).

Africa is home to around 17% of the world's forests, including a number of worldwide biodiversity hotspots (FAO, 2001). The East African Mountains, in particular, have the most diverse plant species. Among these, Afromontane vegetation covers more than half of Ethiopia's land, with dry montane forests accounting for the majority of this (Tamrat, 1994).

Ethiopia is home to the Eastern Afro-montane and Horn of Africa biodiversity hotspots with high biodiversity (Mittermeier *et al.*, 2004). Ethiopia is rich in biodiversity, and the country's biodiversity is linked to the country's different environmental and climatic conditions, which have aided to have diverse flora and fauna in ecosystems (Teklu, 2016). An estimated 6,000-7,000 higher plant species are found in Ethiopia. Approximately, 12 percent of Ethiopia's plant species are endemic (Tewolde-Berhan, 1991).

Dry Evergreen Montane Forest is a very complex vegetation type that occurs at elevations ranging from 1500 to 2700 meters (Friis, 1992). The Ethiopian highlands cover more than 50% of the country's land area with Afromontane vegetation (Tamrat, 1994), of which dry Afromontane forests form the largest part. The dry Afromontane forests are either Juniperus-Podocarpus forests or other broad leaved species. They occur in both the Northwest and Southeast highlands, especially on the plateau of Shewa, Wello, Sidama, Bale and Harerge at altitudes of 1500-2700m (Friis, 1992; Zerihun, 1999). The average annual temperature varies between 14 and 20°C and the annual rainfall between 700 and 1100 mm, with most of the rain recorded in July (Friis, *et al.*, 2010). It experiences long dry seasons (4-8 months). This type of forest develops in area of relatively high humidity, but not much rain. During dry season, not only moisture stress but also temperature in-

creases and dynamic humidity drops and water courses either dry up or greatly diminish in flow. Soils have become shallow as a result of soil erosion that has been taking place for centuries (Zerihun, 1999). About 460 species, subspecies and varieties of woody species occur in this vegetation type, from these 128 (27.8%) are reported only from this vegetation type. This indicates that this vegetation type is rich with species composition and endemism (Friis *et al.*, 2010).

Legay forest is one of the natural forests found in Oromia regional state, South West Shoa, Seden Sodo Woreda and Legay kebele. The forest has an elevation of 1800–2500 m a.s.l (personal observation). Accordingly, the forest could be categorized under the dry afro-montane Forest type that occurs at elevations ranging from 1500 to 2700 meters (Friis, 1992). Currently, similar to other forest in the country, Legay forest has been threatened as a result of deforestation. The forest has been vulnerable to anthropogenic activities such as human encroachment and agricultural activities. However, no previous attempt was made to study (no documented data was available) on the local biodiversity, floristic composition; regeneration and structural analysis of Legay forest. Therefore, this study was conducted in Legay forest to determine the floristic composition, diversity, and population structure and regeneration status of woody species in the forest.

## 1.2. Statement of the problem

Forest ecosystems are being destroyed at an alarming rate through out Ethiopia (Feyera and Demel, 2003; Kefyalew *et al.*, 2012). Lack of well documented information is one of the serious problems that hamper sufficient conservation and management of the forest.

Legay forest is affected by deforestation. Some of the problems are illegal cutting (timber, non-timber products) and fire-wood collection, charcoal production, agriculture expansion and grazing problems in the study area. On the other hand, no data was found on local floristic composition, regeneration and structural analysis of Legay forest. Therefore, this study aimed at addressing data gap and knowledge on the woody composition, diversity, structure and regeneration potential of the forest. The findings of this study will serve as a base line information and a knowledge which may guide the local communi-

ty, regional and federal governments towards the conservation and management plan to reduce anthropogenic disturbance that pose serious degradation on the forest.

### 1.3. Objective of the study

#### 1.3.1. General objective

The main objective of this study was to determine woody species composition, community type and vegetation structure of Legay forest.

#### 1.3.2. Specific objectives

- To identify and document plant species diversity and their respective life forms in Legay forest
- To identify woody species composition and community types in the Legay forest.
- To determine the regeneration status of selected woody species of the vegetation.
- To make phyto-geographical comparisons with other related forests in Ethiopia.

### 1.4. Research questions

- How many plant species including endemics are found in Legay forest and what are their dominant life forms?
- How floristic composition and community types does distributed in the Legay forest?
- What are the regeneration potential of selected woody species and how this is related to anthropogenic factors?
- Does Legay forest phyto-geographically related with others forest found in Ethiopia?

### 1.5. **Significance of the Study**

In Ethiopia, various attempts have been made to study the forests in different areas. However, the assessment of woody plant species composition, diversity and structural analysis, and other attributes has not been studied so far in Legay forest. Legay forest is one of the forests currently facing some anthropogenic impacts probably due to lack of management from concerning bodies in the area. Thus, to tackle the growing problem, science based evidence is very important on species documentation, community identification and description of this forest. So, this study was initiated to contribute to generate data and knoweledge that may support decision making and policy directives. Furthermore, the study fills existing gap related to woody species composition, population structure and regeneration status in the study area. It may also serve as an input for planners and decision-makers considering future development plans in the forest and to mitigate problems that may be encountered. Hence, this study aimed to fill the research gaps described above by addressing the research objectives and questions.

## **2. LITERATURE REVIEW**

### **2.1. Forest and biodiversity**

The diversity of plants, animals, and microbes that inhabit forests, as well as their genetic diversity, are included in the concept of forest biological diversity. Consideration of forest biological diversity can take into account the ecosystem, landscapes, species, populations, and genetics. Complex interactions are possible both within and between these layers. Because of their complexity, organisms in biologically diverse forests are able to adapt to rapidly shifting environmental conditions while sustaining the health of the ecosystem. Species richness, species endemism, evenness, and taxonomic diversity are ways to view the diversity of plant species (Eyasu and pattnaik, 2016).

Every year, nearly 13 million hectares of the world's forests are lost by deforestation. Human-caused factors are the most significant contributors to forest biological diversity loss. Forest conversion to agricultural land, overgrazing, unrestricted shifting cultivation, unsustainable forest management, introduction of invasive alien plant and animal species, infrastructure development, mining and oil exploitation, anthropogenic forest fires, pollution, and climate change are all having negative effects on invasive alien plant and animal species (FAO,2007).

### **2.2. Vegetation of Ethiopia**

In Ethiopia, forest is distributed in many parts of the country. The tropical lowland rainforest in the southwest, arid and semi-arid dry woodlands in the east, and Afroalpine forests in the north and southeast are a few of Ethiopia's numerous vegetation types (Mengesha *et al.*, 2020). Ethiopia's southern and southwestern regions contain the majority of the country's remaining natural forests. The forest distributed in the country provides various products such as fuel wood, forest coffee and spices, construction material, timber, farm implements, medicines, animal fodder, bee forage and edible fruits. Beside its importance, forests in the country face different challenges; tree cutting for various purposes, farmland expansion and investment activities are the major threats to the forest resources (Getahun and Anteneh, 2016).

### 2.3. The vegetation type of Ethiopia

Ethiopia has a diverse range of vegetation types due to its high biodiversity, topographical complexity, and climate variations. The country's geological history and temperature are principally responsible for the development of various vegetation types, which range from drought-tolerant vegetation in the lowlands to cold-tolerant species at the mountain's summit in the highlands (Mengesha *et al.*, 2020).

At various times, different scholars have investigated Ethiopian vegetation (Sebsebe *et al.*, 2004; Abyot *et al.*, 2014; Mengesha *et al.*, 2020). According to the findings of these studies, Ethiopian vegetation can be classified into 9 major types based on elevation and climate. These are:-Afroalpine and Subafroalpine Vegetation, Dry Evergreen Montane Vegetation, Moist Evergreen Montane Forest, Evergreen Scrub, Combretum-Terminalia woodland, Acacia Commiphora woodland, Wetlands, Lowland Dry forest, and Desert and semi-Desert. Other scholars like white (1983) were classified Ethiopian vegetation based on topography. IBC (2005) and Sebsebe *et al.* (2004) classified Ethiopian vegetation into 8 types depending on climate and elevation. These 8 vegetation types are:- Afroalpine and sub-afroalpine vegetation, Dry evergreen Afromontane forest and grassland complex, Moist evergreen Afromontane forest vegetation, Acacia-Commiphora woodland vegetation, Combretum-Terminalia woodland vegetation, Lowland semi-evergreen forest vegetation, Desert and semi-desert scrubland vegetation, and Aquatic vegetation. (Friis *et al.*, 2010).

#### 2.3.1. Dry evergreen montane forest vegetation

According to Friis *et al.* (2010), dry evergreen montane forest is typically found between 1800 and 3000 m above sea level, where human settlements and activity are most prevalent. Dry evergreen montane forest is characterized by a complex set of successions and wide-ranging grasslands rich in legumes, shrubs, and small to large-sized trees. It also closed forest with vertical canopy stratification.

Dry evergreen montane forest has the largest flora, containing many unique species among Ethiopia's vegetation types. The most common species in this vegetation type are *Juniperus procera*, *Podocarpus falcatus*, *Olea europaea*, and *Eucalyptus*. This ecosys-

tem's vegetation structure is largely influenced by grazing. Ethiopia has the largest cattle population in Africa and the tenth largest in the world, which has significant implications for ecological and biological conservation in the country (Mengesha *et al.*, 2020).

#### 2.4. Threats on biodiversity in Ethiopia

Due to its large number of endemic species, genetic diversity of numerous produced crops, and animal breeds, Ethiopia is one of the most diverse and important sources of biodiversity in the world for wild, cultivated, or domestic organisms. However, as a result of a drastic decline in mature forest cover and ongoing pressures such as population growth, rudimentary farming techniques, land use competition, land tenure, and forest degradation and conversion, Ethiopia's trees and forests are under severe stress, and the forest resources' status should be considered endangered. Limited political, institutional, and legal capability; population expansion; land degradation; poor management of protected areas; and deforestation are all threats to Ethiopia's biodiversity, and tropical forests (USAID, 2008).

Forest decrease in Ethiopia is thought to be the result of a combination of socio-political changes, economic activities, population growth, cultural traditions, and agricultural changes. The introduction and priority of certain crops are two major events that could shift the course of change. Many authors have demonstrated how the introduction of coffee, haricot beans, and chat/khat accelerated changes by boosting economic activity, the creation of new markets, immigration, and settlement, all of which contributed to forest decrease in the decline. (Gessesse *et al.*, 2007).

Despite this richness, Ethiopia's biological resources are currently under severe threat, potentially arise to fast population growth. Since natural products and lands are the basis of the population's existence, and demand for both is increasing steadily. This contributes significantly to Ethiopia's rapid loss of natural vegetation (Terefe *et al.*, 2017).

## 2.5. **The role of forest resources of Ethiopia**

Ethiopia's forest resources are used for a variety of purposes, including economic, ecological, and social. Their biodiversity is crucial in ensuring food security and long-term livelihoods for millions of Ethiopian households. Provisioning, regulating, sustaining, and cultural functions are among the ecosystem services offered by forest biodiversity (FAO, 2010).

Ethiopian forests generated economic benefits in different forms (cash and in-kind). It plays a significant role in the conservation of forest ecosystems, especially in agriculture. Flows of wood fuel (firewood and charcoal) and livestock fodder from forests provided the greatest market income benefits. Wood fuel and fodder are so valuable because their use is widespread in Ethiopia (UNEP, 2016).

## 2.6. **Regeneration of Woody Species**

For the forecast of both the present and future status of forests, it is crucial to analyze the regeneration status of a forest area. The population structure indicated by the existence of a sufficient number of seedlings, saplings, and adults shows successful regeneration of forest lands and the presence of saplings beneath the canopies of mature trees also suggest the future make-up of a community (Demel, 2002). One of the major areas of forestry is the study of forest tree regeneration, which has significant implications for the conservation and management of natural forests (Tesfaye and Birhanu, 2013). It depends on environmental variables for the seedling population to regenerate from the available seed. Because of this, a thorough understanding of how any plant community regenerates naturally requires knowledge of factors such as the existence or absence of persistent soil seed banks or seedling banks, the quantity and quality of seed rain, the longevity of seeds in the soil, losses of seeds due to predation and deterioration, triggers for seed germination in the soil, and sources of regrowth after disturbances. It is important to characterize the strategies used in both the regenerative (immature) and established (mature) stages of a plant's life cycle in order to understand a plant population or species. The recruitment, establishment, and growth of the desired seedlings can all be improved through research on

natural regeneration and seedling ecology, which can also offer alternatives to the development of forests (Demel, 2002).

## **2.7. The Plant Community**

A group of functionally related species populations that coexist in a certain location and period are known as plant communities (Magurran, 2004). Based on indicator species and a particular floristic composition, plant communities can be distinguished from one another. A community's size is not fixed. They might be very small or vary in size, with grassland or forests (Reiss and Chapman, 2008). The number of species, relative abundance of species, and type of species that make up a community are all characteristics of the structure of the plant community (Manuel and Molles, 2007).

## **2.8. Natural forest conservation and utilizations in Ethiopia**

In 2011, Ethiopia's government launched the Climate Resilient and Green Economy Strategy (CRGE Strategy), with the goal of achieving middle-income status by 2025 while maintaining a carbon-neutral growth path. One of the pillars of the CRGE Strategy is REDD<sup>+</sup> implementation. CRGE also promotes afforestation and forest conservation as main actions for achieving green economy and strengthening climate resilience in Ethiopia. According to the strategy, Ethiopia's greenhouse gas emissions in 2010 were around 150 megatonnes CO<sub>2</sub> equivalent. The implementation of REDD<sup>+</sup> is expected to significantly aid the country in meeting its development goals while keeping greenhouse gas emissions close to current levels (FDRE, 2011; UNEP, 2016).

If the country is to accomplish its development goals, deforestation and forest degradation must be reversed, according to the CRGE Strategy. Forests also provide important ecological services such as carbon sequestration, crop pollination, agricultural soil protection, and water discharge regulation to streams and rivers. Even if afforestation and forest conservation are main actions for achieving green economy and strengthening climate resilience in Ethiopia, forests are already under threat and the country's growing population will require more wood fuel and food in the future. Without action, 90 thousand km<sup>2</sup>

(56% of total forest area) might be deforested between 2010 and 2030. Annual wood fuel consumption could rise by 65% (FDRE, 2011; UNEP, 2016).

Forests play a crucial role in the lives of communities and nations. Apart from being reservoirs of other forms of biodiversity, forests are important as water catchments, soil erosion barriers, source of timber and non-timber materials. Forests also provide a very important service in the new and growing leisure industry, which involves the non-consumptive use of biological diversity for example eco-tourism. Forests also provide very important ecosystem services that are generally considered to be free. Such essential services include nutrient cycling, soil formation, oxygen production, carbon sequestration and climate regulation (Mogaka *et al.*, 2001).

### 2.9. **Species diversity, evenness and richness**

Biodiversity refers to the diversity and variability of all living organisms found in a specific ecological area. The term "biodiversity" can refer to the number of species present, their genetic diversity, or the diversity of their habitats. Species richness and species evenness are the two key significant components of biodiversity. 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. The amount of diverse species present in an area is species richness. The more species indicate greater richness (Zerihun, 1985; as cited in Abiyot, 2009). Species evenness indicates the relative abundance of different species in a given area. The greater evenness is similar with abundance. Changes in land use; habitat fragmentation, nutrient enrichment, and environmental stress often lead to reduced plant diversity in ecosystems. Diversity has two components: species richness, or the number of plant species in a given area, and species evenness, or how well distributed abundance or biomass is among species within a community.

Evenness is a measure of abundance of the different species that make up the richness of the area. Species diversity shows the product of species richness and evenness. Species diversity indices provide information about species endemism, rarity and commonness (Muller-Dombois and Ellenberg, 1974).

### 3. MATERIALS AND METHODS

#### 3.1. Description of the study area

The study was conducted in Legay forest which is located in Seden Sodo woreda, South west Shoa, Oromia Regional State. The study area is 112 km from Addis Ababa toward the south west direction and 34 km from Woliso, the capital city of south west shoa zone. Harbu Chululle is the capital town of the District. The forest is a natural forest, and located between  $08^{\circ}.13.547$  and  $038^{\circ}.14.081$  E and  $08^{\circ}.27.223$  and  $08^{\circ}.27.354$  N (Fig.1). The altitudinal range of the study area is 1800 - 2500 m a.s.l (GPS reading during field-work). The total area of the forest is around 3500 ha (google earth).

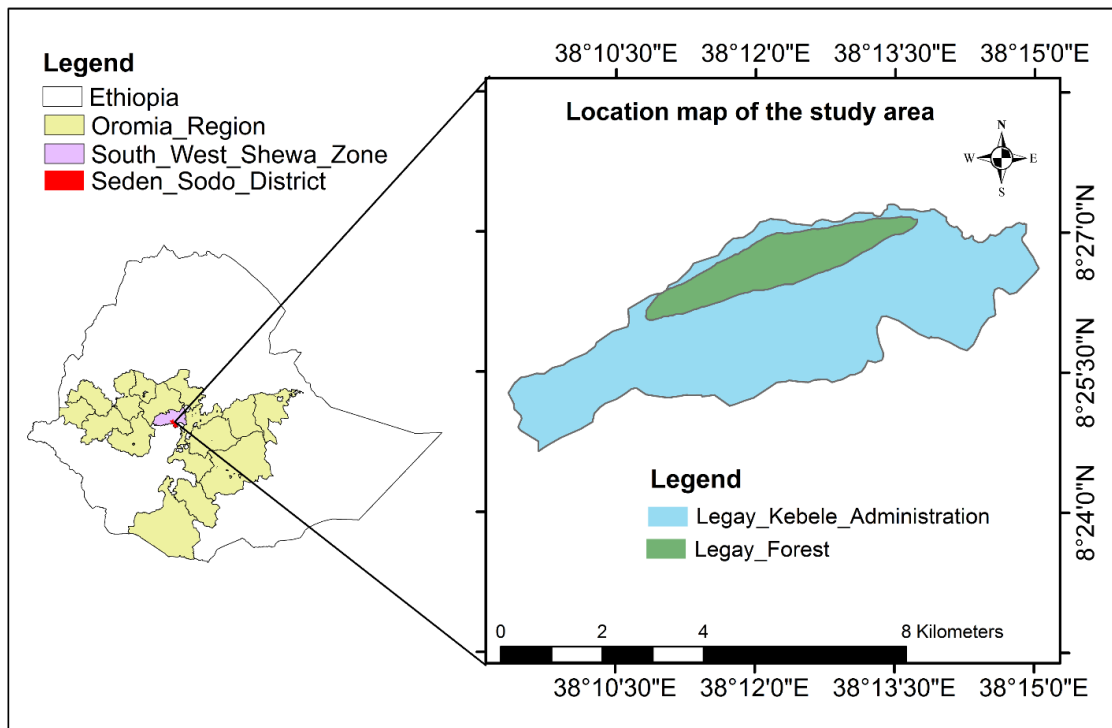


Figure 1. Map of the study area

##### 3.1.1. Climate

The climate of Seden Sodo Woreda is considered to belong to the Dega and Weina Dega agro-ecological zones of Ethiopia. Meteorological data obtained from National Meteorology Service Agency (NMSA, 2023), indicates that Seden Sodo area obtains high rainfall between June and September and low rainfall from December to February. According to

the data, the highest mean annual rainfall of the study area recorded for nine years (2012 - 2021) was 1232 mm and recorded in July whereas the lowest mean annual rainfall was 14.4 mm and recorded in February. No data of temperature obtained from NMSA for the study site, but the data obtained from the nearest station Woreda of Gedebano Gutazer-Welene Woreda indicated that the daily average temperature ranges between 15 °C and 24 °C (Kedir *et al.*, 2017).

### 3.1.2. **Topography**

Topographically, the forest is generally determined by rough topography with deep valley, undulating plain, hills, slopes, and gorges. One perennial river, which is called Gong River and another one seasonal river, which is called Aleltu River are flowing through crossing the forest. Aleltu River is a tributary of Gong River, and Gong River is influent of Gibe River. Both rivers emerge from the highland area. The topography of the forest bounded in the north and north east by Gong River, in the south, east and west by Legay district.

### 3.1.3. **Land use**

Subsistence agriculture is the main economic activity of the community, with mixed livestock rearing and crop production. Coffee and honey production is also practiced by the local community. The traditional farming systems enforce the population to exploit the forest, particularly at the marginal areas for agricultural expansions and charcoal production.

Some of main crops grown in Seden Sodo Wereda were cereal crops (teff, wheat, maize, barely), pulses (peas and beans) and oil crops (noug and linen), vegetables (tomato, onion, tomato, pepper and cabbage). Also “enset” is one of the staple food in Seden Sodo woreda. During the 2010-2012 E.C. The most common livestock populations in the district were cattle, sheep, goats, poultry, horses, mules and donkeys.

### 3.1.4. **Vegetation**

The vegetation of Legay forest is contains several flora and fauna. The forest contains a different plant species such as *Podocarpus falcatus*, *Juniperus procera*, *Olea europea*,

*Carissa edulis*, *Rytigynia neglecta*, *Euclea divinorum*, *Rhus glotinoso*, *Dodenea aguisti-folia*, *Myrsine africana*, *Polyscias fulva*, *Maesa lanceolata*, *Acrachne racemosa* and *Osyris quadripartite*.

### **3.2. Data collection**

#### **3.2.1. Reconnaissance Survey**

Reconnaissance survey was conducted for a week in October, 2020 in and around Legay forest to gather relevant information concerning the study area, observe vegetation distribution, get an impression of the site conditions, and to identify the possible sampling sites. Systematic sampling was applied for the study of floristic composition and vegetation structure of Legay forest. During the visit, additional information and relevant materials to strengthen our study were collected from the local surrounding people, Woreda agriculture and natural resource protection office. Vegetation data collections were made from March 7 to April 05, 2021.

#### **3.2.2. Sampling technique**

Systematic sampling technique was used to collect vegetation data following the method used by Muller-Dombois and Ellenberg (1974) and Kent and Coker (1992). For vegetation data collection, 18 transect lines were laid. Three transect lines from west to east, three from east to west and thirteen from south to north direction following the altitude from bottom to top of the forest. Each transect contains different numbers of plots depending on the length of each transect. Sampling plots of 20 m x 20 m (400m<sup>2</sup>) for trees and 5m x 5m (25 m<sup>2</sup>) for shrubs were created based on the total area of the study site. Vegetation data was collected from fifty-two plots from a total transect of eighteen. The sampling plots were placed at every 200 m intervals on flat and 50 m altitudinal difference on slopy areas. Transect lines were laid at 500 m apart each other. The first sampling plot was established systematically to collect data on woody species from each established sample plot from west to east.

### **3.3. Data collection methods**

#### **3.3.1. Floristic data collection**

All woody species of trees and shrubs in each sample plots were recorded using the vernacular and local names. Woody species identification was done by using Flora of Ethio-

pia and Eritrea for those which cannot be identified in the flora of Ethiopia and Eritrea, fresh specimens were collected and then pressed properly and finally brought to the national herbarium of Addis Ababa University for species name identification.

### 3.3.2. Structural data collection

To determine population structure, diameter at Breast Height (at about 1.3m) was measured using caliper and meter tape. The height, number, and DBH > 2.5 cm was documented for each tree individuals in the plots. Regeneration pattern of species was assessed by counting of seedlings (woody species of height  $\leq 1$  cm and DBH  $\leq 10$ cm) and saplings (woody species of height > 1m and DBH  $\leq 2.5$  cm) within the main quadrats. Altitude and geographical coordinates were measured for each plot using Garmin GPS 72

After collection, the samples were dried under dryer for two weeks and placed inside fridge for 72 hours or three days for woody plants to protect the plant from fungal and bacterial attack. Identification of vascular plants species done by using different volumes of Flora of Ethiopia and Eritrea, and by comparing with already existed plant species specimens at National Herbarium of Ethiopia, Addis Ababa University.

## 3.4. Data analysis

### 3.4.1. Structural data analysis

The plant species that was collected were subjected to the vegetation structure analysis by applying the following methods. There are a direct relationship between DBH and basal area.

$$BA = \epsilon \Pi \left(\frac{d}{2}\right)^2,$$

Where BA = Basal area in m<sup>2</sup> per hectare

d= diameter at breast height

$$\Pi = 3.14$$

Basal area of all investigated plots was converted to mean basal area per hectare. Basal area provides a better measure of the relative importance of tree species than simple stem counts (Tamrat Bekele, 1993).

$$\text{Relative dominance} = \left( \frac{\text{Dominance* of tree species}}{\text{Dominance of all species}} \right) \times 100$$

Where dominance \* is mean basal area per tree times the number of tree species.

Density: The number of individuals of each tree and shrub (woody species) were counted in the total plots. All the dominant trees and shrubs were counted. The number of samples within which a species found (frequency) and the number of individuals of a species in a sample (abundance) were calculated for all tree and shrub species (woody species). Finally, the average number of individuals of each tree and shrub species was converted into individuals per hectare for each community as indicated in Kent and Coker (1992).

Density is defined as the number of plants of a certain species per unit area. It is closely related to abundance but more useful in estimating the importance of a species.

$$\text{Density} = \frac{\text{Total number of stems of all trees}}{\text{Sample size in hectare}}$$

$$\text{Relative density} = \left( \frac{\text{Number of individuals of tree species}}{\text{total number of individuals}} \right) \times 100$$

Frequency: The frequency of quadrates occupied by a given species. It is calculated with formula:

$$\text{Frequency} = \left( \frac{\text{Number of plots in which a species occur}}{\text{total number of plots}} \right) \times 100$$

The importance of the species with the frequency can be obtained by comparing the frequency of occurrences of all tree species present. The result is called relative frequency and it is calculated as:

$$\text{Relative frequency} = \left( \frac{\text{Frequency of tree species}}{\text{Frequency of all species}} \right) \times 100$$

Importance value index: Importance value index combines data for three parameters (relative frequency, relative density and relative abundance). That is why ecologists consider it as the most realistic aspect in vegetation study (Curtis and McIntosh, 1950). It is useful to compare the ecological significance of species (Lamprecht, 1989). The importance value index (IVI) for each woody plant species were calculated following Curties and McIntosh (1950) using the formula indicated below.

Importance value index = Relative density + Relative frequency + Relative dominance. The IVI was computed using Microsoft excel spreadsheet program. Eventually, woody species having the least IVI values were prioritized for the purpose of conservation and management interventions.

#### 3.4.2. **Plant community analysis**

A plant community is generally recognized as a relatively uniform piece of vegetation in a uniform environment, with a recognizable floristic (plant) composition and structure, which is relatively distinct from the surrounding vegetation (Van der Maarel and Franklin, 2013). An important quantitative criterion in identifying different plant communities is the frequency and abundance of species in sampling units. To identify plant communities, the cover– abundance data was analyzed and classified using the Cluster and Vegan packages in R Package 3.2 (Oksanen *et al.*, 2014). Clustering is a multidimensional analysis that consists in partitioning the collection of sampling plots (Legendre and Legendre, 1998). The cut point of the Clusters was decided by plotting the within groups sum of squares against number of clusters. The resulting graph was used to decide the cut level subjectively. Consequently, after determining the optimum number of clusters, an agglomerative Hierarchical Cluster Analysis was performed using Similarity ratio to classify sites and species. Plant community types will further refine in a Synoptic table. The resulting groups were recognizing as community types and the species occurrences will summarized by synoptic cover abundance values. The community types were named based on the tree and shrub with high synoptic value.

#### 3.4.3. **Diversity analysis**

It is the most applicable index of diversity (Greig-Smith, 1983). Like Simpson's index, Shannon's index accounts for both abundance and evenness of species present. The pro-

portion of species relative to the total number of species ( $p_i$ ) is calculated, and multiplied by the natural logarithm of this proportion ( $\ln p_i$ ).

The Shannon diversity index ( $H'$ ) is calculated using the following formula,

$$H' = - \sum_{i=1}^S p_i \ln p_i$$

Where,  $H'$ =Shannon Weiner diversity index,  $S$ =total number of species,  $P_i$ =the proportion of individuals or abundance of the  $i^{\text{th}}$  species as a proportion of total cover and  $\ln$ =log base.

Evenness ( $J$ ) is a measure of the relative abundance of the different species making up the richness of an area. Evenness compares the similarity of the population size of each of the species present.

$J = H' / H'_{\text{max}}$ . Where,  $J$ =evenness,  $H'_{\text{max}} = \ln S$ .

Sorenson's Similarity ratio was used to evaluate the similarity between community types of the vegetation in the study area.

$$S_s = \frac{2a}{2a+b+c}$$

Where,  $S_s$ : Sorensen's similarity coefficient

$a$  = number of woody species common to Legay forest and other forest in comparison

$b$  = number of woody species found only in Legay forest.

$c$  = number of woody species found only in the forest in comparison with Legay forest.

### 3.5. Regeneration of woody species in the Forest

For determination of regeneration status of Legay, counting method was used and all the seedlings and saplings found in each established quadrats were counted and recorded. The ratio of seedlings to adult individuals of woody species, seedling to saplings and sapling to mature individuals was calculated. The total density of seedling of woody species as well as the densities of tree, shrub and was also calculated. For setting priority, some

selected tree species in the study area were grouped into different groups. For each woody species, regeneration pattern was expressed and analyzed.

### **3.6. Ecological disturbances of the forest**

Ecological disturbances of the forest such as grazing and impacts of human beings (cutting, collecting firewood, and producing charcoal in the vegetation) were noticed and recorded as present or absent in the sampled plots.

## 4. RESULTS AND DISCUSSION

### 4.1. Floristic composition

A total of 57 plant species were identified and documented (Appendix 1). Of the total plant species, twenty one species (36.84%) were trees, thirty species (52.63%) were shrubs, three (5.26%) species were climbers, and three (5.26%) species were lianas (Fig. 2). The identified plant species belong to 54 genera and 42 families (Appendix 2).

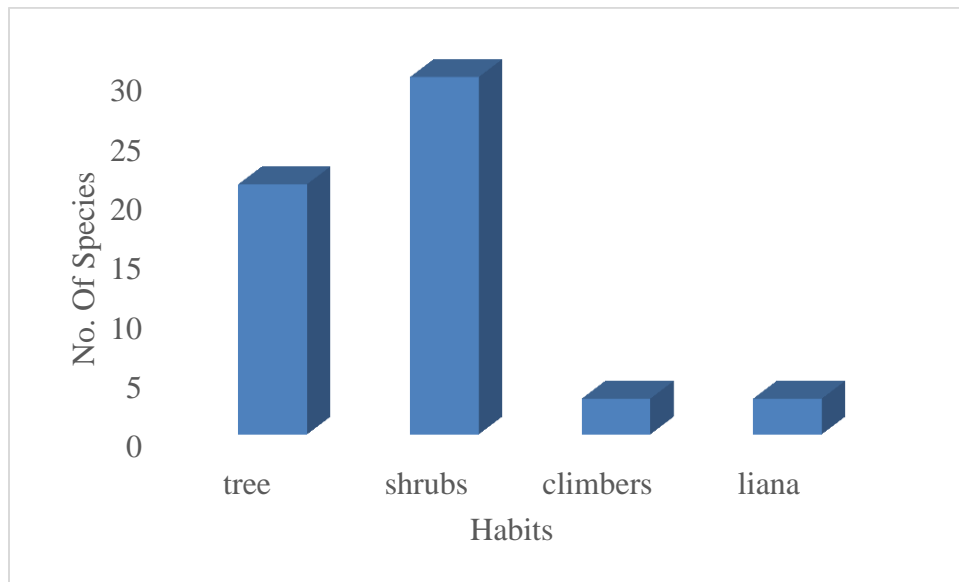


Figure 2. Growth forms and number of plants species in Legay forest.

The Legay forest has more number of plant species when compared with Gola natural forest (Abdulbasit and Tasisa, 2022), Shello Giorgis (Abate *et al.*, 2020) and Wanzaye forest (Ambachew, 2018) which reported 52,49,47 plant species, respectively, but has less number of species when compared with similar forests such as Dangila church forest (Tayachew, *et al.*, 2021), jibat forest (Tesfaye, *et al.*, 2013), Bale forest (Haile, *et al.* 2008) and Gedo forest (Birhanu *et al.*, 2014), Kimphe lafa forest (Kedir *et al.*, 2015) which reported 59. 183, 230, 235 and 130 plant species, respectively. High forest disturbance brought on by anthropogenic (human disturbance) influences may be the cause of having low number of species.

Fabaceae was the most dominant family in the Legay forest, represented by 4 species (9.52%) followed by Asteraceae, Lamiaceae, Myrtaceae, Oleaceae, Rosaceae each with 3

species (7.1 each), Acanthaceae, Asparagaceae, Cupressaceae, Flacourtiaceae, Myrsinaceae, Poaceae, Rutaceae each of them with 2 species (4.76% each), and the rest families were represented by 1 species (Table 1). Similar to the present study, Zerihun *et al.* (2017) and Kedir *et al.* (2015) and Abdulbasit (2022) have found Fabaceae as the dominant family in Ilu Gelan forest, Kimphe lafa natural forest and Gola natural vegetation, respectively. Fabaceae and Asteraceae might have got the top dominant position probably due to having efficient pollination and successful seed dispersal mechanisms that might have adapted them to a wide range of ecological conditions in the past (Ensermu and Teshome, 2008). Feyera and Denich (2006) also reported that family dominance indicates that environmental condition of the study area is more favorable to fabaceae than other families.

Table 1. The most dominant families and plant species in Legay forest

NO.	Family	No. of species	Percentage (%)
1	Fabaceae	4	9.52
2	Asteraceae	3	7.1
3	Lamiaceae	3	7.1
4	Myrtaceae	3	7.1
5	Oleaceae	3	7.1
6	Rosaceae	3	7.1
7	Acanthaceae	2	4.76
8	Asparagaceae	2	4.76
9	Cupressaceae	2	4.76
10	Flacourtiaceae	2	4.76
11	Poaceae	2	4.76
12	Myrsinaceae	2	4.76

#### 4.2. Vegetation community classification

Hierarchical agglomerative classification was derived from the cover-abundance of the plot data consisting of 57 species collected in 52 plots and five community types were obtained in HCA (C1–C5) (Fig. 3). The adjacent branches of the dendrogram show prox-

imity in slope and altitudinal ranges and hence exhibit corresponding similarity in species composition. The highest number of species was recorded in C4 and C2, respectively with 34 and 31 species. The least number of species was recorded in C1 (Fig. 3).

The vertical axis of the dendrogram represents the distance or dissimilarity between labeled clusters, and the horizontal axis represents the sampled sites (plot 1–52) clustering in five branches (Fig. 3).

Species having high indicator value ( $P^* < 0.05$ ) were considered as indicator species in their community types and were used to name community types. These indicator species are those that can be observed easily being widely distributed throughout the forest (Table 2).

The five plant communities obtained from the study site were: Community 1 (*Olea europaea subspcupidata- Rytigynianeglecta*), Community 2 (*Rhus glotinosa- Rosa abyssinnica*), Community 3 (*Dodeneaaguiatifolia -Quercus sp.*), community 4 (*Maytenusundata- Carissa edulis*), Community 5 (*Polyscias fulva-Eucleadivinorum*)(Fig. 3).

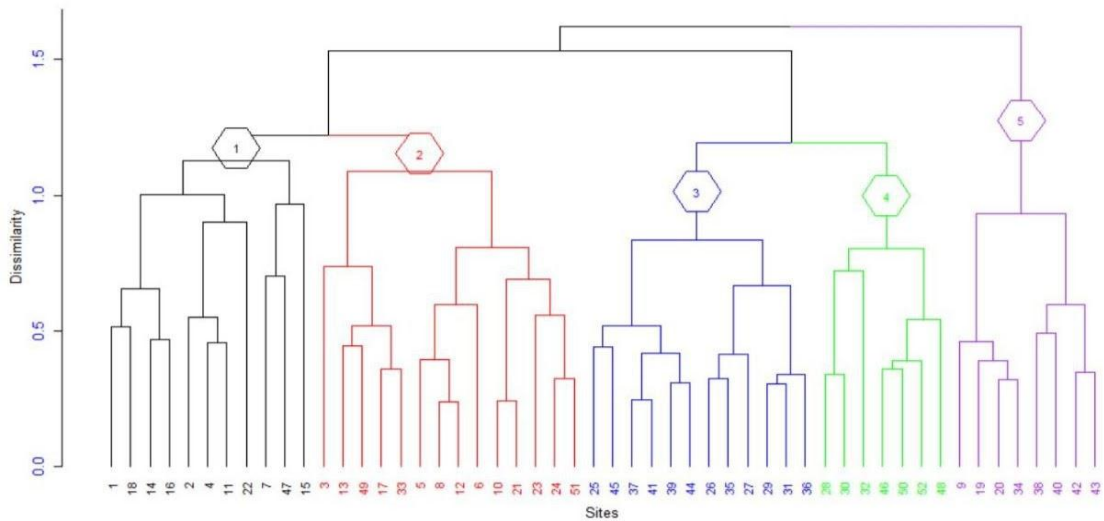


Figure 3. Dendrogram of hierarchical clustering using similarity ratio showing five community types of the Legay forest (Ward’s method, similarity ratio).

### **4.3. Distribution of community types in the Legay forest**

#### **4.3.1. *Olea europaea*- *Rytigynia neglecta* community**

This community is located between the altitudinal ranges of 2280 and 2430 m a.s.l. It was represented by 11 plots and 25 species. The two species unique to this community type are *Acacia brevispica* and *Erica arborea*. Among the indicator plant species used in the naming of the community; *Olea europaea subspcuspidata* and *Rytigynia neglecta* were the dominant species in the tree and shrub layer of the community respectively. Some of the plant species found in the community were *Acacia brevispica*, *Myrsine africana*, *Rosa abyssinica*, *Smilax aspera*, *Asparagus africanus*, *Acacia tortolis*, *Caesalpinia decapetala*, *Erica arborea*, *Acacia abyssinica*, *Phytolacca dodecandra* and *Brucea antidy-sitrica* (Table 2).

#### **4.3.2. *Rhus glotinos* - *Rosa abyssinica* community**

*Rhus glotinos* - *Rosa abyssinica* community is located between the altitudinal ranges of 2270 and 2421 m a.s.l. It was represented by 14 plots and 31 species. Species exclusive to this community include *Cupressus lusitanica*. Among the indicator plant species used in the naming of the community; *Rhus glotinos* and *Rosa abyssinica* were the dominant species in the shrub layer of the community, respectively and *Urtica simensis* was the dominant species in layer. Some of the plant species found in the community were *Helichrysum italicum*, *Rytigynia neglecta*, *Acacia tortilis*, *Ajuga reptans*, *Albiza gummifera*, *Clausena anisata*, *Myrsine africana*, *Olea europaea subspcuspidata*, *Periploca linearifolia*, *Phytolacca dodecandra*, and *Smilax aspera* (Table 2).

#### **4.3.3. *Dodenea agustifolia* -*Quercus* sp. Community**

This community is located between the altitudinal ranges of 2220 and 2470 m a.s.l. It was represented by 12 plots and 29 species (Appendix 3). Among the indicator plant species used in the naming of the community; *Dodenea agustifolia* and *Quercus* sp. were the dominant species in the shrub and tree layer of the community, respectively. Some of the plant species found in the community were *Acacia tortilis*, *Lippia adoensis*, *Acanthus eminens*, *Buddleja davidi*, *Eucalyptus gomphophocephala*, *Ficus sychomorus*, *Rhus glotinos*, *Olea europaea*, *Lippia adoensis*, *Dovyalis verrucosa*, and *Polyscias fulva* (Table 2).

#### **4.3.4. *Maytenus Undata* - *Carissa edulis* community**

This community is located between the altitudinal ranges of 2270 and 2465 m a.s.l. It was represented by 8 plots and 34 species (Appendix 3). This community had highest number of species (34) species. Exclusive species to this community are *Hypericum revolutum*, *Olea capensis* and *Vernonia amygdalina*. Among the indicator plant species used in the naming of the community; *Maytenus undata* and *Carissa edulis* were the dominant species in the shrub layer of the community, respectively. Some of the plant species found in the community were *Acacia tortilis*, *Bersema abyssinica*, *Caesalpinia decapetala*, *Croton macrostachyus*, *Clausena anisata*, *Helichrysum italicum*, *Hypericum revolutum*, *Eucalyptus globulus*, *Eucalyptus gomphophocephala*, *Vernonia amygdalina*, *Momordica foetida*, *Periploca linearifolia*, *Olea capensis*, *Ocimum lamifolium*, *Podocarpus falcatus*, *Quercus* sp. and *Teclea nobilis* (Table 2).

#### **4.3.5. *Polyscias fulva*- *Euclea divinorum* community**

*Polyscias fulva* –*Euclea divinorum* community is located between the altitudinal ranges of 2265 and 2370m a.s.l. It was represented by 7 plots and 29 species (Appendix 3). Among the indicator plant species used in the naming of the community; *Polyscias fulva* and *Euclea divinorum* were the dominant species in the shrub and tree layer of the community, respectively. Some of the plant species found in the community were; *Acacia abyssinica*, *Acacia tortilis*, *Brucea antidysitrica*, *Buddleja davidi*, *Caesalpinia decapetala*, *Dovyalis verrucosa*, *Ekebergia capensis*, *Ficinia clandestina*, *Helichrysum italicum*, *Jasminum abyssinicum*, *Opuntia ficus-indica*, *Osyris quadripartite*, *Ilex mitis*, *Mytenus undata*, *Myrsine africana*, *Opuntia ficus-indica*, *Osyris quadripartite*, *Vernonia purpurea*, *Rosa abyssinica*, *Podocarpus falcatus*, *Quercus* sp., *Olea europae* and *Phoenix reclinata* (Table 2).

Table 2. Indicator values of each species for each community with their P-value.

Species name	Community types					P* value
	1	2	3	4	5	
<i>Acacia abyssinica</i>	0	0	0.64	0	11.54	0.562
<i>Acacia brevispica</i>	18.18	0	0	0	0	0.066
<i>Acacia tortilis</i>	7.66	15.04	19.82	17.19	10.53	0.721
<i>Albiza gummifera</i>	0	3.99	3.10	3.65	0	0.976
<i>Asparagus acutifolias</i>	1.75	1.08	2.94	4.33	0	0.918
<i>Bersema abyssinica</i>	0.35	0.86	0	23.86	2.97	0.058
<i>Brucea antidysitrica</i>	6.36	2.24	2.20	2.24	12.02	0.541
<i>Buddleja davidi</i>	1.97	1.62	8.28	0	16.76	0.291
<i>Caesalpinia decapetala</i>	8.52	5.48	5.03	5.61	13.67	0.736
<i>Carissa edulis</i>	4.45	3.33	1.81	<b>26.18</b>	2.73	0.045
<i>Clausena anisata</i>	4.80	6.67	0.19	17.23	0	0.218
<i>Croton macrostachyus</i>	0	0.43	1.77	10.39	0	0.364
<i>Cupressus lusitanica</i>	0	7.14	0	0	0	1
<i>Dodenea agulistifolia</i>	0.93	5.30	<b>20.57</b>	1.64	1.45	0.031
<i>Dovyalis abyssinica</i>	4.17	6.01	5.84	0	0	0.888
<i>Dovyalis verrucosa</i>	3.73	3.86	7.75	0	19.10	0.213
<i>Ekebergia capensis</i>	5.42	0	1.46	0	13.16	0.315
<i>Erica arborea</i>	17.27	0	0	0	0	0.219
<i>Eucalyptus globules</i>	0	1.81	4.63	5.44	0	0.842
<i>Eucalyptus gomphocephala</i>	1.26	4.13	7.03	7.23	3.16	0.978
<i>Euclea divinorum</i>	1.54	0.79	2.22	0	<b>25.16</b>	0.041
<i>Ficus sychomorus</i>	1.75	3.78	13.71	0	2.75	0.39
<i>Helichrysum italicum</i>	5.32	23.47	<b>19.55</b>	21.09	8.52	0.047
<i>Hypericum revolutum</i>	0	0	0	14.29	0	0.131
<i>Ilex mitis</i>	0.40	2.46	0	0	19.60	0.093
<i>Jasminum abyssinicum</i>	0.63	0.39	0	1.56	9.58	0.642
<i>Juniperus procera</i>	5.94	0.28	7.68	0	4.32	0.783

<i>Justitia schimperiana</i>	0	1.93	6.08	0	0	0.679
<i>Lippia adoensis</i>	0.96	0.38	13.16	0	3.95	0.321
<i>Maesa lanceolata</i>	4.82	0.85	7.53	<b>24.29</b>	0.87	0.0395
<i>Maytenus undata</i>	1.17	5.44	0.99	0.24	5.18	0.965
<i>Momordica foetida</i>	0	1.65	0	20.98	0	0.056
<i>Myrsine Africana</i>	13.59	21.16	2.39	0	4.93	0.241
<i>Ocimum lamifolium</i>	4.17	0	0	7.73	0	0.531
<i>Olea capensis</i>	0	0	0	14.29	0	0.155
<i>Olea europae</i>	<b>30.87</b>	22.65	10.15	2.10	5	0.039
<i>Opuntia ficus-indica</i>	0	2.98	0.51	0	18.26	0.146
<i>Osyris quadripartite</i>	6.56	1.83	1.95	2.07	18.50	0.191
<i>Periploca linearifolia</i>	3.74	9.62	1.75	9.24	2.55	0.833
<i>Phoenix reclinata</i>	6.38	0.66	7.37	2.63	6.03	0.935
<i>Phytolaca dodecandra</i>	1.76	7.51	1.36	1.67	0	0.696
<i>Podocarpus falcatus</i>	0	0.78	3.85	4.24	4.54	0.948
<i>Polyscias fulva</i>	3.27	0	10.17	0	<b>28.80</b>	0.029
<i>Quercus sp.</i>	17.29	20.45	<b>21.69</b>	9.54	21.80	0.0389
<i>Rhamnus prinoides</i>	0	6.73	0	11.59	0	0.742
<i>Rhus glotinoso</i>	1.02	<b>31.32</b>	14.15	2.85	0	0.036
<i>Rosa abyssinica</i>	21.69	<b>30.27</b>	7.09	10.35	10.70	0.032
<i>Rubus steudneri</i>	0	3.86	0.73	8.27	4.40	0.641
<i>Rytigynia neglecta</i>	<b>28.32</b>	20.84	11.70	13.51	5.29	0.0446
<i>Salvia officinalis</i>	0	3.25	0	7.79	0	0.442
<i>Smilax aspera</i>	20.40	18.44	0	0.67	0.86	0.168
<i>Solanum incanum</i>	0	5.19	0	0	7.95	0.529
<i>Stephania abyssinica</i>	1.40	2.59	0	6.91	0	0.642
<i>Syzygium guineense</i>	3.54	8.73	0	0	0	0.451
<i>Teclea nobilis</i>	0	0	0.68	13.99	5.36	0.229
<i>Vernonia amygdalina</i>	0	0	0	14.29	0	0.126
<i>Vernonia purpurea</i>	0	1.14	0	0	10.50	0.353

NB: The number written in bold indicates these species from each community with the highest abundance.

The number of plant community types in Legay forest that had five community type is comparable with Gesho and Sayilem forest (Admassu *et al.*, 2020), which located in the wolata zone, Boda evergreen montane forest (Fikadu *et al.*, 2014), which located in West Shewa zone. The result of plant community types in the present study also comparable with Belete forest (Kflay and Kitessa, 2014), which located shabeshombo district Jimma zone, indicating that the ecological resembles of Legay forest compared with the forests mentioned above.

#### **4.4. Species richness, evenness and diversity of the five plant community types**

The Shannon-Weiner diversity index computed for the five community types (Table 3) indicates that community type IV has the most diverse and has the most even distribution of species which implies that the community has relatively less anthropogenic intervention such as cutting for charcoal production, firewood and less grazing of cattles.

Community type I has the least diversity index with the least number of species. The difference in the diversity index between community IV ( $H' = 3.15$ ) and community 1 ( $H' = 1.19$ ) could be due to anthropogenic disturbances in the community I. Human influence and grazing intensity could affect species composition in the forest (Gholinejad *et al.*, 2012). Community type II has the highest number of species but, with the less species evenness for the community type was dominated by only *Vernonia urticifolia* and *Croton macrostachyus*. According to Kent and Coker (1992), the Shannon-Weiner index is the most frequently used for the combination of species richness and relative abundance. Shannon-Weiner diversity index usually lies between 1.5 and 3.5. Hence, the value of Shannon -Wiener diversity index of study area was found in between 1.19 and 3.15, which was inline with the given ranges (Table 3). The evenness (J) of the distribution of species within a community increases with increasing number of species (Table 3). Thus, community type III and IV has the highest even distribution whereas community type I has the least even distribution of species.

In this study, the highest Shannon diversity indices were recorded for plots 46, 44, 45, 50, 39 and 48, with corresponding values of  $H' = 3.65, 3.38, 3.31, 3.3, 3.24$  and  $3.2$  respectively. Corresponding numbers of species were 48, 38, 33, 40, 36 and 38 demonstrating that many species occur at these plots. On the other hand, the lowest diversity index were observed for plot, 16, 27, 25, and 19 with values of  $H' = 2.38, 2.36, 2.24, 2.12$  having 2, 47, 22, 15 species, respectively. When compared with other forest studied in Ethiopia, e.g., Wofwasha forest ( $H' = 3.25, J = 0.8$ ) (Fisaha *et al.*, 2013), Gemechis forest ( $H' = 3.04, J = 0.77$ ) (Sudi *et al.*, 2018), Legay forest has relatively less diversity and evenness value. The reason for this low diversity could be due to anthropogenic factors such as grazing of cattle, wood for fire and charcoal production.

Table 3. Shannon-Weiner Diversity Index ( $H'$ ) and evenness ( $J$ ) for the five community types of Legay forest

Communities	Altitude (m)	Number of Species	Diversity index ( $H'$ )	Species evenness ( $J$ )
I	2280 - 2430	25	1.19	0.84
II	2270 - 2421	31	2.94	0.86
III	2220 - 2470	29	3.04	0.90
IV	2270 - 2465	34	3.15	0.90
V	2265 - 2370	29	2.92	0.87

#### 4.5. Vegetation structure analysis

##### 4.5.1. Frequency

Frequency is percentage of plots where a species is present. It is a measure of occurrence of a given species in a given area. It indicates how the species are dispersed and is an ecological meaningful parameter. In other words, it gives an approximate indication of the homogeneity of the stand under consideration (Kent and Coker, 1992).

*Carissa edulis* was found to be the most frequent species, with a frequency of 88.46, followed by *Rhus glotinoso*, *Maesa lanceolata*, *Myrsine africana*, *Rytigynia neglecta*, *Helichrysum italicum*, *Polyscias fulva*, *Dovyalis verrucosa*, *Quercus sp.*, and *Osyris quadri-*

*partita*, with frequencies of 84.61, 80.77, 78.85, 71.15, 69.23, 67.30, 65.38, 63.46, and 61.53, respectively (Table 4).

Table 4. List of most frequent trees and shrubs in Legay forest

S.no.	Species name	Frequency (%)	Relative frequency
1	<i>Carissa edulis</i>	88.46	4.42
2	<i>Rhus glotinoso</i>	84.61	4.23
3	<i>Maesa lanceolata</i>	80.77	4.03
4	<i>Myrsine Africana</i>	78.85	3.94
5	<i>Rytigynia neglecta</i>	71.15	3.55
6	<i>Helichrysum italicum</i>	69.23	3.46
7	<i>Polyscias fulva</i>	67.30	3.36
8	<i>Dovyalis verrucosa</i>	65.38	3.26
9	<i>Quercus</i> sp.	63.46	3.17
10	<i>Osyris quadripartite</i>	61.53	3.07

According to Lambrecht (1989), frequency is an indicator of a given vegetation type's homogeneity and heterogeneity. The higher number of species in higher frequency classes and lower number of species in lower frequency classes demonstrate homogeneity, while the high number of species in lower frequency classes and low number of species in higher frequency classes demonstrate species heterogeneity.

Based on the frequency value, the woody plant species of the area were classified into five frequency classes. Frequency class A (0-20), B (21-40), C (41-60), D (61-80), E (81-100). Plant species distributed in frequency class E were *Rhus glotinoso*, *Myrsine africana*, *Dodenea aguistifolia*, *Maesa lanceolata*, *Rytigynia neglecta*, *Osyris quadripartita*, *Polyscias fulva*, *Quercus* sp. and *Carissa edulis* which account 28.06 %. Plant species distributed in frequency class D were *Vernonia amygdalina*, *Olea europae*, *Phoenix rec- linata*, *Acacia tortilis*, *Helichrysum italicum*, *Dovyalis verrucosa*, *Rosa abyssinica* and *Juniperus procera* which account 20.05 %. Those species distributed in frequency class C were *Acrachne racemosa*, *Teclea nobilis*, *Rubus steudneri*, *Lippia adoensis*, *Brucea anti- dysitrica*, *Ekebergia capensis*, *Podocarpus falcatus*, *Ficus sychomorus*, *Euclea*

*divinorum*, and *Bersema abyssinica* with 18.48 %. The remaining species were distributed in frequency class B and A having 25.61 % and 7.26 %, respectively.

From the pattern of woody plant species distribution in the five frequency classes, it was shown that there were high number of species in higher frequency classes and low number of species in Lower frequency classes. Legay forest thus has a high level of floristic homogeneity.

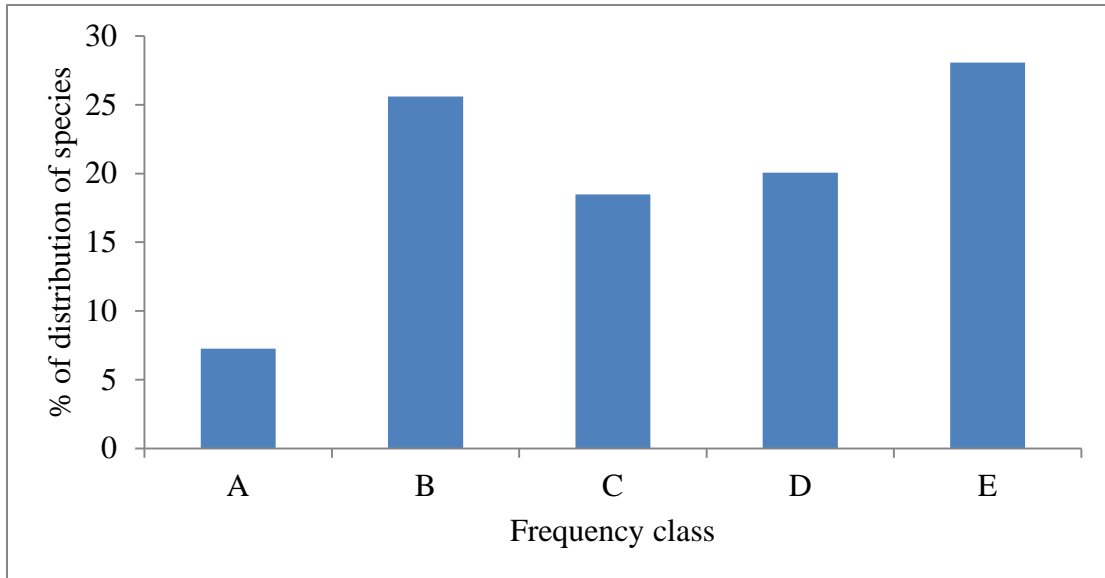


Figure 4. Frequency distribution of woody species in Legay forest

In this study high values were obtained at middle and higher classes (class B and E) and low frequency were obtained in the lower frequency class (Fig.4), indicating that relatively less floristic heterogeneity in the study area.

#### 4.5.2. Tree density

For the description of the structure (density) of Legay forest, woody species with individuals having DBH greater than  $\geq 2.5$  cm and height  $\geq 2$  m were used. The total density of individual trees and shrubs of Legay forest with DBH  $\geq 2.5$  cm and height  $\geq 2$  m was  $342 \text{ ha}^{-1}$ . Those with DBH below 10 cm, between 10 and 20 cm and above 20 cm were 132, 115 and  $95 \text{ ha}^{-1}$ , respectively (Table 5). As Quackenbush *et al.* (2000) indicated, the number of trees or shrubs per unit area is used to describe the density of trees and shrubs also evaluate and figuring out how well they are regenerating.

Table 5. Density of individual tree and shrub species with DBH < 10 cm, between  $\geq 10$  and  $\leq 20$  cm, and > 20 cm and their percentage coverage in the Legay forest

DBH (cm)	Density <sup>-1</sup>	Percentage (%)
<10	132	38.59
$\geq 10$ - $\leq 20$	115	33.62
>20	95	27.77

According to Grubb *et al.* (1963), an indicator of how plants are distributed by size class is the ratio of the density of woody trees and shrubs with DBH between 10 cm and  $\geq 20$  cm and greater than 20 cm. Medium-sized tree and shrub species are represented by individuals with DBH between  $\geq 10$  and  $\leq 20$  cm, whereas large-sized tree and shrub species are represented by individuals with DBH greater than 20 cm. This indicates that for Legay forest, the ratio of medium-sized to large-sized trees (115: 95) was 1.2. This demonstrates that there are more medium-sized individuals of trees and shrubs (DBH between 10 and 20 cm) than large-sized individuals of trees and shrubs. The ratio described as a/b is taken as the measure of size class distribution (Breitenbach, 1963). Legay forest has more trees in the lower DBH classes than in the higher classes when compared to Sinko community forest (Abeje and Belayneh, 2013), Angada forest (Shambel and Ensermu, 2011) and Denkoro forest (Abate *et al.*, 2006) forest. However, the ratio is relatively smaller than the results obtained from Chilimo forest (Dinkissa and Sebsebe, 2011). The proportion of small-sized individuals (DBH <10 cm) was much larger.

The ratio of tree and shrub densities (A/B) Legay forest explains that there are nearly similarities between Dodola, Komto, Wof-Washa, Gelesha and Kimphe lafa natural forest which reported 1.5, 1.53, 1.5, 1.29, 1.36, respectively (Table 6). Legay forest has more medium-sized individual trees and shrubs than Egdu forest which reported 0.8, according to the density ratio value. In comparison, all other forests have a higher density of trees and shrubs than the Legay forest; this indicates that, Legay forests are dominated by trees and shrubs with DBH of lower classes. Legay forest may have fewer tree and shrub individuals in the lower DBH class than almost all other forests in comparison because, large trees are used for various purposes such as house construction, timber and charcoal pro-

duction, also the area is used as grazing land for livestock. Overgrazing by cattle or any other domestic animal, cause the number of seedlings and saplings that will grow into mature trees and shrubs to be damaged during the seedling and sapling stages. The forest is surrounded by the local community and that is the major factor that exposes the forest to overgrazing.

Table 6. Comparison of tree/shrub densities with DBH between 10 and 20 cm and > 20 cm of Legay with other fourteen (14) forests in Ethiopia

Forests	DBH 10-20cm	DBH > 20cm	A/B	References
Komto	330	215	1.53	Fekadu <i>et al.</i> (2010)
Dindin	437	219	1.99	Simon and Girma (2004)
Chato	333	194	1.71	Feyera <i>et al.</i> (2010)
Kimphe Lafa	183.9	135.3	1.36	Kedir <i>et al.</i> (2015)
Egdu	155	197	0.8	Abiyou <i>et al.</i> (2009)
Dodola	521	351	1.5	Kitesa <i>et al.</i> (2007)
Menagesha	529	198	2.67	Dinkissa and Sebsebe (2011)
Chilimo	638	250	2.6	Tamrat (1993)
Gelesha	315.42	244.58	1.29	Bilew <i>et al.</i> (2015)
Bibita	500.5	265.6	1.9	Dereje <i>et al.</i> (2007)
Wof-Washa	329	215	1.5	Tamrat (1993)
Menagesha	484	208	2.3	Tamrat (1993)
Denkoro	526	285	1.9	Abate <i>et al.</i> (2006)
Magada	608	332	1.8	Genene and Reddy (2015)
<b>Legay</b>	115	95	1.21	Present Study

### 4.5.3. Diameter at breast height (DBH)

The DBH distribution pattern of woody plant species indicates the general trend of population dynamics and recruitment status of the species (Haileab *et al.*, 2011). From Legay forest, a total of 1930 individuals of woody plant species were counted, with DBH and heights of  $\geq 2.5$  cm and  $\geq 2$  meters, respectively. The DBH was classified into eight classes for data analysis of the forest. Class I includes individuals with DBH  $< 10$  cm, class II includes individuals with DBH 10.01–20cm, class III individuals with DBH 20.01–40 cm, class IV individuals with DBH 40.01–60 cm, class V individuals with DBH 60.01–80 cm, class VI individuals with DBH 80.1–100 cm, class VII individuals with DBH 100.01–120 cm, class VIII individuals with greater than 120 cm (Fig. 5).

Table 7. Distribution of DBH classes, density  $\text{ha}^{-1}$  and percentage of tree and shrub species in Legay

DBH class	DBH Range(cm)	Density $\text{ha}^{-1}$	Percentage (%)
I.	$< 10$	132	38.59
II.	10.01-20	115	33.62
III.	20.01-40	26	6.51
IV.	40.01-60	20	7.6
V.	60.01-80	16	4.67
VI.	80.01-100	14	4.09
VII.	100.01-120	11	3.21
VIII.	$> 120$	8	2.33

The general pattern of DBH class distribution of the forest was calculated and showed inverted J-shaped distribution (Fig. 5). This DBH class distribution pattern suggests that, the forest has good potential for reproduction. Similar outcomes were reported in Delomenna forest by Motuma (2010), komto forest by Fekadu *et al.* (2010), Chato forest by Feyera *et al.* (2010), Gedo forest by Birhanu *et al.* (2014) and Gendo forest by Teshome *et al.* (2015).

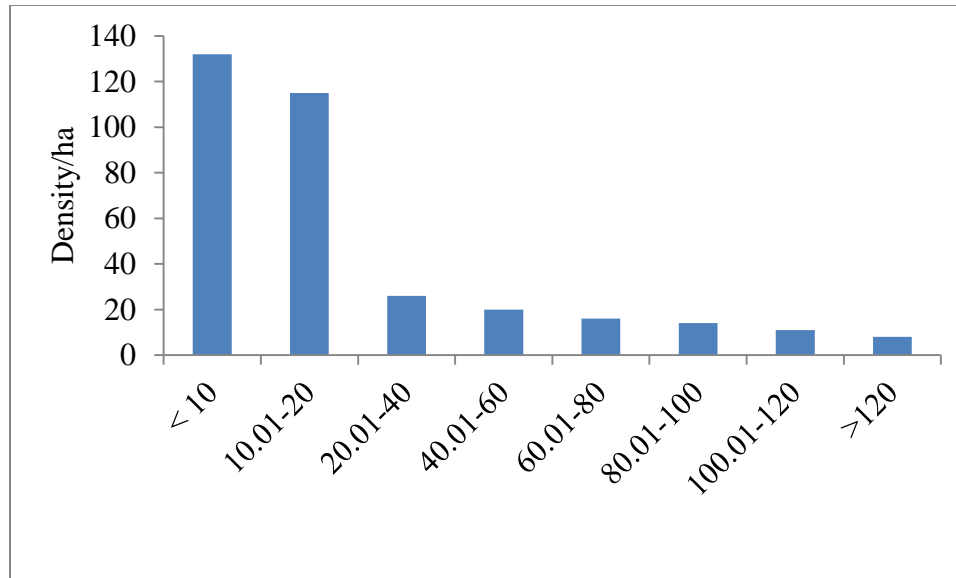


Figure 5. Distribution of DBH (cm) class and density of woody plant species in Legay forest

Individuals of woody plant species decreased significantly from the lower size classes to the higher size classes, according to the DBH analysis of Legay forest. The distribution of all individuals in different DBH size classes was inverted J-shaped. Similar findings have been made by Denkoro forest (Abate *et al.*, 2006), Wanzaye natural forest (Ambachew, 2018), Chato forest (Feyera *et al.*, 2010), Gedo forest (Birhanu *et al.*, 2010), and Wofwasha forest (Gebremicael *et al.*, 2013) and Kimphe lafa forest (Kedir *et al.*, 2015). This inverted J-shaped pattern indicates that the majority of the species had the highest number of individuals in the lower DBH class, indicating that the forest vegetation has good reproduction potential.

The highest number of individuals of woody plant species of the forest was distributed in the DBH class I with 132 individuals  $\text{ha}^{-1}$  (38.59%). The distribution of trees in DBH class II was 115 individuals  $\text{ha}^{-1}$  (33.62%), class III 26 individuals  $\text{ha}^{-1}$  (6.51%), class IV 20 individuals  $\text{ha}^{-1}$  (7.6%), class V 16 individuals  $\text{ha}^{-1}$  (4.67%), class VI 14 individual  $\text{ha}^{-1}$  (4.09%), class VII 11 individual's  $\text{ha}^{-1}$  (3.21%) class VIII 8individuals  $\text{ha}^{-1}$ (2.33%) (Table 7).

#### 4.5.4. Height distribution of woody plant species in Legay forest

The height distribution of trees and shrubs showed similar pattern to DBH distribution in the study area. In Legay forest, 40 plant species and 1930 individuals were used to describe distribution of plant based on the height of the forests. Height of trees and shrubs in the forest was classified into six height classes based on the height of plants in the forest. These classes are: Class I) 1-5 m, Class II) 6-10 m, Class III) 11-15 m Class IV) 16-20 m, Class V) 21-25 m, Class VI) > 26 m (Fig. 6).

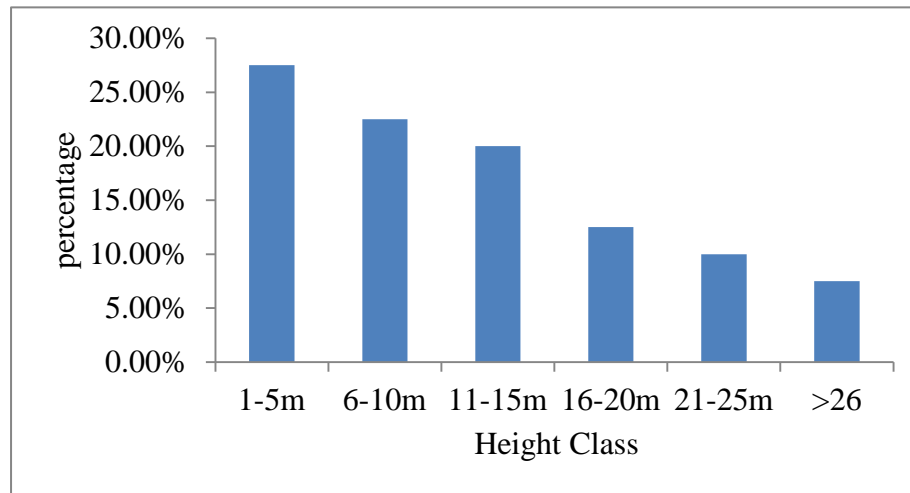


Figure 6. Percentage distribution of height classes of woody plant species in Legay forest

The different growth stages or ages of tree species are reflected in their height. It is a good indicator of a species' role because each one occupies a different layer and practically determines the stand's vertical structure (Pascal and Pelissier, 1996). As indicated in figure 6, as the height of woody plant species in the Legay forest has increased, the numbers of woody plants were decreased. The general pattern of height class distribution in the Legay forest is reversed J-shaped. This demonstrates that the large woody plant species located in the forest are used by the local people for different purposes.

More number of individuals per hectare was seen in the first height class (1-5 m) which account for 27.5% and class (6-10m) accounts 22.5%. This confirms that woody plants of Legay forest are dominated by plant species of lower height classes (class I and II). Plant species under lower class (class I) are *Maesa lanceolata*, *Buddleja davidi*, *Carissa edulis*,

*Rhus glotinososa*, *Ilex mitis*, *Achyranthes aspera*, *Albiza gummifera*, *Justitia schimperiana*, *Dodenea agustifolia*, *Maytenus undata* and *Dovyalis abyssinica*. Trees in height class II (6-10 m), III (11-15 m), IV (16-20 m), V (21-25 m), VI (>26 m) contribute about 27.5, 22.5, 20, 12.5, 10 and 7.5%, respectively (Fig. 6). From the data analysis, trees such as *Podocarpus falcatus*, *Ekebergia capensis*, *Quercus* sp., *Ficus sychomorus*, *Eucalyptus globulus*, *Acacia brevispica*, *Juniperus procera*, and *Olea europae* in the height class of V and VI, and were the dominant in the upper canopy of the forest.

The general pattern of tree height class distribution was decrease from the lower height class to the higher height classes. It is high in the lower height class, decreased in the middle classes and high height classes. From the above data analysis, Legay forest shows similarity with the studies reported in Menagesha Amba Mariam forest (Tilahun, 2009), Menagesha Forests of central plateau of Ethiopia (Tamrat, 1994), Denker forest (Abate *et al.*, 2006) and Wurg forest (Girma and Melesse, 2020) and Angada forest (Shambel and Ensermu, 2011). The distribution of high number of tree species in the lower height classes, and lower number of large tree species in the medium and higher height classes indicate that the low abundance of large trees in the forest (Binyam, 2014). Large trees are used, by the local people as wood for fuel, construction materials (fence and houses) and charcoal production which could be a reason for low abundances of medium and higher height classes of trees.

#### **4.5.5. Basal area and dominance**

The total basal area of Legay forest was about 69.22 m<sup>2</sup> ha<sup>-1</sup> for woody plant species that have DBH ≥ 2.5 cm and height ≥ 2 m. Based on the basal area calculated for each species of the forest, *Ficus sur*, *Podocarpus falcatus*, *Olea europae* was the most important plant species of the forest with basal area 19.79m<sup>2</sup> ha<sup>-1</sup>, 12.93m<sup>2</sup> ha<sup>-1</sup> and 7.57m<sup>2</sup> ha<sup>-1</sup>, respectively (Table 9). Naturally, *Ficus sur* is not used for production of charcoal, as wood for fire and construction materials as well as for timber production. As a result, the basal area of this plant is large in comparison to the other species in the study area. The second plant species with high basal area was *Podocarpus falcatus* which was 12.93m<sup>2</sup> ha<sup>-1</sup>. This may be due to high number of plant species as a result of climate of the area. Other plant species are *Vernonia amygdalina* with 6.47, *Juniperus procera* with 4.16, *Quercus* sp. with

3.59, *Ekebergia capensis* with 3.24, *Phoenix reclinata* with 3.03, *Osyris quadripartite* with 2.87, and *Eucalyptus globules* with 2.69 basal areas in m<sup>2</sup> ha<sup>-1</sup> (Table 8).

Table 8. Basal area and relative basal area of top ten plant species in Legay forest

Species	Basal area	Relative basal area
<i>Ficus sychomorus</i>	19.79	26.15
<i>Podocarpus falcatus</i>	12.93	17.07
<i>Olea europae</i>	7.57	10.00
<i>Vernonia amygdalina</i>	6.47	8.54
<i>Juniperus procera</i>	4.16	5.49
<i>Quercus</i> sp.	3.59	4.74
<i>Ekebergia capensis</i>	3.24	4.28
<i>Phoenix reclinata</i>	3.03	4.00
<i>Osyris quadripartite</i>	2.87	3.79
<i>Eucalyptus globules</i>	2.69	3.56

The basal area of Legay forest is less than Masha Anderacha (Kumelachew and Taye, 2003), Magada (Tamrat, 2005), Dodola (Kitessa *et al.*, 2007), Menna Angetu (Ermias *et al.*, 2008), Menagesha Suba (Dinkissa and Sebsebe, 2011) and Kimphe lafa (Kedir *et al.*, 2015). On the other hand, the basal area for Legay forest is greater than all basal areas of the forests under comparison. From the total basal area of thirteen forests of Ethiopia, five of them (Menagesha Suba, Masha Anderacha, Menna Angetu, Kimphe lafa and Dodola) are greater than that of Legay forest with basal area 158.68, 81.9, 94.22, 114.4 and 129 m<sup>2</sup> ha<sup>-1</sup>, respectively and all the rest forests have basal area lower than Legay forest. This may be due to the presence of plant species with larger stems than those found in the previously mentioned forests (Table 9).

Table 9. Comparison of the basal area of Legay forest with basal areas of other forests in Ethiopia in m<sup>2</sup> ha<sup>-1</sup>

Forest	BA	Author
Menagesha Suba	36.1	Tamirat (1994)
Denkoro	45.0	Abate <i>et al.</i> (2006)
Dindin	49.0	Simon and Girma (2004)
Masha Anderacha	81.9	Kumelachew and Taye (2003)
Magada	68.52	Tamirat (2005)
Menna Angetu	94.22	Ermias <i>et al.</i> (2008)
Bibita	69.9	Dereje <i>et al.</i> (2007)
Wof-Washa	64.32	Gebremicael <i>et al.</i> ,(2013)
Kimphe Lafa	114.4	Kedir <i>et al.</i> (2015)
Menagesha Suba	158.68	Dinkissa and Sebsebe, 2011
Dodola	129	Kitessa <i>et al.</i> (2007)
Legay	71.68	Present study
Gatira George's	7.84	Andualem (2020)
Jibat	60.9	Tesfaye <i>et al.</i> (2013)

#### 4.5.6. Important value index (IVI)

The top ten plant species leading with greatest importance value and dominance in Legay forest were *Carissa edulis*, *Rytigynia neglecta*, *Euclea divinorum*, *Rhus glotinoso*, *dodenea aguistifolia*, *Myrsine africana*, *Polyscias fulva*, *Maesa lanceolata*, *Acrachne racemosa* and *Osyris quadripartite* in relative to other species of the area. According to Getahun (2014); Simon and Girma (2004), species with less than 10 ranks in the IVI values needs appropriate conservation measures. On other way, top ten plant species that need high priority for conservation and management in the Legay forest were *Croton macrostachyus*, *Stephania abyssinica*, *Buddleja davidi*, *Erica arborea*, *Cupressus lusitanica*, *Dovyalis abyssinica*, *Solanum incanum*, *Asparagus acutifolias* and *Salvia officinalis* based on their IVI (Table 10).

Table 10. The IVI for all species of the forest with their corresponding relative frequency, relative density and relative dominance in Legay forest

Scientific name	RF	RD	RDO	IVI
<i>Acacia abyssinica</i>	0.67	0.21	0.62	1.51
<i>Acacia brevispica</i>	0.88	0.41	0.92	2.20
<i>Acacia tortilis</i>	2.42	1.25	1.01	4.69
<i>Acanthus eminens</i>	0.88	0.25	0.56	1.69
<i>Albiza gummifera</i>	1.14	0.64	1.09	2.88
<i>Asparagus acutifolias</i>	0.54	0.10	0.37	1.01
<i>Bersema abyssinica</i>	2.09	1.05	0.98	4.12
<i>Brucea antidysitrica</i>	1.89	2.45	2.54	6.88
<i>Buddleja davidi</i>	0.67	0.15	0.42	1.24
<i>Caesalpinia decapetala</i>	1.28	0.91	1.39	3.58
<i>Carissa edulis</i>	3.30	9.80	5.80	18.91
<i>Clausena anisata</i>	1.35	1.45	2.10	4.89
<i>Croton macrostachyus</i>	0.74	0.16	0.42	1.31
<i>Cupressus lusitanica</i>	0.67	0.14	0.41	1.22
<i>Dodenea agustifolia</i>	2.83	5.06	3.50	11.39
<i>Dovyalis abyssinica</i>	0.67	0.13	0.39	1.20
<i>Dovyalis verrucosa</i>	2.63	1.66	1.23	5.52
<i>Ekebergia capensis</i>	1.89	0.83	0.86	3.58
<i>Erica arborea</i>	0.67	0.14	0.41	1.22
<i>Eucalyptus globules</i>	0.81	0.82	1.98	3.61
<i>Eucalyptus gomphophocephala</i>	0.81	0.22	0.53	1.56
<i>Euclea divinorum.</i>	2.02	5.15	4.98	12.14
<i>Ficus sychomorus</i>	1.95	0.62	0.62	3.19
<i>Helichrysum italicum</i>	2.63	3.20	2.38	8.21
<i>Hypericum revolutum</i>	0.94	0.83	1.72	3.50
<i>Ilex mitis</i>	1.08	0.47	0.85	2.39
<i>Jasminum abyssinicum</i>	0.88	0.27	0.60	1.75

<i>Juniperus procera</i>	2.76	1.68	1.19	5.62
<i>Justitia schimperiana</i>	0.88	0.75	1.67	3.29
<i>Lippia adoensis</i>	1.75	2.42	2.70	6.88
<i>Maesa lanceolata</i>	2.96	4.26	2.81	10.03
<i>Maytenus undata</i>	1.08	2.02	3.67	6.77
<i>Momordica foetida</i>	0.94	0.24	0.50	1.69
<i>Myrsine Africana</i>	3.43	4.42	2.51	10.37
<i>Ocimum lamifolium</i>	0.47	0.24	1.00	1.72
<i>Olea capensis</i>	1.14	0.29	0.50	1.94
<i>Olea europae</i>	2.29	1.69	1.44	5.42
<i>Opuntia ficus-indica</i>	0.67	0.30	0.88	1.86
<i>Osyris quadripartite</i>	3.03	3.27	2.11	8.41
<i>Periploca linearifolia</i>	0.88	0.47	1.04	2.38
<i>Phoenix reclinata</i>	2.36	0.51	0.42	3.28
<i>Phytolaca dodecandra</i>	1.14	1.32	2.25	4.71
<i>Podocarpus falcatus</i>	1.95	2.92	2.92	7.79
<i>Polyscias fulva</i>	3.23	4.31	2.61	10.15
<i>Quercus sp.</i>	3.23	2.38	1.44	7.05
<i>Rhamnus prinoides</i>	0.94	0.33	0.68	1.94
<i>Rhus glotinos</i>	3.43	5.09	2.89	11.42
<i>Rosa abyssinica</i>	2.69	1.97	1.43	6.09
<i>Rubus steudneri</i>	1.75	2.78	3.11	7.64
<i>Rumex nervos</i>	0.81	0.19	0.45	1.44
<i>Rytigynia neglecta</i>	3.03	6.79	4.38	14.20
<i>Salvia officinalis</i>	0.47	0.10	0.42	0.99
<i>Smilax aspera</i>	0.94	0.59	1.22	2.76
<i>Solanum incanum</i>	0.54	0.12	0.45	1.11
Total	100	100	100	100

Where RF= Relative frequency, RD= Relative density, RDO= Relative dominance, IVI= Important value index

#### 4.5.7. Vertical structure of the forest

The vertical structure of the Legay forest was described, and three vertical structures were identified in forests using the International Union for Forestry Research Organization classification system (Lamprecht, 1989). The three vertical structures are lower storey, middle storey and upper storey. The forest was also subdivided into three different vertical height storeys for the purposes of the study. The upper storey has tree heights > 2/3 of top height, the middle storey has tree heights between 1/3 and 2/3 of top height and the lower storey has tree heights < 1/3 of top height. Trees were classified into their respective storeys based on their height. The tallest of all trees in Legay forest was *Podocarpus falcatus* with 40 m height. Hence, trees contained under lower, middle and upper storey were those having height ranges < 10.5 m, 10.5 - 21 m and > 21 m, respectively (Table 11).

Table 11. Density, number of individual plants and percentage of Legay forestStoreys

Story	Density ha <sup>-1</sup>	No. of trees	Percentage (%)
Lower	196.2	1105	57.25
Middle	94.3	535	27.72
Upper	51.5	290	15.02

The middle storey (10.5-21 m) contained 94.3 individuals of trees and shrubs ha<sup>-1</sup> (27.72%) (Table 11). The plant species occupied the middle storey were *Osyris quadripartita* (9.21%), *Croton macrostachyus* (8.02%), *Olea europae* (7.28%), *Podocarpus falcatus* (6.67%), *Vernonia amygdalina* (4.38%), *Syzygium guineense* (3 %), and *Dovyalis verrucosa* (2.75%).

The upper storey (>21m) of the forest was composed of 51.5 individuals of trees ha<sup>-1</sup> (15.02%) (Table 11) and tree species dominated this storey were *Podocarpus falcatus* (8.7%), *Olea europea* (7.34%), *Juniperus procera* (6.8%), *Ficus Sychomorus* (10.34%), *Quercus* sp. (5.49%) and *Acacia tortilis* (2.80%). Generally, percentage distributions of plants in legay forest were 57.25, 27.72 and 14.02% in lower, middle and upper storeys,

respectively (Fig. 7). Lower in number in the upper storey indicate that the larger plants were used by the local people for different purpose (Getahun and Anteneh, 2016).

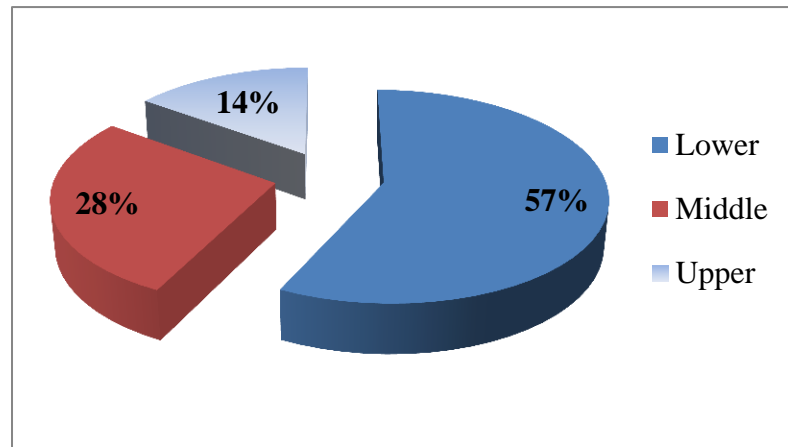


Figure 7. Percentage distribution of trees and shrubs in the three storey in Legay forest.

#### 4.6. Regeneration status of Legay forest

Regeneration status of woody species of forests was analyzed by comparing the density values of seedlings, saplings and matured plants. Presence of sufficient number of seedlings, saplings and adult plant species shows good regeneration status of a forest and predicts the future floristic composition of that forest (Dhaulkhandi *et al.*, 2008). According to Dhaulkhandi *et al.* (2008) and Tiwari *et al.* (2010), the regeneration status is good, if seedlings > saplings > adults; fair regeneration, if seedlings > or  $\leq$  saplings  $\leq$  adults. As the above mentioned authors stated, the regeneration status is poor regeneration, if the species survives only in sapling stage, and if a species is present only in an adult form it is considered as not regenerating.

Analysis of seedlings and saplings of Legay forest indicated that the total density of seedlings and saplings of woody plants species of the forest were 570.29 and 407.77 ha<sup>-1</sup>, respectively and that of mature individuals was 261.81 ha<sup>-1</sup> (Fig.8). Beside the anthropogenic activities in and in surrounding the forest, the present results indicate that the regeneration status Legay forest is categorized under the status of good (Dhaulkhandi *et al.*, 2008).

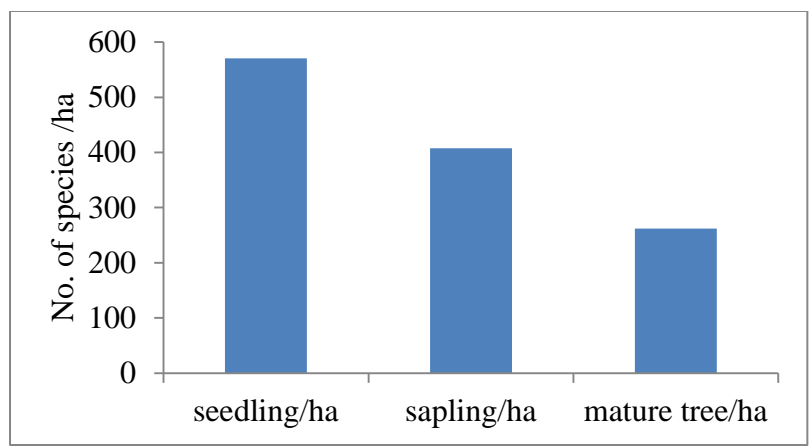


Figure 8. Density ha<sup>-1</sup> of seedlings, saplings and mature trees of Legay forest

Similarly, the density of mature woody tree, seedlings and saplings of plant species were 157, 475.8 and 310 ha<sup>-1</sup>, respectively. The density of mature individuals, seedlings and saplings of shrub species were 99.8, 152 and 109.6 ha<sup>-1</sup>, respectively and the density of mature individuals, seedlings and saplings of lianas were 9.4, 41.8 and 12.3 ha<sup>-1</sup> respectively (Fig.9).

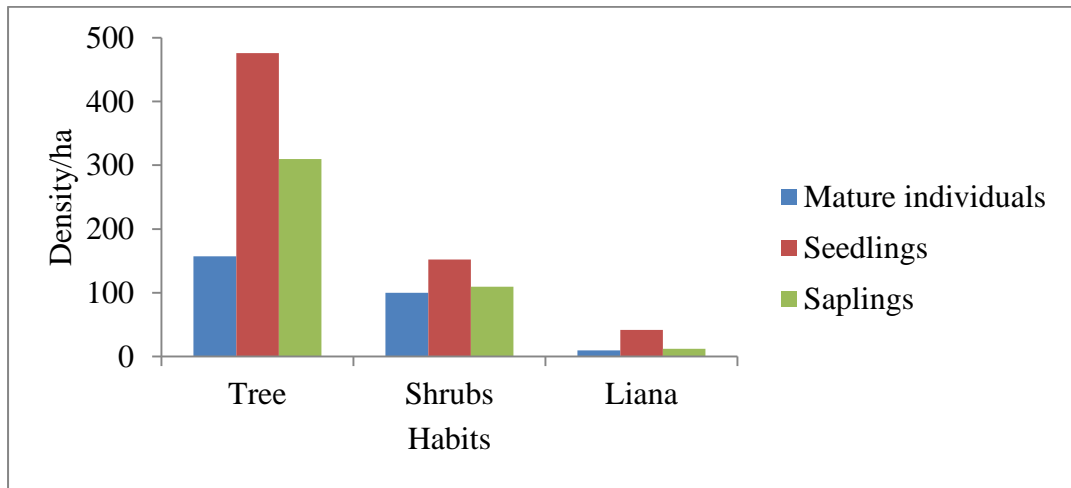


Figure 9. Mature individuals, seedling and sapling distribution of woody species in Legay forest

The density of seedlings and saplings of the study forest is greater than matured trees (Fig. 9). This indicates that the regeneration potential of Legay forest is good due to the high potential of the forest for regeneration. The ratio of seedlings to saplings was 1.39, seedlings to mature trees were 2.17 and saplings to mature trees were 1.6 (Fig. 9). These shows that the distribution of seedlings as a whole is greater than that of saplings and mature trees and that of saplings is greater than mature trees. This ratio value indicates that the number of seedlings and saplings being regenerated in the forest is almost more than matured trees of the forest. Therefore the regeneration status is good, because the regeneration status of seedlings more than saplings and that of sapling is more than adults.

Based on the number of seedlings and saplings of woody plant species counted from all 52 sample plots, they were divided into four classes (class I, II, III and IV). This was done for prediction of which plant species could be the dominant in the future, which plant species need special conservation measures and which plant species is in risk of extinction. Class I includes the number of seedlings and saplings > 200, Class II includes number of seedlings and saplings 100-199, Class III includes number of seedlings and saplings 1-99 and Class IV include number of plant species that do not have any seedling and sapling from the area.

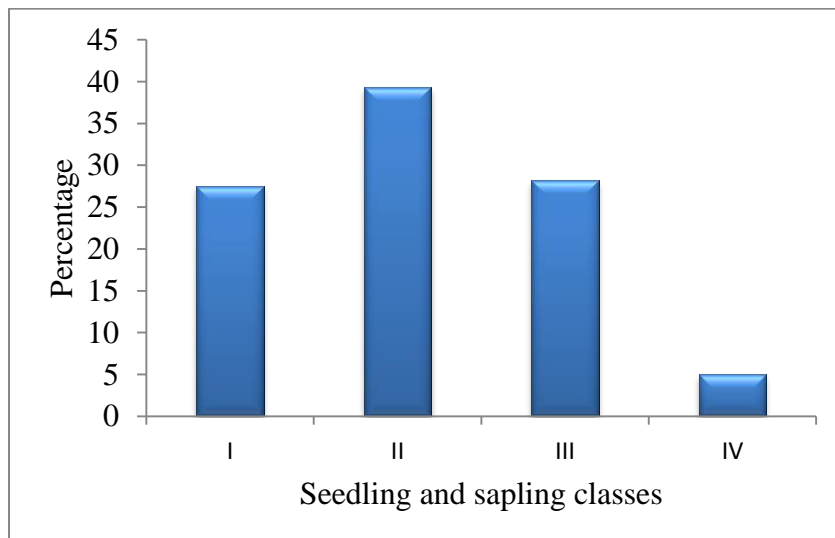


Figure 10. Percentage distribution of seedlings and saplings of woody plant species of four classes in Legay forest

Woody plant species under class I cover about 27.51% of all woody plant species of the area, and the top plant species under this class include *Podocarpus falcatus*, *Juniperus procera*, *Dodenea agustifolia*, *Olea capensis* and *Euclea divinorum*. Class II covers about 39.27% of woody plant species, and these include *Phoenix reclinata*, *Rhus glotinos*, *Ficus sychomorus*, *Acacia tortilis* and *Acacia abyssinica*. Class III covers about 28.22% and includes woody plant species like *Dovyalis verrucosa*, *Rytigynia neglecta*, *Osyris quadripartita*, *Quercus* sp. and *Maytenus undata*. Class IV, plant species with no any seedling and sapling covers about 5 % of woody plant species. This class has four plant species were *Ekebergia capensis*, *Teclea nobilis*, *Bersama abyssinica* and *Brucea antidysitrica*. Based on this classification, special conservation priority should be given to plant species classified under class IV (Fig.10).

#### **4.6.1. Regeneration patterns of some selected woody plant species in Legay forest**

Population structures of trees have significant implications to their management, sustainable use and conservation (Simon and Girma, 2004). One of the effective criteria for successful conservation and management of the forest resources are determining the regeneration status of the forest on the basis of the composition, distribution and density of seedling and sapling (Demel, 2005). Some selected plant species with high density of seedlings and saplings were analyzed from the study area. *Podocarpus falcatus* had the highest density of seedlings and saplings which was 182.7 individual/ ha<sup>-1</sup> followed by *Juniperus procera*, *Vernonia amygdalina*, *Quercus* sp. and *Acacia abyssinica* with density of 142, 127.22, 104 and 98.4 individuals' ha<sup>-1</sup>, respectively (Fig.11). On the other hand, plant species with no seedlings and saplings were encountered from the study area, which need high priorities for conservation. These species were *Ekebergia capensis*, *Teclea nobilis*, *Bersama abyssinica* and *Brucea antidysenterica*. These species with no seedling and sapling (with poor regeneration) might be caused by due to the human impacts (Bhuyan *et al.*, 2003).

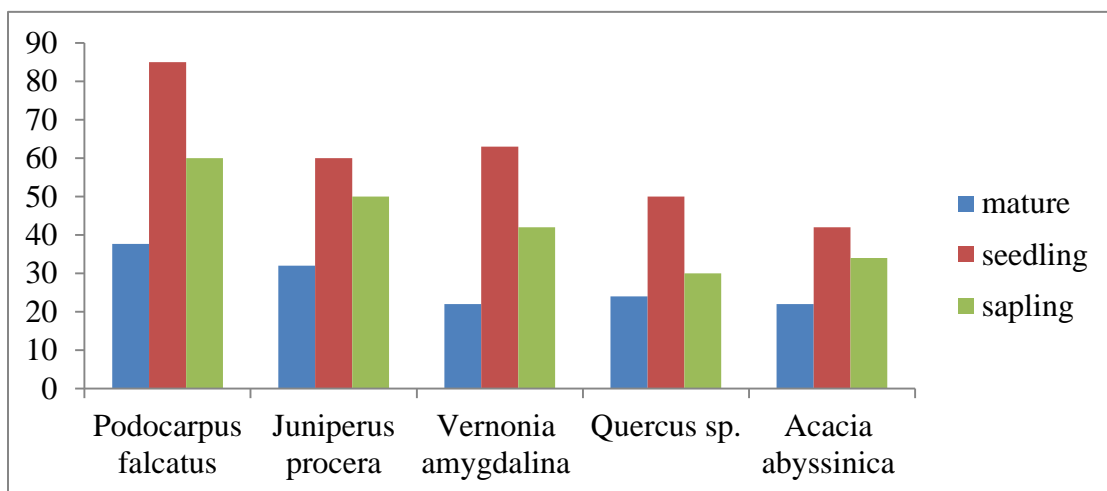


Figure 11. Regeneration patterns of some selected woody with high number of seedlings and saplings in Legay forest

The regeneration patterns of selected woody mature, seedling and sapling plant species in Legay forest (*Podocarpus falcatus*, *Juniperou sprocera*, *Vernonia amygdalina*, *Quercus sp.* and *Acacia abyssinica*) shows that inverted J-shape (Fig. 11). The above mentioned plant species has a large number of individuals at seedling stage and smaller number at sapling stage and mature stage, which typical J in verted curve and it indicates that these species have a high capacity for regeneration. Awoke *et al.* (2023) indicated that inverted J curve happens in the case of environmental factors when increase to stimulate germinating and the local people have selectively cutting the mature trees in the area.

#### 4.7. Phytogeographical Comparison with similar forests

According to Tadesse (2003), direct comparison of species diversity among forests is impossible due to differences in factors like size of forests, survey methods and objective of the study. However, the overall species richness of the forest can give more or less a general impression of diversity and phytogeographical similarity between the forests in comparison (Tadesse, 2003). The Legay forest was compared with other six (6) montane forests of the country. The six montane forests (3 dry evergreen and 3 moist montane) of

Ethiopia compared with Legay forest were, Gemmechis, Debrelibannos, Ades, Chato, Gendo and Webero forests (Table 12).

Ades natural forest, located in Oromia Regional State at Western Harerge Zone, 371 Km from Addis Ababa, to the Eastern part of Ethiopian. The area has an average altitude of 1600 - 3100 m. a.s.l. The area is mainly covered by an irregular topography with depressions, numerous chain mountains, flat lands, gorges scattered trees and dense shrubs of patch natural vegetation (Dereje and Duguma, 2019).

Gemechis mountain forest which is located, in West Hararghe Zone of Oromia National Regional State, Ethiopia. The forest is located between the geographical coordinates of 34°18'43"- 43° 04' 33" E longitude and 10° 09' 24"- 30° 18' 43"N. The altitude of this forest ranges between 2,118 and 3,017 m. a.s.l. (Sudi *et al.*, 2018).

Debrelibanos forest is located in north Shewa, Ethiopia with geographical location of 09°43' 30" N longitudes and 38°51'0"E latitudes. It has an altitudinal range of about 2400 - 2560 m a.s.l. (Getachew *et al.*, 2013).

Gedo forest is located in Cheliya District, West Shewa Zone of Oromia National Regional State. The northwestern part of the District is covered with hilly slopes and mountainous escarpments rising to an elevation of about 1300 - 3060 m.a.s.l at Tullu Jarso Mountain. The study area District lies approximately between latitudes 9° 02' and 9° 01' North and longitudes 37° 25' and 37° 16' East (Birhanu *et al.*, 2010).

Wabero forest, which is located in Dello-mena district of Bale zone of Oromia Regional National State. The forest is located between 6° 27' 24" to 6° 31' 673" N latitude and 39° 42' 883" to 53° 26' 320" E. Its altitudinal range is between 1500-2500 m above sea level. The mean annual rainfall of the area is 700 mm. The mean annual minimum and maximum temperatures of the area ranges between 21 and 38°C while the mean annual temperature is about 29.5°C (Nigatu *et al.*, 2019).

Chato natural forest which is located in the Horo –Guduru Wollega Zone of Oromia National Regional State, Ethiopia. The forest lies approximately between 9° 40' - 9°42' N latitudes and 36° 59' -37° 00'E longitudes. This forest is located along altitudinal ranges

between 1700 m and 2350 m a.s.l and covers an area of about 42,000 hectares, of these 18, 000 ha is the natural forest (Feyera *et al.*, 2010).

The Sorensen's similarity index calculated for all the forests in comparison with Legay forest ranged 0.12-0.37 from the lowest to highest in similarity. The calculated similarity indices of Ades, Gemmechis, Debrelibannos, Webero, Gendo and Chato forests were 0.37, 0.36, 0.33, 0.29, 0.18 and 0.12, respectively (Table 12). Ades, Gemmechis and Debrelibannos forests; those categorized under the dry evergreen montane forests, showed the highest similarity with Legay forest in species composition. High similarity of forests in species composition is attributed due to similarities in environmental factors like climate, altitude and geographical attributes, and similar climate condition may have resulted in a similarity in terms of species composition (Demel and Tamrat, 1995; Tadesse Woldemariam, 2003). Based on the results obtained from Sorensen's similarity index analysis, Legay forest is categorized as one of the dry ever green montane forests of Ethiopia.

Table 12. Sorensen’s coefficient of plant species between Legay and other six montane forests of Ethiopia.

S.No	Forests	Altitude (m)	A	B	C	Ss	Ss(%)	Authors
1	Ades	1600 – 3100	15	36	15	0.37	37	Dereje and Duguma (2019)
2	Gemechis	2118 – 3017	17	35	24	0.36	36	Sudi <i>et al.</i> (2018)
3	Debreli- banos	2400 – 2560	13	40	13	0.33	33	Getachew <i>et al.</i> (2013)
4	Webero	1500 – 2500	12	41	18	0.29	29	Nigatu <i>et al.</i> (2019)
5	Gedo	2180 – 2300	16	50	92	0.18	18	Birhanu <i>et al.</i> (2010)
6	Chato	1700 – 2350	10	56	88	0.12	12	Feyera <i>et al.</i> (2010)

Where; “A” represents species that is present in both Legay and the forest under comparison, “B” represents species that are unique to Legay forest, “C” represents species that are unique to the forest under comparison to Legay, and Ss is Sorensen's similarity coefficient.

#### 4.8. Some indicators of forest disturbances in Legay forest

During the study period, the researchers observed human impacts as major threats to the vegetation composition in the legay forest. In addition, very poor protection and management of the forest was also seen during the stay in the forest for data collection. As a result, Legay forest is exposed for complicated factors highly threatening it. The local people live the area damage the forest for different purposes; such as grazing of cattles, charcoal production, timber production, and expansion of farm land, fire wood, and construction materials are among the main factors threatening the forest (Plate 1-5).



Plate 1. The stump of *juniperous procera* in the legay forest



Plate 2. Regrowing spp. (*Syzygium guineense* and *Podocarpus falcatus*) in the Legay forest.



Plate 3. Location of charcoal production and collection of wood for charcoal production in the Legay forest



Plate 4. Wood extraction (logging or harvesting wood for different purposes) in the Legay forest.



Plate 5. The burning the forest and some of the burned plant species in the forest (*Junierus procera*, *Ficus sychomorus* and *Carissa edulis*).

## 5. CONCLUSIONS AND RECOMMENDATIONS

### 5.1. Conclusions

A total 57 species were recorded which belonging to 54 genera and 42 families. From the total species, 21 species were trees, 13 were shrubs, 3 species were climbers and 3 species were lianas. Shrubs were dominant in terms of species richness and followed by tree species. At a family level, Fabaceae was the most dominant followed by Asteraceae, Lamiaceae, Myrtaceae, Oleaceae and Rosaceae. *Carissa edulis* was the most frequent plant species in Legay forest followed by *Rhus glotinoso*, *Maesa lanceolata*, *Myrsine africana*, *Rytigynia neglecta*, *Helichrysum italicum* and *Polyscias fulva*.

The diameter at breast height (DBH) and height results indicate that all individuals in different DBH and height classes showed an inverted J-shaped distribution in the Legay forest. This pattern indicates that the majority of the species had the highest number of individuals in lower DBH and height classes which in turn show that the forest vegetation has good reproduction potential. Legay forest had highest density in the lower DBH and height classes. Analysis of seedlings and saplings of the forest also indicated that Legay forest is regenerating.

Importance value index (IVI) indicate that *Carissa edulis*, *Rytigynia neglecta*, *Euclea divinorum*, *Rhus glotinoso* and *Dodenea agustifolia* were the top plant species leading with greatest importance value and dominance in Legay forest in relative to other species. However, *Croton macrostachyus* *Stephania abyssinica*, *Buddleja davidi*, *Erica arborea*, *Cupressus lusitanica*, *Dovyalis abyssinica*, *Solanum incantum*, *Asparagus acutifolias* and *Salvia officinalis* were least in number and need high priority to conserve and manage them in the forest.

## 5.2. Recommendations

Based on the finding of the present study; the following activities of continuous monitoring and further investigations are recommended:

1. The local people should be aware about the importance of the forest, and encouraged to grow trees in the area where a land surface is defforested to provide the forest with a buffer zone.
2. The mechanisms by which human impacts can be minimized like discussion and experience sharing and the community participatory forest management should be created.
3. In order to promote the regenerationof woody species naturally in forest, it is necessary to reduce livestock grazing, tree cutting, making charcoal, enchroachment and others human disturbances.
4. As a starting point which could be used for the management and conservation of the forest, the current study identified the floristic composition, structure, and regeneration of the forest. Further research is recommended to conduct on the soil seed banks, distributions of plant species along gradient and carbon stock are recommended.
5. In addition, previous studies on floristic composition, structure and regeneration status of plant species in Legay forest were not available. Therefore, the data recorded in the present study may serve as benchmark information for future studies.

## 6. REFERENCES

- Abate Ayalew, Tamrat Bekele and Sebsebe Demissew (2006). The undifferentiated afro-montane forest of Denkoro in the central highland of Ethiopia: A floristic and Structural Analysis. *SINET: Ethiopian Journal of Science*. **29**(1): 45-56.
- Abdulbasit Hussein and Tasisa Temesgen (2022). Woody species diversity and population structure of Gola natural vegetation, Eastern hararge zone, Oromia, Ethiopia. *Biosc.Biotech.Res.Comm.* 2022; 15(1)
- Abeje Zewdie and Belayneh Ayele (2013). *Assessment of diversity and structure of woody plant species and land cover changes of Sinko community forest, Fogera district, Northwestern Ethiopia*. M.Sc. Thesis, Bahir Dar University, Ethiopia.
- Abiyot Tilahun, Teshome Soromessa, Ensermu Kelbessa and Abyot Dibaba (2009). *Floristic composition and structure of vegetation in Menagesha Amba Mariam Forest in Central highlands of Ethiopia*. M.Sc. Thesis, Addis Ababa University, Addis Ababa, Ethiopia.
- Abyot Dibaba, Teshome Soromessa, Ensermu Kelbessa and Abiyot Tilahun (2014). Diversity, Structure and Regeneration Status of the Woodland and Riverine Vegetation of Sire Beggo, Eastern Ethiopia. *Momona Ethiopian Journal of Science*. **6**(1): 70-96.
- Admassu Addi, Teshome Soromessa and Tura Bareke (2020). Plant diversity and community analysis of Gesho and sayilem forest in kaffa zone, Southwestern Ethiopia. *Journal of biodiversity*. **21**(7): 2878-2888.
- Ambachew Getnet (2018). Woody species composition, diversity and vegetation structure of Wanzaye dry afro-montane forest. *Journal of agriculture and ecology resource international*. **60** (3): 1 – 20.
- Andualem Ayalew (2020). Floristic composition and vegetation structure of Gatira Georges forest Habru Woreda North Eastern, Ethiopia. *Black sea journal of agriculture*. **3**(10): 6-16.
- Awoke Kassaw, Ramaraj, M. and Endale Adamu (2023). Composition and structural analysis of woody plant species in Jib godo natural forest, Farta district, South Gondar zone, Amhara region, Ethiopia. *International journal of forestry research*. Open research access.

- Bhuyan, P. Khan, M. and Tripathi, R. (2003). Tree density and population structure in un disturbed and human impacted stands of tropical wet evergreen forest in Arunachal Pradesh, Eastern Himalayas, India. *Biodiversity and conservation*. **12**: 1753-1773.
- Bilew Alemu, Kitessa Hundera, and Balcha Abera (2015). Floristic and structural analysis Gelesha forest, Gambella regional state, Southwest Ethiopia. *Journal of ecology and the natural environment*. **7**(7): 218-227.
- Binyam Alemu (2014). The role of forest and soil carbon sequestrations on climate change mitigation. *Journal of Environment and Earth Science*. **4**: 98–111.
- Birhanu Kebede, Teshome Soromessa and Ensermu Kelbessa (2010). *Floristic Composition and Structural Analysis of Gedo Dry Evergreen Montane Forest, West Shewa Zone of Oromia National Regional State, Central Ethiopia*. M.Sc. Thesis, Addis Ababa University, Addis Ababa, Ethiopia.
- Birhanu Kebede, Teshome Soromessa and Ensermu Kelbessa (2014). Structural and regeneration status of Gedo dry evergreen montane forest, West Shewa zone of Oromia national regional state, central Ethiopia. *Science, technology and Arts Research journal*. **3**(2): 119 - 131.
- Breitenbach, V. (1963). Forests and woodlands of Ethiopia: A geobotanical contribution to the knowledge of the principal plant communities of Ethiopia with special regard to forestry. *Journal of Life, Earth & Health Sciences*. **1**: 5–16.
- Curtis, J.T. And McIntosh, R.P. 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*. **31**: 434 - 455.
- Demel Teketay (2002). Country brief. **In**: *State of forests and forestry research in Ethiopia*. Indicators and tools of restoration and sustainable management of forests in east Africa.
- Demel Teketay (2005). Seed Ecology and Regeneration of Dry Afrotomontane Forest in Ethiopia: II. Forest disturbances and succession. *Tropical ecology*. **46**(1): 45 – 64.
- Dereje Atomsa and Duguma Dibbisa (2019). Floristic composition and vegetation structure of Ades forest, Oromia regional state, West Hararghe zone, Ethiopia. *Tropical Plant Research*. **6**(1): 139 – 147.

- Dereje Denu, Sebsebe Demissew and Zerihun Woldu (2007). *Floristic composition and Ecological Study of Bibita Forest (Gura Ferda), Southwest Ethiopia*. M.Sc. Thesis, Addis Ababa University, Addis Ababa, Ethiopia.
- Dhaulkhandi, M., Dobhal, A., Batt, S. and Kumar, M. (2008). Community structures and regeneration potential of Natural Forest site in Gangotri, India. *Journal of Basic and Applied sciences*. **4**(1): 49 – 52.
- Dinkisa Beche and Sebsebe Demissew (2011). *Floristic Composition, Diversity and Structure of Woody Plant Species in Menagesha Suba State Forest, Central Ethiopia*, M.Sc. Thesis, Addis Ababa University, Addis Ababa, Ethiopia.
- EMSA (2023). *Rainfall and temperature data for Seden Sodo District*. Ethiopian Meteorological Services Agency. Addis Ababa, Ethiopia.
- Ensermu Kelbessa and Teshome Soromessa (2008). Interfaces of Regeneration, Structure, Diversity and Use of Some Plant Species in Bonga Forest: A Reservoir for Wild Coffee Gene Pool. *SINET: Ethiopian Journal of Science*. **31**: 121–134.
- Ermias Lulekal, Ensermu Kelbessa, Tamrat Bekele and Haile Yineger (2008). Plant species composition and structure of the mana angetu moist montane forest, south-eastern Ethiopia. *Journal of East African Natural History*. **97**(2): 165-185.
- Eyasu Chama and pattnaik, S. (2016). Community dynamics and floristic composition of natural vegetation in Abaya Hamassa, rift valley of Ethiopia.
- FAO (2001). *State of the World's Forests*. Food and Agriculture Organization, Rome, Italy.
- FAO (2007). *State of the World's Forests*. Food and Agriculture Organization, Rome, Italy.
- FAO (2010). *State of the World's Forests*. Food and Agriculture Organization, Rome, Italy.
- FDRE (2011). Ethiopia's Climate-Resilient Green Economy Strategy, Addis Ababa: Federal Democratic Republic of Ethiopia.
- Fekadu Gurmessa, Ensermu Kelbessa and Teshome Soromessa (2010). *Floristic Composition and Structural Analysis of Komto Afromontane Rainforest, East Wollega Zone of Oromia Region, West Ethiopia*, M.Sc. Thesis, Addis Ababa University, Addis Ababa, Ethiopia.

- Feyera Abdena, Sileshi Nemomsa and Feyera Senbeta (2010). *Floristic composition and structure of vegetation of Chato Natural Forest in Horo Guduru Wollega Zone, Oromia National Regional State, west Ethiopia*, M.Sc. Thesis, Addis Ababa University, Addis Ababa, Ethiopia.
- Feyera Senbeta and Denich, M. (2006). Effects of wild coffee management on species diversity in the Afromontane rainforests of Ethiopia. *Forest Ecology and Management*. **232**(3): 68-74.
- Feyera Senbeta and Demel Teketay (2003). Diversity, Community types and Population Structure of Woody plants in Kimphee Forest, a virgin Nature Reserve in Southern Ethiopia. *Ethiopian Journal of Biological Sciences*. **2**: 169–187.
- Fikadu Erenso, Melesse Maryo and Wendawek Abebe (2014). Floristic composition, diversity and vegetation structure of woody plant communities in Boda dry evergreen Montane Forest, West Showa, Ethiopia. *International Journal of Biodiversity and Conservation*. **6**(5): 382-391.
- Friis, I. (1992). *Forests and Forest Trees of Northeast Tropical Africa: Their Natural Habitats and Distribution patterns in Ethiopia, Djibouti and Somalia*. Kew Bulletin Additional Series XV, Her Majesty's Stationary Office (HMSO), London, England.
- Friis, I., Sebsebe Demissew and van Bruegel, P. (2010). *Atlas of the Potential Vegetation of Ethiopia*. The Royal Danish Academy of Science and letters, Biologiske Skrifter 58 P.
- Gebremicael Fisaha, Kitesa Hundera and Gemedo Dalle (2013). Woody plants' diversity, structural analysis and regeneration status of Wof Washa natural forest, Northeast Ethiopia. *African Journal of Ecology*. **51**(4): 599-608.
- Genebe Bekele and Reddy, R. (2015). Study of vegetation composition of Magada forest, Borana zone, Oromia, Ethiopia. *Universal journal of plant science*. **3**(5): 87 – 96.
- Gessesse Dessie, Carl, Ch., Johan, K. and Peter, K. (2007). *Forest decline in South Central Ethiopia extent, history and process*. 4r5 dissertation. University of Stockholm, Sweden.
- Getachew Demie, Mulgeta Lemenih and Belliethanthan, S. (2013). Plant Community Types, Vegetation Structure and Regeneration Status of Remnant Dry Afromon

- tane Natural forest Patch within Debrelibanos Monastery, Ethiopia. Open research access.
- Getachew Demie, Mulugeta Lemenih and Satishkumar Belliethanthan (2013). Plant community types, vegetation structure and regeneration status of remnant dry afro-montane natural forest patch forest within Debrelibanos Monastery, Ethiopia. Open research access e70081972.
- Getahun Yakob and Anteneh Fekadu (2016). Diversity and Regeneration Status of Woody Species: the case of keja Araba and Tula Forest, South West, Ethiopia. **3**(4): 1-15.
- Girma Boz and Melesse Maryo (2020). Woody species diversity and vegetation structure of Wurg forest, South West Ethiopia. *International journal of forestry research*. **2020**: 17.
- Greig-Smith, P. (1983). Pattern in vegetation. *Journal of Ecology*. **67**(3): 755–779.
- Grubb, P., Lloyd, J., Pennington, J. and Whitmore, J. (1963). A comparison of montane and lowland rain forest in Ecuador. The forest structure, physiognomy and floristic. *Journal of Ecology*. **51**: 567–601.
- Haile Yineger, Ensermu Kelbessa, Tamrat Bekele and Ermias Lulekal (2008). Floristic composition and structure of the dry afro-montane forest at bale mountains national park, Ethiopia. *SINET: Ethiopian Journal of Science*. **31**: 103-120.
- Haileab Zegeye, Demel Teketay and Ensermu Kelbessa (2011). Diversity and regeneration status of woody species in Tara Gedam and Ababay forests, Northwestern Ethiopia. *Journal of Forestry Research*. **22**(3): 315.
- Hosonuma, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L. and Romijn, E. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*. **7** (4): 044009.
- Hunter, M., Smith, R., Schipanski, M., Atwood, L. and Mortensen, D. (2017). Agriculture in 2050: recalibrating targets for sustainable intensification. *Bioscience*. **67**(4): 386-391.
- IBC (2005). National Biodiversity Strategy and Action Plan. Addis Ababa, Ethiopia.
- Kedir Abdellah, Tigist Wondimu, and Sebsebe Demissew (2017). Ethnotaxonomy and ethnomedicine of *enset ventricosum* in Gedebano Gutazer Welene district, Gurage

- zone, Southern nations, nationalities and peoples' regional state, Ethiopia. *Ethiopian journal of biological sciences*. **16** (2): 143-170.
- Kedir Aliyi, Kitessa Hundera and Gemedo Dalle (2015). Floristic Composition, Vegetation Structure and Regeneration Status of KimpheLafa Natural Forest, Oromia Regional State, West Arsi, Ethiopia. *Research & Reviews: A Journal of Life Sciences*. **5**: 19-32.
- Kefyalew Sahle, Marohn, C. and Cadisch, G. (2016). Assessment of land use and land cover change in South Central Ethiopia during four decades based on integrated analysis of multi-temporal images and geospatial vector data. *Remote Sensing Applications: Society and Environment*. **3**:1-19.
- Kent, M. and Coker, P. (1992). *Vegetation Description and Analysis. A practical approach*. John Wiley and Sons, New York, 363 P.
- Kflay Gebrehiwot and Kitessa Hundera (2014). Species composition, plant community structure and natural regeneration status of Belete moist evergreen montane forest, Oromia regional state, Southwestern Ethiopia. *Momona Ethiopian journal of science*. **6**(1): 97-101.
- Kitessa Hundera, Tamrat Bekele and Ensermu Kelbessa (2007). *Floristic composition and structure of the Dodolla forest, Bale zone, Oromia Regional State*. M.Sc thesis, Addis Ababa University, Addis Ababa, Ethiopia.
- Kumelachew Yeshitela and Tamrat Bekele (2002). Plant community analysis and ecology of Afromontane and transitional rainforest vegetation of southwestern Ethiopia. *SINET: Ethiopian Journal of Science*. **25**: 155–175.
- Lamprecht, H. (1989). *Silviculture in the tropics*. Tropical forest ecosystems and their tree species possibilities and methods for their long-term utilization. T2 Verlagsgesellschaft GmbH, Robdort, Germany.
- Legendre, P. and Legendre, L. (1998). *Numerical ecology*. (2<sup>nd</sup> Eds), Amsterdam, Netherlands, 853 p.
- Magurran, A. (2004). *Measuring Biological Diversity*. Blackwell Publishing, Oxford, United Kingdom.
- Manuel, C. and Molles, Jr. (2007). *Ecology concepts and applications*. McGraw-Hill, Inc., New York, USA.

- McFarland, J., Hussar, B., Wang, X., Zhang, J., Wang, K., Rathbun, A. and Mann, F. (2018). The Condition of Education 2018. NCES 2018-144. *National Center for Education Statistics*, USA.
- Mengesha Asefa, Cao M., Yunyun H., Ewuketu Mekonnen, Song X., Yang J. (2020). Ethiopian vegetation types, climate and topography. *Plant Diversity*. **42** (4): 302-311.
- Mittermeier, R, Robles, G. and Hoffmann, M. (2004). *Hotspots Revisited: Earth's biologically richest and most endangered terrestrial Eco-regions*. Cemex, Mexico City.
- Mogaka, H., Simons, G., Turpie, J., Emerton, L. and Karanja, F. (2001). *Economic Aspects of Community Involvement in Sustainable Forest Management in Eastern and Southern Africa* (No. 8). IUCN.
- Motuma Didita (2010). Floristic and structural analysis of the woodland vegetation around Dello Menna, Southeast Ethiopia. *Journal of Forestry Research*. **21**(4): 395 - 408.
- Mueller-Dombois, D. and Ellenberg, H. (1974). *Aims and Methods of Vegetation Ecology*. John Wiley & Sons, Inc. New York, USA. 547 P.
- Nigatu Dejene, Firew Kebede, and Mulugeta Kebede (2019). Floristic composition, vegetation structure and regeneration status Of Webero forest, Oromia regional state, Ethiopia. *International journal of biodiversity and conservation*. **11**(9): 272-279.
- Oksanen, J., Blanchet, F., Kindt, R., Legendre, P., Minchin, P., O'hara, R., Simpson, G. and Wagner, H. (2014). *Vegan: Community ecology package*. R Package version 2.2-0.
- Pascal, J. and Pelissier, R. (1996). Structure and floristic composition of a tropical ever green forest in South-west India. *Journal of Tropical Ecology*. **12** (2):191- 214.
- Payn, T., Carnus, J., Freer Smith, P., Kimberley, M. (2015). Changes in planted forests and future global implications. *Forest ecology and management*. **352**: 57-67.
- Quackenbush, L., Hopkins, P. and Kinn, G. (2000). Developing forestry products from high resolution digital aerial imagery. *Photogrammetric Engineering and Remote Sensing*. **66** (11):1337-1346.

- Reiss, M. and Chapman, J. (2008). *Ecology: Principles and Applications* (2<sup>nd</sup>Eds.). Cambridge University Press, Cambridge, England.
- Sebsebe Demissew, Phillip Cribb, P. and Rasmussen F. (2004). *Field guide to Ethiopian orchids*. Royal Botanic Gardens, Kew.
- Shambel Alemu and Ensermu Kelbessa (2011). *Woody species composition, diversity and structural analysis of Angada forest in Merti district, Arsi zone of Oromia region*. M.Sc. thesis, Addis Ababa University, Addis Ababa, Ethiopia.
- Shannon, C. and Weiner, W. (1949). *The mathematical theory of communication*. University of Illinois press.
- Simon Shibiru and Girma Balcha (2004). Composition, structure and regeneration status of woody species in Dindin natural forest, Southeast Ethiopia: An implication for conservation. *Ethiopian Journal of Biological Science*. **1** (3): 15-35.
- Stevenson, P. C., Bidartondo, M., Blackhall- Miles, R., Cavagnaro, T., Cooper, A., Geslin, B. and Suz, L. (2020). The state of the world's urban ecosystems: What can we learn from trees? *Plants, People, Planet*. **2**(5): 482-498.
- Sudi Dawud, Meseret Chimdessa and Satishkumar, J. (2018). Floristic Composition, Structural Analysis and Regeneration Status of Woody Species of Gemechis Natural Forest, West Hararghe Zone, Oromia, Ethiopia. *Journal of natural sciences research*. **8**: 24.
- Tadesse Woldemariam, Thomas, B., Manfred, D. and Demel Teketay (2008). Floristic composition and environmental factors characterizing coffee forests in southwest Ethiopia. *Forest Ecology*. **255** (7): 2138-2150.
- Tamrat Bekele (1993). Vegetation Ecology of Afromontane Forests on the Central Plateau of Shewa, Ethiopia. *ActaphytogeographicaSuecica*. **79**: 1-59.
- Tamrat Bekele (1994). Phytosociology and ecology of a humid Afromontane forest on the central plateau of Ethiopia. *Journal of Vegetation Science*. **5**(1): 87-98.
- Tayachew Birhanu, Ali Seid, Amare Bitew and Moral, M. (2021). Floristic composition, structure and regeneration status of woody plants in church forests of Dangila, Northwestern Ethiopia. *Cogent Food Agriculture*. **7**:1.
- Teklu Gebretsadik (2016). Causes for biodiversity loss in Ethiopia: a review from conservation perspective. *Journal of Natural Sciences*. **6**(11): 32-40.

- Tesfaye Burju, Kitessa Hundera and Ensermu Kelbessa (2013). Floristic Composition and Structural Analysis of Jibat Humid Afromontane Forest, West Shewa Zone, Oromia National Regional State, Ethiopia. *Ethiopian Journal of Education & Sciences*. **8**(2): 11-34.
- Teshome Gemechu, Teshome Soromessa and Ensermu Kelbessa (2015). Structure and regeneration of Gendo moist montane forest, east Wellega East Zone, western Ethiopia. *Journal of environmental & Earth Sciences*. **5**(15):148-168.
- Tewelde-berhan Gebre Egziabher (1991). *Diversity of Ethiopian Flora*. In: Engels JMM, Hawkes JG, Melaku Worede (Ed.), *Plant Genetic Resources of Ethiopia*, Cambridge University Press, Cambridge. 75-81 P.
- Tilahun Tolessa, Feyera Senbeta and Muluken Kidane (2017). The impact of land use/land cover change on ecosystem services in the central highlands of Ethiopia. *Ecosystem Serve*. **23**:47–54.
- Titshall, L., O'Connor, T. and Morris, C. (2000). Effect of long-term exclusion of fire and herbivory on the soils and vegetation of sour grassland. *African Journal of Range and Forage Science*. **17**: 70–80.
- Tiwari, K., Arande, F. and Tiwari, S. (2010). Community structure and regeneration potential of *Shorea robusta* forest in subtropical submontane zone of Garhwal Himaliya, India. *Nature and Science*. **8**(1).
- UNEP (2016). The contribution of forests to national income in Ethiopia and linkages with REDD+. United Nations Environment Programme: Nairobi University of Illinois press, Urbana III.
- USAID (2008). United States Agency for International Development (Ethiopia)
- Van der Maarel, E. and Franklin, J. (2013). *Vegetation ecology* (2<sup>nd</sup> Eds.) 556 P.
- White, F. (1983). The vegetation of Africa: A description Memoir to accompany the UNESCO/AETFAT/UNESCO vegetation map of Africa. Natural Resource Research 20. UNESCO. Paris, France.
- Woodward, F. and Williams, B. (1987). Climate and plant distribution at global and local scales: *Vegetation*. **69**: 189-197.
- Yohannes Mulugeta, Tamrat Bekele and Ensermu Kelbessa (2015). Floristic composition, species diversity and vegetation structure of Gera moist montane forest,

Jimma zone of Oromia national regional state, southwest Ethiopia. *Ethiopian Journal of Biological Sciences*. **14** (1): 45-68.

Zerihun Tadesse, Ensermu Kelbessa and Tamrat Bekele (2017). Floristic composition and plant community analysis of vegetation in Ilu Gelan district, West Shewa Zone of Oromia region, Central Ethiopia. *Tropical Plant Research*. **4** (2): 335 - 350.

Zerihun Woldu (1999). Forests in the vegetation types of Ethiopia and their status in the geographical context. In: *Forest Genetic Resources Conservation: Principles, Strategies and Actions*, (Edwards, S., Abebe Demissie, Taye Bekele and Haase, G., eds). Workshop Proceedings. Institute of Biodiversity Conservation and Research, and GTZ, Addis Ababa, Ethiopia. 1-38 P.

## APPENDICES

### Appendix 1. List of plant species collected from Legay forest

S. no	Botanical name	Family	Local name	Habit	Code
1	<i>Acacia abyssinica</i> Hochst ex Benth.	Fabaceae	Laaftoo	T	AC1
2	<i>Acacia brevispica</i> Harms	Fabaceae	Harangamaa	S	AC2
3	<i>Acacia tortilis</i>	Leguminosae	Laaftoo	T	AC3
4	<i>Albiza gummifera</i> (J.F.Gmel.)	Fabaceae	Birbirraa	S	AC4
5	<i>Asparagus acutifolias</i> L.	Asparagaceae	Muka gannoo	S	AC5
6	<i>Bersema abyssinica</i> Fres.	Melianthaceae	Lolchiisaa	T	AC6
7	<i>Brucea antidysitrica</i> J.F. Mill	Simarobiaceae	Qobanyoo	T	AC7
8	<i>Buddleja davidi</i> Franch	Scrophularia	Adaadii	S	AC8
9	<i>Caesalpinia decapetala</i> ( Roth)	Fabaceae	Harangamaa	L	AC9
10	<i>Carissa edulis</i> (Forsk.) Vahl.	Apocyanaceae	Agamsa	S	AC10
11	<i>Clausena anisata</i> (Willd.) Benth.	Rutaceae	Baala rae	S	AC11
12	<i>Croton macrostachyus</i> Hochst. Ex	Euphorbiaceae	Bakanisaa	T	AC12
13	<i>Cupressus lusitanica</i> Mill.	Cupressuceae	Gaattiraafara	T	AC13
14	<i>Dodenea agvistifolia</i> L.f.	Sapindaceae	Ittacha	S	AC14
15	<i>Dovyalis abyssinica</i> (A. Rich.).	Flacourtiaceae	Kooshima	S	AC15
16	<i>Dovyalis verrucosa</i> (Hochst.).	Flacourtiaceae	Maxxajja	S	AC16
17	<i>Ekebergia capensis</i> Sparm.	Meliaceae	Somboo	T	AC17
18	<i>Erica arborea</i> L.	Ericaceae	Astii	S	AC18
19	<i>Eucalyptus globulus</i> Labill.	Myrtaceae	Baargamooa-dii	T	AC19
20	<i>Eucalyptus gomphophocephala</i>	Myrtaceae	Baargamoo-diimaa	T	AC20
21	<i>Euclea divinorum</i> Hiern.	Ebenaceae	Mieessaa	S	AC21

22	<i>Ficus sychomorus</i> L.	Moraceae	Harbuu	T	AC22
23	<i>Helichrysum italicum</i>	Asteraceae	Baala daala- cha	S	AC23
24	<i>Hypericum revolutum</i>	Clusiaceae	Asxaaxirraa	S	AC24
25	<i>Ilex mitis</i> (L.) Radlk	Aquifoliaceae	Ama'ee	T	AC25
26	<i>Jasminum abyssinicum</i> Hochst. ex	Oleaceae	Baala ra'ee	L	AC26
27	<i>Juniperus procera</i> Hochst. ex	Cuppressaceae	Gaattiraahaba	T	AC27
28	<i>Justitia schimperiana</i> T.anders	Acanthaceae	Dhummuugaa	S	AC28
29	<i>Lippia adoensis</i> Hochst.ex	Verbenaceae	Kusaayee	S	AC29
30	<i>Maesa lanceolata</i> Forsk	Myrsinaceae	Abbayyii	S	AC30
31	<i>Maytenus Undata</i> (Thunb.)	Celastraceae	Kolfaa	T	AC31
32	<i>Momordica foetida</i> schumach.	Cucurbitaceae	Hoolotoo	C	AC32
33	<i>Myrsine africana</i> L.	Myrsinaceae	Qacama	S	AC33
34	<i>Ocimum lamifolium</i> Hochest ex	Lamiaceae	Dammaakasee	S	AC34
35	<i>Olea capensis</i> L.	Oleaceae	Gajaa	T	AC35
36	<i>Olea europaea</i>	Oleaceae	Ejersa	T	AC36
37	<i>Opuntia ficus-indica</i> (L.) Mil- ler.	Cactaceae	Adaamii	S	AC37
38	<i>Osyris quadripartite</i> Decn.	Santalaceae	Qadiidaa	S	AC38
39	<i>Periploca linearifolia</i>	Asclepiadaceae	Hidda mara- maa	L	AC39
40	<i>Phoenix reclinata</i> Jack.	Arecaceae	Meexxii	T	AC40
41	<i>Phytolaca dodecandra</i> L' Herit	phytolacaceae	Handoodee	S	AC41
42	<i>Podocarpus falcatus</i> (Thunb.) C. N.	Podocarpaceae	Birbirsa	T	AC42
43	<i>Polyscias fulva</i> (Hiern.) Harms	Araliaceae	Kaaroo	S	AC43
44	<i>Quercus</i> sp.	Fagaceae	Tagaba	T	AC44
45	<i>Rhamnus prinoides</i> L'Herit	Rhamnaceae	Geeshoo	S	AC45
46	<i>Rhus glotinoso</i> Hochst ex Rich.	Anacardiaceae	Xaaxessaa	S	AC46
47	<i>Rosa Abyssinica</i>	Rosaceae	Ingooxoo	S	AC47

48	<i>Rubus steudneri</i> Schwiens.	Rosaceae	Goraa	S	AC48
49	<i>Rytigynia neglecta</i> Robyns	Rubiaceae	Mixoo	S	AC49
50	<i>Salvia officinalis</i> L.	Lamiaceae	Baala urgoof- tuu	S	AC50
51	<i>Smilax aspera</i>	Smilacaceae	Baala rae	C	AC51
52	<i>Solanum incanum</i> L.	Solanaceae	Hidii	S	AC52
53	<i>Stephania abyssinica</i> Dillon & A.	Menispermaceae	Kalaalaa	C	AC53
54	<i>Syzygium guineense</i>	Myrtaceae	Goosuu	T	AC54
55	<i>Teclea nobilis</i> Del.	Rutaceae	Hadheessa	T	AC55
56	<i>Vernonia amygdalina</i> Del.	Asteraceae	Eebicha	T	AC56
57	<i>Vernonia purpurea</i> Sch. Bip.ex	Asteraceae	Sooyyama	S	AC57

Where; T = Tree, S= Shrub, C = Climber, L= Liana

Appendix 2. Families and Percentage distribution of Species and Genera in Legay forest

No	Family	Spe- cies	% of Species	Genera	% of Genera
1	Acanthaceae	2	3.03	2	3.33
2	Anacardiaceae	1	1.52	1	1.67
3	Apocyanaceae	1	1.52	1	1.67
4	Aquifoliaceae	1	1.52	1	1.67
5	Araliaceae	1	1.52	1	1.67
6	Areaceae	1	1.52	1	1.67
7	Asclepiadaceae	1	1.52	1	1.67
8	Asparagaceae	1	1.52	1	1.67
9	Asteraceae	3	4.55	2	3.33
10	Cactaceae	1	1.52	1	1.67
11	Celastraceae	1	1.52	1	1.67
12	Clusiaceae	1	1.52	1	1.67
13	Cucurbitaceae	1	1.52	1	1.67
14	Cupressaceae	2	3.03	2	3.33
15	Ebenaceae	1	1.52	1	1.67
16	Ericaceae	1	1.52	1	1.67
17	Euphorbiaceae	1	1.52	1	1.67
18	Fabaceae	4	6.06	3	5.00
19	Fagaceae	1	1.52	1	1.67
20	Flacourtiaceae	2	3.03	1	1.67
21	Lamiaceae	2	3.03	2	3.33
22	Leguminosae	1	1.52	1	1.67
23	Meliaceae	1	1.52	1	1.67
24	Meliantaceae	1	1.52	1	1.67
25	Menispermaceae	1	1.52	1	1.67
26	Moraceae	1	1.52	1	1.67

---

27	Myrsinaceae	2	3.03	2	3.33
28	Myrtaceae	3	4.55	2	3.33
29	Oleaceae	3	4.55	2	3.33
30	Phytolacaceae	1	1.52	1	1.67
31	Podocarpaceae	1	1.52	1	1.67
32	Rhamnaceae	1	1.52	1	1.67
33	Rosaceae	3	4.55	3	5.00
34	Rubiacea	1	1.52	1	1.67
35	Rutaceae	2	3.03	2	3.33
36	Santalaceae	1	1.52	1	1.67
37	Sapindaceae	1	1.52	1	1.67
38	Scrophularia	1	1.52	1	1.67
39	Simarobiaceae	1	1.52	1	1.67
40	Smilacaceae	1	1.52	1	1.67
41	Solanaceae	1	1.52	1	1.67
42	Verbenanaceae	1	1.52	1	1.67

---

Appendix 3. The five community types, their sample plots, number of species and Altitude

Community type	Plots	Total plots	No.of species	Altitudinal range(m)
I	1, 18, 14, 16, 2, 4, 11, 22, 7, 47, 15	11	25	2280-2430
II	3,13,49,17,33,5,8,12,6,10,21,23,24,51	14	31	2270-2421
III	25,45,37,41,39,44,26,35,27,29,31, 36	12	29	2220-2470
IV	28, 30, 32, 46, 50, 52, 48	7	34	2270-2465
V	9, 19, 20, 34, 38, 40, 42, 43	8	29	2265-2370