

Addis Ababa University



**College of Natural and Computational Sciences
Department of Zoological Sciences**

**Diversity and Ecology of woody plants around selected churches in Tahitay-
Koraro Woreda, North western Tigray, Ethiopia**

**By
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Fulfillment of the Requirements for the Degree of
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College of Natural and Computational Sciences

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This is to certify that the thesis prepared by Tekle Tikue entitled “**Diversity and Ecology of woody plants around selected church area in Tahitay-Koraro Woreda, North western Tigray, Ethiopia**” and Submitted to the partial fulfillment of the requirement for the degree of Masters of Science in Zoological Science complies with the regulation of the University and meets the accepted standard with respect to originality and quality.

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Examiner: _____ Signature _____ Date _____

Chair of department or Graduate Program coordinator

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Diversity and ecology of woody plants around church area in Tahitay koraro Woreda, Northern west Zone Tigray, Ethiopia

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ABSTRACT

The main purpose of this study was to investigate diversity of plant species and Churches of Tahitay-Koraro District in North West Tigray, Northern Ethiopia. During data collection process 40 plots of 225m²(15 m x 15 m) size were established at every 100m distance between them. Quadrats were selected purposely from five church areas based on homogeneity of vegetation cover. In each quadrat, data on species identity and abundance of woody plant species were recorded. The richness and evenness of species in the plant communities were analyzed using Shannon-Wiener diversity index. For the collection of indigenous knowledge of the local community on management of forest resources, semi-structured questionnaire were prepared and used. A total of 54 species of plants representing, 47 genera and 34 families were recorded from the study area. Among these plants, 33(61.11%) were trees, 13 (24.07%) tree/shrub and 8 (14.8%) were shrubs. The family Fabaceae had the highest number of genera (10.6%; n = 5) followed by Anacardiaceae (6.4%, n = 3). Similarly Fabaceae had the highest number of plant species (14.8%, n = 8) followed by Anacardiaceae (5.6%, n = 3). From the collected plant species. *Olea europaea*, *Calpurnia aurea* and *Grewia trichocarpa* were the most common trees at all selective church area. Cluster analysis of the church areas showed with different level of species richness, diversity and evenness. The churches Enda Abune Teklehaymanot Koyetsa and Enda Abune Aregawi Adiwenfeto had the highest species richness while, Enda Mariam Sew Sekel and Enda Abanew Kelakil exhibited the least species richness. Establishment time (period) and population density might be the main reason for this variation in plant diversity. The overall survey implies church areas of the study area harbor a number of native plant species and the church rule of forest conservation was most respected among followers of Orthodox churches in the study area than that of government rule. So, the federal as well as the regional government should provide incentive for the churches for their contribution in conserving forests and preventing extinction of plant diversity.

Key words: Churches, Distribution of species, Ecological function, Plant conservation, Species

Richness and Vegetation composition

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Abbreviations and Acronyms

CBD	Convention on Biological Diversity
CSA	Central Statistical Agency of Ethiopia
EFAP	Ethiopian Forests Action Program
EOTC	Ethiopian Orthodox Tewahdo Churches
FAO	Food and agriculture organization
FDRE	Federal Democratic Republic of Ethiopia
MA	Ministry of Agriculture
NGO	Non Governmental Organization
OOARD	Office of Agriculture and Rural Development
SCBD	Secretariat of the Convention on Biological Diversity
TFAP	<i>Tigray Forest Action Program</i>
WBISPP	Woody Biomass Inventory and Strategic Planning Project

CHAPTER ONE

1. INTRODUCTION

These forests are essential for human survival and wellbeing. They harbor two thirds of all terrestrial animal and plant species. They provide us with food, oxygen, shelter, recreation, and spiritual sustenance, and they are the source for over 5,000 commercially-traded products, ranging from pharmaceuticals to timber and clothing Murthy *et al.* (2002); World Bank (2004); SCBD (2009). In addition, these resources help to maintain the fertility of agricultural land, used as habitat for wild life, protect water resources and reduce the risk of natural disasters such as land slide and flooding World Bank, (2004). Throughout history humans have used the environment resources plants, animals and others to gain great economic rewards; however, many of the methods are now being seen as unsustainable Abdelfattah Mohamed (2009).

Forest areas can be reduced either by deforestation or by natural disasters such as volcanic eruptions. As a result, forest areas are declining across the globe, partly through logging activities and also due to conversion of habitats to crop lands (agricultural expansion) accounts for up to 40 percent of Ethiopian forest losses Tesfaye Awas (2007). The growing human population and the demand for natural resources have great difference Eyayu *et al.*(2009; Winberg, (2010). Especially deforestation is high and severe in the north eastern Ethiopia. Because of the disappearance of forests, most of the mountainous sides are bare. Valleys have been gullied, striping and streams, which is used to have water the whole year around are now mainly dry in dry season Abate Ayalew (2003). Some of the factors accelerated the decline of woody species diversity in Ethiopia are, the size and distribution pattern of human and domestic animal populations, the level of resource consumption, market factors and policies. In addition, understanding of woody plant species conservation in a narrow sense due to low level of awareness, the attention on woody species conservation and sustainable use has so far been inadequate put great pressure on the biodiversity wealth of the world through deforestation, habitat fragmentation, and overexploitation of species Terborgh and van Schaik (1997); Noss (1999).Habitat loss and change, over-harvesting, pollution, and climate change have been the direct causes of global biodiversity loss Wood *et al.* (2000), while population growth,

changes in economic activities, socio-political factors, cultural factors, and technological change are indirect drivers MA (2005).

The average forest decline between 1990 and 2000 in Ethiopia was 1 % FAO (2007). Currently, natural forests in Ethiopia mainly occur in the south-western part of the country, while the forests that originally existed in central and northern Ethiopia have almost disappeared EFAP (1994); Feoli *et al.* (2002); Bekele (2003). According to pollen and charcoal studies in northern Ethiopia, forest disturbance has a 3000-year history Darbyshire *et al.* (2003), and soil erosion following vegetation clearance in Tigray occurred in the middle Holocene Bard *et al.* (2000)

Among these techniques, protecting forest areas with restricted access for local communities have often been introduced as a solution to tackle deforestation and its effects (Putz 1994; Winberg 2010). There are 14 administrative Kebelies covering the total area of 65492.02 ha, which include 2 Kebelie towns and 12 rural Kebelie. When we look the forest cover of woreda Tahitay koraro, rehabilitation and recovering of natural process were started from the Derg government. Nowadays ,rehabilitation and recovering of natural process increased from time to time showing the percentage progress to 26314 ha (19.6%) in both enclosed natural forest land and rehabilitated forest land. Besides, there are about 66 churches in woreda Tahitay-koraro. These churches cover 6.43% of the surface area of that woreda and their range area vary from 0.524 ha to 9 ha of woreda Tahitay-koraro. Therefore, the present study was done with the objectives of assessing floristic composition and plant diversity of the churches around the study area; and to document the local practices in conservation of vegetation

1.1 Statement of the problem

Ethiopian churches and monasteries have a long standing tradition of preserving and conserving their forests, including many native plants and animals Bongers *et al.* (2006). Many biologists studied the role of churches in conserving plants. Forests undergo changes in various ways. Its areas can be reduced either by deforestation or by natural disasters. As a result, the forest areas are declining across the globe, partly through logging activities and also due to conversion of habitats to croplands (agricultural expansion) accounts for up to 40 percent of Ethiopian forest losses Tewoldeberhan Gebrezgabiher (1988); Tesfaye Awaw (2007); Winberg (2010). Specially, some of the current factors accelerate the decline of plant diversity in Ethiopia are, the size and

distribution pattern of human, level of resource consumption, policies and market factors Tesfaye Awas (2007).

Several studies have been taken place to explore plant diversity and structural composition of forests remnants in the Ethiopian highlands and analyze remnant forests around churches and monasteries in northern Ethiopia. However, comprehensive studies on ecology and plant diversity around churches still need to be studied for many regions of Ethiopia. These sorts of studies have paramount conservation benefits particularly in Northern regions of Ethiopia where forest degradation and deforestation have brought havoc on the ecosystems sustainability and livelihoods of the people. This may also promot the government and the local community to pay attention to conserveation issues and further protect and preserve these important biodiversity refugia in and around chruche compounds. Therefore, the present study provides information about the status of plant species and conservation practices of local community around churches in Tahitaykoraro district, Northernwest Tigray.

1.2. Objectives

1.2.1 General objective

The general objective of the study was to assese and investigates the diversity and ecology of woody plants of selected church areas in Tahitaykoraro woreda, Northwestern Tigray, Northern Ethiopia.

1.2.2 Specific objectives

The specific objectives of the study

- To document floristic composition in the study area.
- To assess the fioristic diversity in the study area.
- To explore ecological knowledge of the church areas.

1.3. Research questions

The study was designed to search solutions for the following questions.

1. Why do we observe many plants cover around the churches?
2. How do individuals/ followers of the Ethiopian Orthodox Tewahedo Church behave towards plant diversity and ecology, while they are in and around churches and in other forest areas?
3. What are the importances of church forest in terms of religion or culture of the community in and around churches?

1.4 Significance of the study

The study provides relevant information about the role of churches in conserving plant species and related human disturbance factors that decrease the diversity and abundance of plant species in the study area. For instance humans use almost all their activities from the flora of the habitat for the purpose of timber production, fire wood, grazing of livestock and wood marketing obtained from the wild life habitat. The study on diversity and abundance of plant species provided information about the ecological structure and evaluated the role of churches in conserving plant species. As different writers have agreed, sustainable use of environment depends on the factors of having appropriate local knowledge, technology to use resources, and the environmental ethics that guides the relationship between human and nature in a sustainable way Alemayehu Wassie, (2007). The present study is essential to enhance in understanding the indigenous knowledge and practices in the Orthodox Tewahedo church, which are positively contributing in conserving the plant diversity and to document the plant species adapted in the area.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Knowledge of the Society in Religion

Well educated persons do not agree on the idea of what religion actually mean. As a result formulating a definition of “religion” that can command wide assent has proven to be an extremely difficult task Harrison, (2006). In the case of Ethiopia, religion has a long last relation to health. For instance, in the prehistoric culture, the mixture of herbal portion together with religious ritual and magic like formulas were part of all healing practices. Most of the herbal remedies are interrelated to Ethiopian Orthodox Christianity religious practices. In addition to herbal remedies, priests of the Ethiopian Orthodox Church always taking the cross where ever they go and bless the people is usual here and they give massage over the disease-affected part with the cross Ragnathen (2009) .“With the help of incantation, priest convert ordinary water to holy water, they spill it over the patients, and they enchantment spiritual words to drive away the evil spirit from the people those who suffered by evil attack”.

Religion is a fundamental aspect of human society. It can influence the social, economic and even political aspects of human society. This is because religion offers prescriptions for social order, individual behavior, and collective action. All religious traditions give expression to the relationship between what are acknowledged and understood to be the most compelling objectives of human life and day-to-day conduct Capps, (1987). Religion as a social institution has its own effect on the nature of interactions in a certain society. The teachings of religious organizations always could be understood in relation to the social life of the people. Any spiritual lesson from religious organizations has its own effect on the social life of religious attendants.

2.2. Religious belief of Ethiopian orthodox Tewahido church and forest Conservation

Many indigenous trees and shrubs, which in some places were destroyed completely over the last century specially, plants found standing in the compounds of remote rural churches Taye, B. (2001). Ethiopian orthodox Tewahido Church is an ancient religion in Africa Alemayehu Wassie (2002). The traditions of planting, taking heed of, and preserving trees is a long history in the church. The spiritual bond between tree planting, conserving and protecting is based on the Holy bibles and church Scholars. The first man or Adam was lived in a place with very beautiful

gardens Church forests provide ecosystem services for the landscape and serve as stepping stones for restoration in long-term forest sustainability. They also provide valuable, often unique, and secured habitats for plants and animals as well as green spaces for people to relieve the stressed mind. Church compounds are the safe places for trees and other biodiversity resources where one can animate trees that escaped from being destroyed forever under the shelter of the church value and esteem. In other words, church compounds are serving as in situ conservation and hot spot sites for biodiversity resources, mainly indigenous trees and shrubs of Ethiopia, which, in turn, give prestige for the religious sites Alemayehu Wassie (2002). Forest restoration and genetic conservation in the degraded landscapes of Ethiopia should depend on remnant church forests and trees around farms Demel Teketay *et al.*, (2010).

2.3 Vegetation types of Ethiopia

Ethiopia has a complex relief and a variety of climates, and thus diverse habitats with rich flora and fauna. The vegetation of Ethiopia is diverse and ranges from afro-alpine vegetation to desert scrub the total flora of Ethiopia consists of 6500 - 7000 species of which 12% are considered endemic. A large proportion of the Eastern Afro montane and Horn of Africa biodiversity hotspots lay in Ethiopia and the country is one of the biodiversity centers of the world Conservation International, (2007). The Ethiopian vegetation is highly influenced by climate, which is associated with elevation Dugdale (1964). South-western Ethiopia receives more precipitation than other parts of the country due to the humid air coming from the Congo basin. The flora of southern Ethiopia is more similar to that of Kenya and Uganda than the flora of northern Ethiopia Dugdale, (1964).

The vegetation on the Afro montane belt (900-3200 m) of Ethiopia has been under tremendous pressure from human activities and over grazing, which has led to the replacement of the evergreen forests by grasslands. The vegetation maps of Ethiopia were reviewed by Friis (2001). The extent and delineation of the vegetation maps are very similar, but differ in the descriptions and terminology of the mapping units Breitenbach (1963) Friis (2001) and Demissew Sebsebe (2001). According to Pichi-Sermolli (1957), the vegetation of northern Ethiopia can be broadly classified as montane evergreen thicket and savanna. The common species in this vegetation type include *Juniperus procera*, *Olea europaea* subsp. *cuspidata*, *Acokanthera schimperi*, *Carissa spinarum*, and species of *Euclea*, *Rhamnus*, *Rhus* and *Maythenus* Friis, (2001). Breitenbach

(1963) mapped the vegetation of Ethiopia and Eritrea into seven basic categories using a physiognomic approach.

According to Breitenbach's vegetation map, the three dominating vegetation types in Ethiopia in a decrease order are Lowland woodlands, and Mountain savannahs Friis, (2001). The Highland forests are found between 1600 and 2600 m.a.s.l. accordingly, the dominant vegetation types in Ethiopia are Forest transitions and mosaics, Woodland, Woodland mosaics and transitions, Bushland and thicket, Semi-desert vegetation, Grassland, Edaphic grassland mosaics, Altimontane vegetation, Azonal vegetation, and Desert. The vegetation on the lower escarpment is classified as bush land and thicket and the vegetation on the Tigrean plateau and the upper scarp as forest transition and mosaics. Friis (1992) classifies the forests of the Horn of Africa into nine vegetation types. According to the classification of the forests and forest trees of northeast tropical Africa Friis (1992), Desa'a and Hugumburda forests are broadly categorized as dry single-dominant Afromontane forests, which are characterized by dry climate (annual precipitation less less than 1000 mm) with *Juniperus procera* and *Olea europaea* subsp. *cuspidata* as dominant species. This dry single-dominant Afromontane forest of the escarpment and transition between single-dominant Afromontane forest and East African evergreen and semi-evergreen bushland that occurs between 1500 and 2400 characterizes the .escarpments in northern Ethiopia.

2.4 Logical denotation of plants in the church

Trees attached with the failure of first man and Lord Jesus Christ saving process of human beings. Christ came to save Adam and his generation. This was done by Jesus' holy blood, crucified on the holy cross-made of wood/special trees. This indicates eating, cutting and destroying trees without permission is causes a serious consequence. In the contrary the ark of Noah by which, he, his family and a pair of female and male animals of all types of the earth were saved from the evil destruction of water, was made of gopher god Thus, trees and other plants are integrated with the Christian's religious life and their mere existence reminds of all the ups and downs of human beings from creation till the end of this world.

Trees and forests have been symbolized on several occasions both, in the Old and New Testaments of the Holy Bible, to remind prospects in the spiritual life of human beings with their

presence and graceful habitation, and the contrary in their absence. In connection with these, some interesting biblical words can be quoted about trees. Therefore, Churches must be furnished and adorned with graceful trees and beautiful gardens. ‘Gardening was the first kind of employment on record in which man was engaged. Though trees and plants produced the necessary flower and fruits by the will of God, dressing and keeping were necessary to maintain the different kinds of trees and plants in their perfection. To cultivate, keep and preserve the garden from all intruders was the duty of man. Church scholars, ‘Mountains are whispered symbol of strength and stability; signify places or sources of strength, the strength of the kingdom of God, the righteousness of God, persons in authority and difficulties, Mighty kings and kingdoms are symbolized as the tall mountain. Aligned with thoughts and teaching most of the Ethiopian Orthodox Tewahido churches and monasteries are built on hills, mountains and high places with dense forest.

2.5 The ecological role of plants for the church communities

The significant material and service importance of trees and forests in church and monasteries compound prioritized by church scholars; respect to God’s place, grace for the churches and monasteries, microclimate amelioration, resting places and sanctuaries for saints, serve as traditional church schools (learning and teaching under the shade of trees), soil erosion control, provide sweet aroma and odor to the church, serve to justify land ownership Taye,B. (1998). In addition, trees and forests around churches and monasteries symbolize the fact that God created Adam and placed him in Eden; trees and forests around churches and monasteries symbolize the appearance of God to Abraham under a tree; trees and forests around churches and monasteries symbolize the faithful laity; trees and forests around churches and monasteries are symbols for life after death; church and monasteries forests are used as symbols or examples in the teaching or propagation of Gospel; church and monasteries forests are national heritage; churches and monasteries are holy places as they are houses of God, therefore, forests and trees grown in God’s compounds are considered as sacred, and trees and forests in the church and monastery compound are symbolic of the presence of angels guarding the church. Therefore, it is precious heritages passed from many generations with the sacrifice of holy fathers and mothers Alemayehu Wassie (2002).

2.6. Institutional values of churches

Church forests are used as a source of income and they represent a unique stroke of good fortune for the conservation community, but without support for continued management of indigenous biodiversity this luck may not hold. Curbing the global biodiversity crisis will require learning from any and all successful conservation institutions, including traditional and religious institutions. These sacred sites in the midst of human dominated agro ecosystems in low-income countries can have a particularly profound impact on conservation outcomes, as much of the remaining land in biodiversity-rich areas is used by rural farmers and pastoralists Cardelus *et al.*, (2013).

The Ethiopian Orthodox Church is one of the oldest Christian churches in Africa and has a long history of protecting and preserving indigenous forest. From an institutional perspective the diverse uses of church forests, often strictly conservationist but sometimes more utilitarian, is a key part of how indigenous trees have been conserved in Ethiopian Orthodox church forests while natural forest has all but disappeared elsewhere. In other words, the thousands of church forests across different parts of Ethiopia can be understood not only as precious islands of biodiversity and culture in need of preservation, but also as invaluable experiments in what works for protected areas management in Ethiopia across a variety of social, economic and environmental contexts.

2.7. The status of plant diversity in Ethiopia

The revised estimate of the closed forest cover of Ethiopia is less than 3.5 per cent Anonymous,.(2004). There are about 300 tree species known to be reported in Ethiopia. Recently, Vivero et al., (2005) have compiled a Red List of plants for Ethiopia and Eritrea.

Biological diversity is the diversity of life at genetic, organism and ecological levels, and there have been attempts to include cultural biodiversity as a fourth component Jeffries, (2005). The various definitions of biodiversity are partly reviewed by Sanderson and Redford (1997), and a more comprehensive definition is given in the Convention on Biological Diversity CBD, (1992) where diversity is "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are

part; this includes diversity within species, between species and of ecosystems". Similarly, accelerated deforestation and habitat fragmentation that arise largely due to the conversion of forests to other agricultural land-use types and the overutilization of forest resources to satisfy the food and energy requirements of the increasing population are major environmental concerns in Ethiopia Machado *et al.*, (19980). The average forest decline between 1990 and 2000 in Ethiopia was 1% FAO, (2007). Ethiopian forest cover is currently estimated to be around 3-3.6% Dessie and Kleman, (2007).

Currently, natural forests in Ethiopia mainly occur in the south-western part of the country, while the forests that originally existed in central and northern Ethiopia have almost disappeared Bekele (2003). According the ministry of agriculture (2003), the natural forest cover in Tigray was only 0.2 % of the total land mass of the region. This showed that, there was severe forest degradation in the area. Currently, the western escarpment of the Great Rift Valley is the only site with an intact Afro montane forest cover in northern Ethiopia. Conversion of forests to agricultural land Nyssen *et al.*, (2004), high dependency on biomass energy Hagos *et al.*, (1999); Gebreegziabher, (2007) and free grazing EFAP, (1994); Worku, (1998); Feoli *et al.*,(2002) are the major causes of forest degradation in northern Ethiopia. According to the Ministry of Agriculture (92003), fuel wood and charcoal contribute 69.2 and 2.5 % of the household energy consumption in Tigray, respectively. To minimize the risk, sustainable forest management has been practiced through applying conservation techniques.

2.8. Measures of species diversity

Diversity refers the variety of species in an area. Beta diversity is type of diversity that shows the difference in species diversity between areas or communities. It is sometimes called habitat diversity because it represents differences in species composition between different areas or environments Whittaker, (1972). Since communities and habitats are often difficult to delineate, beta-diversity is measured among study plots Mark, (2001). The total or gamma diversity of a landscape, or geographic area, is a product of the alpha diversity of its communities and the degree of beta differentiation among them Whittaker, (1972). The difference between alpha and gamma diversity is a matter of scale, which is often subjectively defined Peet, (1974). A large number of diversity indices have been used to measure species diversity. Magurran (2004) provided an in-depth review of concepts and measurements of diversity. Species richness,

meaning a count of the number of plant species in a quadrat, area or community, is often equated with diversity. However, as Magurran states, most methods used in measuring diversity actually consist of two components. The first is species richness and the second is the relative abundance (evenness or unevenness) of species within a sample or community. Whittaker (1972) considers species richness as a strong measure of species diversity.

The Shannon index and Simpson's index of diversity, which combine species richness with relative abundance, are widely used in species diversity studies Kent and Coker, (1992). The Shannon index expresses the relative evenness or equitability of species, while Simpson's index Simpson, (1949) gives weight to dominant species Whittaker, (1972). The diversity indices are biased either on species richness or species evenness, which makes it difficult to obtain one robust index of diversifies measurement Magurran, (2004). The Shannon index is insensitive to rare species Sanjit and Bhatt, (2005). Hill (1973) introduces ratios of the Shannon and Simpson's indices. Though the Hill ratios are not widely used in ecological studies, they describe community structures well. They are relatively unaffected by species richness and tend to be independent of sample size which makes them desirable for comparison of diversity among groups. But they are sometimes difficult to interpret due to the convergence of the Hill's numbers to 1 with decreasing diversity values Peet, (1974). The selection of a particular technique for application to the data analysis will be based on the effectiveness of the technique for sound interpretation of the results and identification of the inter-relationships that may exist among the variables studied. Shannon and Wiener (1949) index of species diversity was applied to quantify species diversity and richness. This method is one of the most widely used approaches in measuring the diversity of species. The two main techniques of measuring diversity were richness and evenness. Richness is a measure of the number of different species in a given Church and can be expressed in a mathematical index to compare diversity between churches. Species richness index has a great importance in assessing taxonomic, structural and ecological value of a given habitat. 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.

CHAPTER THREE

3. Materials and Methods

3.1 Description of the study area

The study was conducted in Tigray region, Northwest zone, in *Tahitay-koraro* woreda located between 13° 59' - 14-13° N latitude to 38° 50' 30"E to 39° 18' 00" E longitude in North western zone of Tigray. Elevation of the woreda is between 2,464-1,113m above sea level, average annual rainfall is 900ml-1,035ml and the average maximum and minimum temperature of the area is 27c and 20c respectively. This study was conducted about 1,068 km north of Addis Ababa and 281.5km away from Mekelle, the capital city of the Tigray regional state. Based on the elevation of this woreda is classified in to traditionally 13% kola, 86% weinadega and 1% dega. Tahitay-koraro woreda is mainly bordering to Medebay-Zanna woreda to east, Asgede-Tsimbila to west, Laelay-Adiabo to north and Asgede-Tsimla and Medebay-Zanna woreda to south. Tahitaykoraro woreda has a surface area of 65,492.02ha of land of which 18,577 is cultivated land. The total population size in the woreda is 80,124 with 40,048 male and 40,076 female. The total number of households are 13,977 and 4098 and 18,075 male and female respectively. Geographically, Tahitay-koraro is found west of Mekelle and the administrative office is at Shire-Endasilassie Town.

The livelihoods of local farmers mainly depend on mixed farming of crops and livestock. There are 14 administrative Kebelies covering of the total Woreda area; 2 Kebelies Town such as kebele Semema and Beles as shown in (Figure1) and 12 Kebelies are rural area

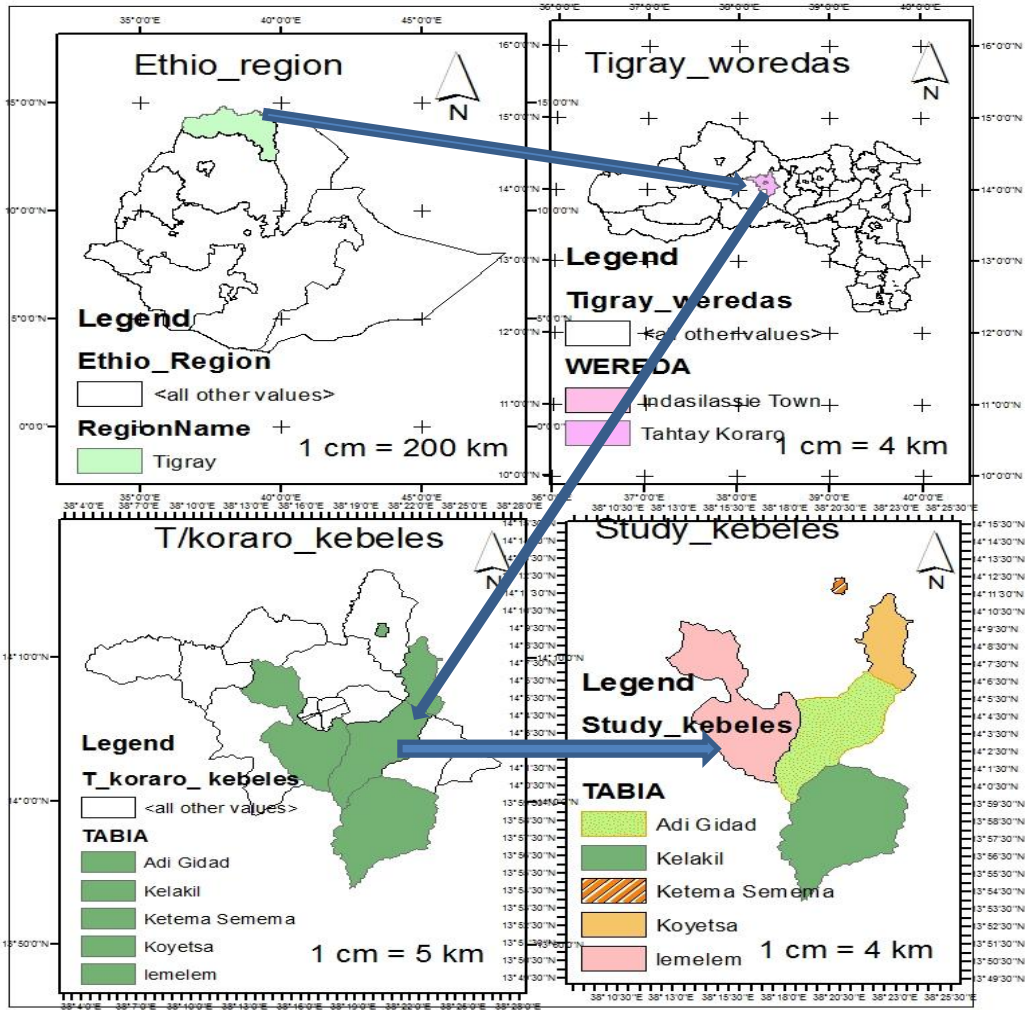


Figure 1 maps and locations of the study area

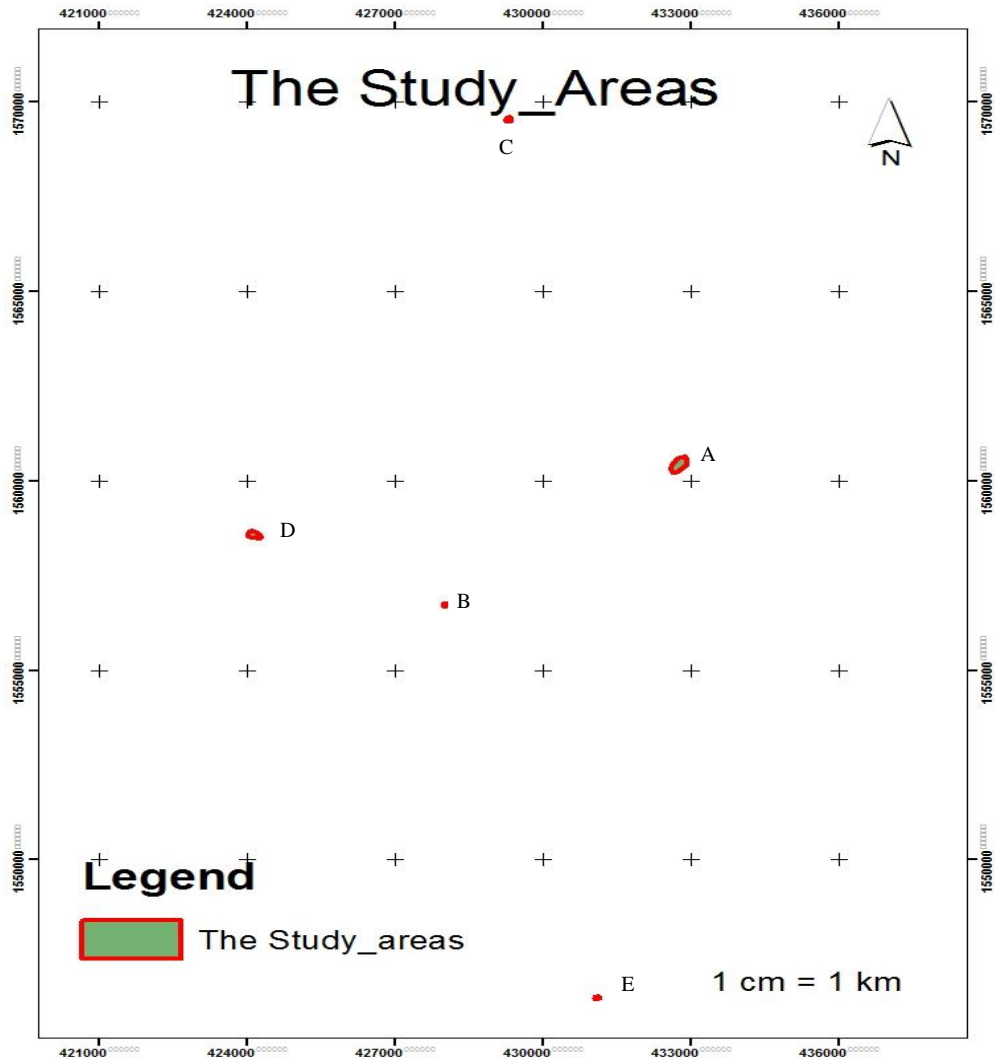


Figure 2 map of the five spesific site area

The five study church area (Figure2) represents as following leters:

A= EndaAbuneTeklehaimanot, B=Enda Mariam Sew skel, C= Enda Mariam Semema,
D= EndaAbuneAregawi E= Endabanew Kelakil

Out of the total area coverage, 4630 ha enclosed natural forest land, 13709 ha rehabilitated forest land, 28576.02ha homestead and grazing land. There are about 66 churches in worda Tahitay-Koraro.

3.1.1 Location

The study was conducted in five church areas that were found in five different Kebeles (Figure1).Such as; Adi-Gidad, Klakil, Ketema Semema, Koyetsa and Lemlem, .This means,(Figure2) Adi-Gidad (Endamariam sew-sekel), Klaki (Endabanew), Ketema Semema (Endamariam Semema), Koyetsa (Enda-Abunetelehaymanot), and Lemlem (EndaAbunearegawi). These study areas are found in Wereda Tahitay Koraro North western Tigray, Northern Ethiopia.

3.1.2 Climate

The climate of Tahitaykoraro (the five study area) could be considered as a tropical summer-rain climate described as Zone biome II (Walter, 1979). Rainfall in the area is highly variable both spatially and temporally as it is influenced by the inter-tropical convergence zone and the rain shadow of the Semen Mountains. The average rainfall recorded in eleven years (2007-2018) varies between 900ml-1,035ml per year and the average temperature is 23.5c^o

3.2 Materials and Method of the study

3.2.1 Materials

Materials used during the study were scientific meter, photographic camera, global positioning system (GPS), rope and rolling metre.

3.2.2 Method of the study

3.2.2.1. Floristic data collection and field activities

Reconnaissance Survey and Selection of Study Sites

A reconnaissance survey of the study area was conducted early October, 2018 to collect visual information about the churches and topography of the study area. Following the survey base line information, vegetation patterns and number of study plots was determined and the data were collected from October to Desmember, 2018.The study was conducted in five church areas out of the sixteen selected church areas..

The criteria to select the study sites were: (1) long establishment age (history) (2) presence of high abundance of plants or vegetation cover by observation (3) through altitude difference. These five sites are found in different kebeles and altitudinal.

Then sample plots were selected by observing the vegetation cover and marking the transect line 15 m width and 15 m length in such a way that the conditions encountered were represented by at least one sample and the sample plots were evenly distributed throughout the forest around the church. Generally, the stands for sampling were selected in such a manner. The vegetation of the area was described by distributing each plot sampled throughout the church area.

Floristic composition data was collected from 40 sample plots (quadrats), size 15 m x 15 m (225 m²) following (Wegner, 1974). During sampling, visually checked homogeneous, representative stands (Andreucci, *et al.*, 2000) were purposely selected and delimited for sampling.

Plant species found within each quadrat were recorded by their vernacular name

3.2.2.. Ethnobotanical data collection

a. Semi-structured interview

Semi-structured interview as described by Martin (1995) and Cotton (1996) used to obtain information from twenty eight key local informants (priests, monks and peoples that are found around the churches) and those were enough to obtain the indigenous knowledge of the local people. The local key informants were selected for interview after contacting the Church administrative units to address qualitative issues concerning community attitudes towards forest management and utilization, and design appropriate solution. During these exercise respondents were asked to respond to pre-determined twenty questions.

3.2.3. Data presentation and analysis

3.2.3.1. Data presentation

The collected data is presented in percent, tables, graphs and figures.

3 2.3.2 Data analysis

Diversity Index

Shannon-Weiner diversity index was used to measure the plant diversity using the formula:

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

Where:

H' = Shannon- Wiener diversity index

P_i = Proportion of the i^{th} species

\ln = Natural Logarithm

Evenness Index (Equitability)

The evenness or equitability index was calculated as

$$E = H'/H_{\max}$$

Where:

E = Evenness index

H' = Shannon Wiener Diversity index

H_{\max} = Natural log of total number of species

3.2.4. Voucher Plant specimen collection and identification

Specimens of Woody plant species were collected from the study sites of five church forests. Species of woody plants in each church forest were identified and their local names were recorded in the field with help experienced local community and agricultural expert. Finally, the scientific name was correlated with their local name. For the identification of scientific name, written materials such as Flora of Ethiopia and Eritrea (volume 2-7) and then identified by comparing with already identified specimens in the National Herbarium of Ethiopia (ETH) were used to identify the woody plant species

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1 Results

4.1.1 Locations and altitudes of the study areas

A. Enda Abune Teklehaymanot Koyetsa Church

This church is located along the Eastern part of Enda Slassie town. It covers 88216 m² and the altitude of the study site is 2356 m above sea level. The natural vegetation of this area is dominated by *Olea europaea* subsp. *Cuspidata*, *Dodonea angustifolia* L.f, *Euclea racemosa* Murr and *Maytenus obscura* (A.Rich) Cuf. This area has the highest altitude than the other study sites.

B. Enda Mariam sewsekel Church

This church is located along the Southern East part of Enda-Silassie town. It covers 6547.5 m² and the altitude of the study site is 2,002 m above sea level. The natural vegetation of this area is dominated by *Justicia schimperiana* (Hochst.ex Nees), *Olea europaea* subsp *cuspidata*, *Calpurnia aurea* (Ait) Benth and *Croton macrostachyus* Del

C. Enda Maryam Semema Church

This church is located along the Northern part of Enda-Silassie town. It covers 12120.97m² and the altitude of the study site is 1927m above sea level. The natural vegetation of this area is dominated by *Acacia lahai*, *Cordia Africana*, *Grewia trichocarpa* (Hochst.ex. A.Rich), *Justicia schimperiana* (Hochst) ex Nees and *Olea europaea subsp.*

D. Enda Abune Aregawi Adiwenfito Church

This church is located along the Southern-East part of Enda-Silassie town. It covers 36,205.5m² and the altitude of the study site is 1881 m above sea level. The natural vegetation of this area is dominated by *Syzygium guineense* (wild) DC), *Phoenix reclinata* (Jacq), *Albizia amara* (Roxb) Boiv, *Pittosporum viridiflorum* Sims

E. Enda Aba-New Kelakil Church

This church is located along the Southern part of Enda-Silassie town. It covers 5857 m² and the altitude of the study site is 1879 m above sea level. The natural vegetation of this area is

dominated by *Olea europaea*, *Justicia schimperiana* (Hochst.ex Nees), *Syzygium guineense* (Willd) DC, *Psyrdrax schimperriana* (A.Rich) and *Diospyros mespiliformis* Hochst.ex.A,DC

4.1.2 Churches and their establishment time

The surface area and the establishment time were obtained from the priest, monks and other key informant individuals (Table 1). So, from the study sites Enda Abune-Teklehaymanot Koyetsa church had the highest area coverage (88216 m²) followed by Enda Abune-Aregawi Addi wenfito church (35205.5 m²). In these areas there was numerous plant species and this was supported by many scholars, reflecting the species area relationship (Figure 3). The number of species is low in smaller forest, although large sized forests are a necessary element of successful reproduction Shafer, (1981). Moreover, not only forest area but selection of remnants across a geographical variation, in this case mainly altitudinal variation, is important in maximizing species diversity Hill and Curran, (2001). Here, there was good information about the study areas location and altitude from the worda Tahitaykoraro agriculture Buerou BOARD, 2018). As you can see below (Table 1) Enda AbuneTeklehaymanot Koyetsa church and Enda Mariam Sew sekels churches were the most ancient and with the highest altitude. Moreover, these churches were having a number of native plant species to Ethiopia. The rest churches were found at the middle to lower altitude with intermediate plant species richness.

Table 1 Church forests selected for the survey

	Name of site	Area in m ²	Area in hactar	Altitude	Year of Estab. of the Church
1	Enda AbuneTeklehaymanot-koyetsa church	88216m ²	8.8 ha	2356m	1352
2	Enda Mriam-Sewsekl church	6547.5m ²	0.7 ha	2002m	1360
3	Enda Mariam Semema	12120.97m ²	1.2 ha	1927m	1736
4	Enda Abune-Aregawi Adi wenfito	36205.5m ²	3.6 ha	1881m	1365
5	Endabanew Kelakil	5857 m ²⁵	0.6 ha	1879m	1843

	Name of site	Area in m ²	Area in hactar	Altitude	Year of Estab. of the Church

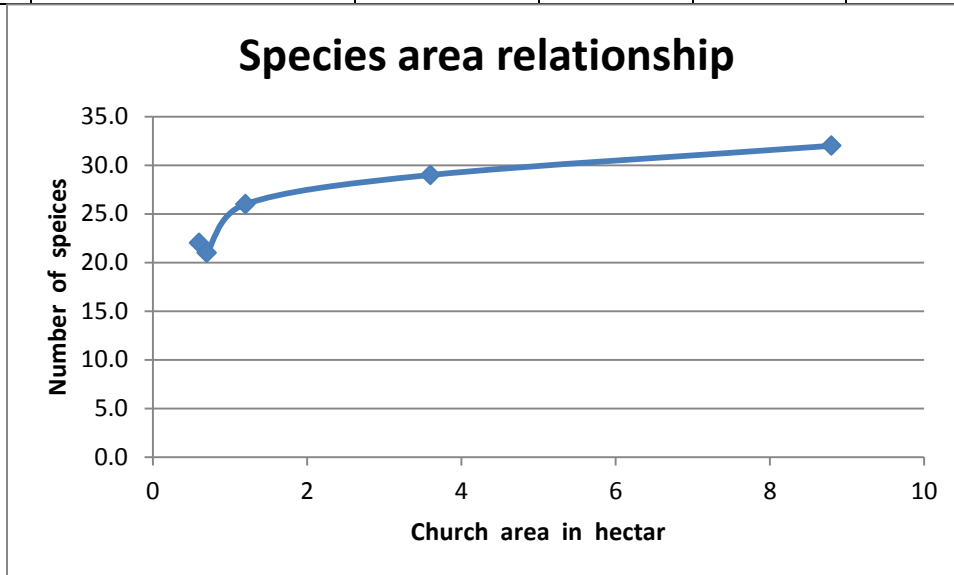


Figure 3 Species area relationship of five churches studied.

4.1.3 Common plant species found in all study sites

In the study areas or in the five sites the following seven plants were present with higher frequency (Table 2). *Acacia abyssinica* Hochst.ex, *Calpurnia aurea*, *Cordia africana*, *Olea europaea* ssp. *cuspidata*, *Coroton macrostachyus* Del and *Grawia trichocarpa* (Hochst.ex.A.Rich.) was the most common plants in these study areas. Higher frequencies were shown by *Olea europaea*, *Calpurnia aurea* and *Grewia trichocarpa* their recorded frequency were 87.5%, %, 77.5% and 72.5% respectively. So, these plants were considered as common for all sites. From these plants *Olea europaea* ssp *cuspidate* and *Calpurnia aurea* were the most common plants in the study areas, because they were found in almost all quadrates

Table 2 Common plant species in all study sites (churches).

Scientific name	Local Name	Frequency	Percentage Cover	Number Of plot they present out of 40
<i>Acacia abyssinica</i> Hochst.ex	Chia	27.5	0.63%	11
<i>Calpurnia aurea</i>	Hitsawts	77.5	7.7%	31
<i>Olea europaea</i>	Awlie	87.5	9.11%	35
<i>Cordia Africana</i>	Awhie	62.5	3.05%	25
<i>Croton macrostachyus</i> (Hochst)	Tambok	55	3.01%	22
<i>Grewia trichocarpa</i> (Hochst.ex. A.Rich.)	Tsinkya	72.5	5.14%	29

4.1.4 Abundance distribution of plant species in the study sites

In Each study sites, there were dominant and characteristics plant species. For example, the types of plants (tree or shrub) that present in the highest abundance in each study (churches) sites. Enda Abune Teklehaymanot Koyetsa church was covered 11.13% by the *Olea europaea* ssp. *Cuspidate* ,the church Enda Mariam Sew sekel was 16.05% covered by *Justicia schimperiana* , Enda Mariam Semema church also covered 21.06% by *Acacia lahai*, the church Enda Abune Aregawi Adi wenfito was covered by *Phoenix reclinata* (Jacq) 14.25% and the.Church Endabanew Kelakil covered 14.9% by *Psydrax schimperiana* (A.Rich) Bridson (Table 3)

Table 3 Frequency of the dominant tree or shrub in each particular site

Study site	The dominant tree	Frequency
Enda Abune Teklehaymanot Koyetsa church	<i>Olea europaea</i> subsp cuspidate	11.13
Enda Mariam Sew sekel church	<i>Justicia schimperiana</i>	16.05
Enda Mariam Semema church	<i>Acacia lahai</i>	21.06
Enda Abune Aregawi Adi wenfito church	<i>Phoenix reclinata</i> (Jacq)	14.25
Enda banew Kelakil	<i>Psydrax schimperiana</i> (A.Rich) Bridson	14.9

4.1.5 Floristic composition of the studied church sites

In the study of plant floristic composition, a total of 54 species of plants representing 47 genera and 34 families were recorded from the study area (Appendix 1). Of these plants 33 (61.11%) were trees, 13 (24.07%) tree/shrub and 8 (14.81%) shrubs.

The family Fabaceae had the highest number of genera (10.63%; n = 5) followed by Anacardiaceae (6.4%, n = 3) and seven other families have with two genera each (4.3%, n=2) genera. Here, like *Acacia*, *Calpurnia*, *Pterolobium*, *Albizia* and *Senna* were the genera found in Fabaceae. *Rhamnus prinoids* L. Herit, *Rhus retinrrhoea* Olive and *Schinus molle* L. were the common genera in family Anacardiaceae. So among these Fabaceae were the most common families in the study site. Moreover, like *Acacia*, *Ficus* and *Olea* were the most known genera. Similarly the family Fabaceae had the highest number of plant species (14.8%, n = 8) followed by Anacardiaceae (5.6%, n = 3). The genera *Acacia* had consisted of the highest number of plant species (7.4%, n=4) followed by *Ficus*, with three plant species each. Here, about twenty-five (73%) of the families were with one genus (Figure 4).

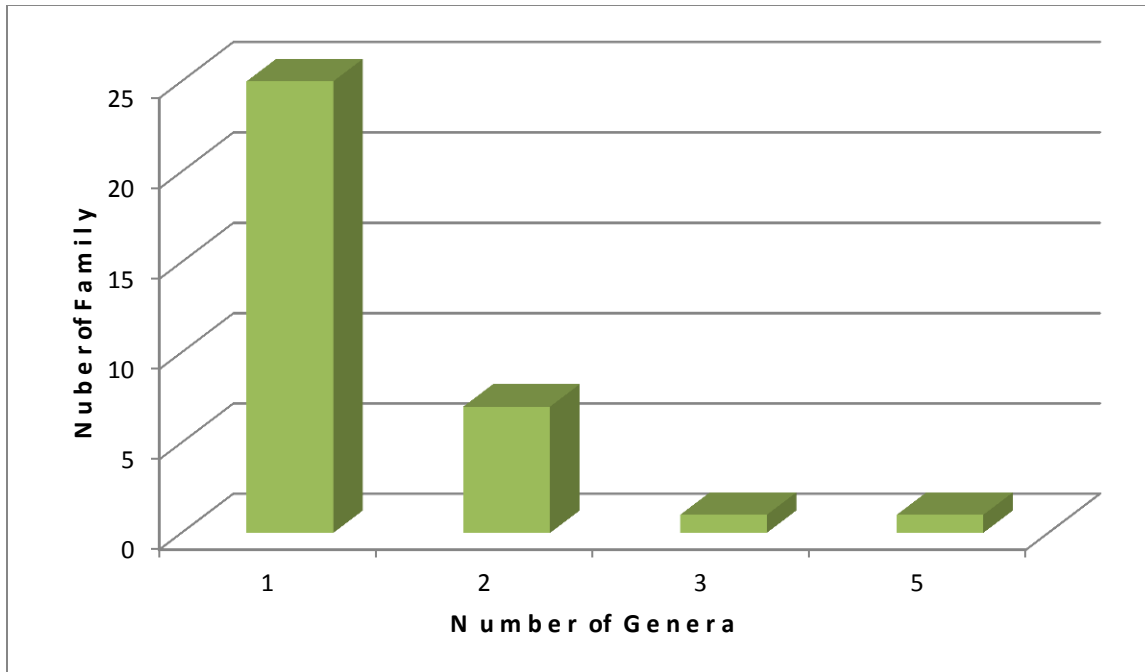


Figure 4 Families and the number of genera they contain.

Therefore, the family Fabaceae and the genera Acacia were the most dominant tax in the study area. Generally, most of the families were with one genera and one species.

Table Families and number of genera (Appendix 4)

4.1.6 Shannon diversity index, evenness and species richness of the study sites

The value of an evenness index falls between 0 and 1. The higher the value of evenness index, the more even the species is distributed within the given area. The richness and evenness of species in the five different churches from the study area is shown in (Table 4). The churches Enda abune Teklehaymanot qoyetsa and Enda Abune Aregawi Adi wenfito had 2.77 and 2.76 Shannon's index of diversity respectively and they possess the highest species richness while, Enadamariyam sew Sekel, Endamariam Semema and Enda banew kelakl churches exhibited the least species richness. The churches Enda abune Teklehaymanot qoyetsa and Enda Abune Aregawi Adi wenfito had 32 and 29 plant species. The reason why these churches possess the highest species richness because; Church scholars could influence the local community to conserve the forests, even on their farm lands. Beside this point in these churches there is no entrance of livestock and they were kept well by the local communities. However, Enda banew Kelakl and Enda Mariyam Sew sekel churches were with the lower species richness this was due

to low awareness of the people in the role of plants for the next generation and because of the local people highly threatened the area for domestic animals rearing and agricultural expansion. Such cases were reported by Ethiopian church forests opportunity and challenges by Alemayehu Wassie (2002). Magurran (1988) stated that the term diversity actually consists of species richness and relative abundance (evenness). The main causative agents for the dynamism of the communities are anthropological activities such as, spiritual conditions awareness toward bibles and overgrazing by domestic animals. In general, the probable reasons for the variability of richness between the five church types raised from spiritual conditions, awareness toward bibles altitude, degree of disturbance involved in the area, cover abundance value and other environmental factors (slope, soil and aspect) which were not included in this study.

Table 4 The Shannon index of diversity, species evenness, species richness and total number of Individuals' plant species in each five selectiv study areas (churches)

Events	Enda abune Teklehaymanot qoyetsa	Enda Mari am sew sekel	Enda Mariam Semema	Enda Abune Aregawi Adi wenfito	Enda banew Kelakl
Shannon's Index	2.77	2.58	2.53	2.76	2.64
Evenness	0.8002	0.8483	0.7774	0.8192	0.8546
Species richness	32	21	26	29	22
Total number of individuals plant species from the eghite plots	719	517	413	372	507
Coverage Percentage	28.44%	20.45%	16.33%	14.72%	20.06%

4.1.7 Conservation practice of the local community in the study area

During this study semi- structured interview was conducted with the respondents, based on a pre-determined question (Appendix 2). The predetermined questions were administered in Tigrigna language. Based on the interviewees knowledge of plant diversity and ecology in the five study area were used, spiritual interaction, ethno-botanical practices, conservation strategies, and so on were collected. All the resulting data were recorded and filled in the data collection format for analysis. Most of the respondents understood the relationship of plants and human being taken long time ago and this situation was started from the time of the first father (Adam). Adam was lived in the forests (Genesis 1). Several respondent agreed that, when we cut a tree from the holy place that is the church, the Angel who keeps that church can hurt our sprite and it must take our life to the bad place which is called the "Hell" the home of Saitane (deviel).

On the forest of Rama Kidist Kidane Miheret monastery revealed that “the church forest lived for a century due to the commitment of holy fathers and mothers who devoted as the natural resource ambassadors without any reward for the provision of biodiversity conservation”. This showed that plants are very important for human as well as for other living organisms.

Out of these twenty-eight respondents 92.85 % provide their answer; plants in the churches were very important for the followers. Plants used as shadow, food, for different furniture’s and used as medicine. Plants also provided good odor and make respectfull for the churches. Apart from undertaking religious activities and guarding church forests, the church community in the study area had interesting to plant trees in churches, because the local communities do had higher respect and trust to their church than to that of government bodies. The followers of the church generally strongly agree with church belief and its rule. The idea was supported in Ethiopia churches forests opportunity and challenges.

Priests and monks can learn and convince the local community to conserve the forests, even on their farm lands. The churches expect recognition of the old age church knowledge in forest conservation and protection. These plants that were found in churches were conserved by the follower’s awareness to the religious belief and unpaid providing education by the priests. And monks this was similarly to the study of Alemayehu Wassie (2002) on forest churches of Gonder. The above result, explain that church forest doesn't exist by chance; it was due to the effort of Church community, in which the church forest can't exist without church. The overall survey result implies that church rules and regulations of forest conservation were most respected among the followers of Ethiopian Orthodox churches in the study area than that of governmental rule. This church rule is not work outside the church. The spiritual interaction between tree planting, conserving and protecting is based on the Holy religious vie and church priests and monks. The result was similar to that of in forest of Rama Kidist Kidane Miheret monastery.

Table 5 Percentage of respondents regarding plants in the churches

NO.	Statements	Responses			
		Yes	%	NO	%
1	Whether or not the plants are important for followers?	26	92.85	2	7.14
2	Whether or not forests in the church are religiously important?	22	78.57	6	21.42
3	Whether or not the relationship of human and plant started from the time of Holy father (Adam)?	25	89.28	3	10.71
4	Whether or not priests and monks give spiritual advice in keeps trees around the churches?	20	71.42	8	28.57
5	Whether or not followers protect forest in other areas just like forests around churches?	10	35.71	18	64.28

Most respondents believe that, the word of God is always in favor of tree and they consider trees in church forest need to be conserved and treated than that of trees in non holy places. Contrary to this, Chandran and Ramachandra (2008) states that, " human being have the domination on everything moves on the earth including plants and animals, which may jeopardize their life". This disagree with the finding of the study area, that might due to high regard of local community around churches for the forest of holy places. Hence destroying the forest of holy places (both monastery and church) considered to be against the religious believes. The respondents suggest that our church will continue to keep forest preservation and to pass to the next generation. The above result shows that 92.85% of the respondents agree with the importance of trees. On the other issue most of the respondents 20 (71.42%) agree religious view keeps those trees in the churches. This mean, the followers of the study area have close relationship with the religious belief than that of the government rule. In addition to this, eighteen (64.28%) church followers cannot protect forest outside the churches just like forests

around churches. Tullu (2011) on the forest of Rama Kidist Kidane Miheret monastery revealed the same result with (Table 5) above which indicates that the church forest lived for a century due to the commitment of holy fathers and mothers who devoted as the natural resource without any reward for the provision of biodiversity conservation.

4.2 Discussion

4.2.1 Churches and their features

The different churches established in different time and contain a number of native plant species to Ethiopia. Based on the above result (table 1), Enda Abune Teklehaymanot Koyetsa and Endamariyam sew Sekel were the most ancient and with the highest altitude. Moreover, these churches had a number of native plant species to Ethiopia. The result was supported in the study of Ethiopian churches and monasteries Bongers *et al.*, (2006). The rest churches were middle and lower altitude even they had medium plant species. So, from the study sites Enda Abune Teklehaymanot Koyetsa had the highest area (88,216 m²) followed by Enda Abune Aregawi Adi wenfeto (36,205.5 m²). This result was supported by Large sized forests contain necessary element for successful reproduction (Shafer, 1981). The number of species is small in smaller forest. This implies that large sized forests has necessary element of successful reproduction processes.

4.2.2 Floristic composition

Totally, 54 species of plants belonging to 47 genera and 34 families were recorded from the study area. Of these plants 33 (61.11%) were trees, 13 (24.07%) tree/ shrub and 8 (14.8%) shrubs. The distribution of forest types depend on site specific physiographic conditions Kunwar *et al.*, (2008). Of all the families Fabaceae, and *Anacardiaceae* were the most dominant and Fabaceae constituted 5 (10.63%) genera and 8 (14.8%) species. The family Fabaceae was the most dominant family followed by *Anacardiaceae*. The family Fabaceae had the highest number of genera as well as species. Similarly, the genera *Acacia*, *Ficus* were the most dominant and common genera in the present study. They constituted 14.8 % of the species. Such result was reported in Hugumbirda-Gratkahssu forest by Leul Kidane *et al.* (2010) and Traditional medicinal plants in Irob and Gulomehada by Tadesse Beyene (2015). Generally, most of the families were with one genus and one species, *Cordia africana*, *Olea europaea*, *Calpurnia aurea*, *Acacia abyssinica*, , *Grewia trichocarpa* and *Croton macrostachyus* were the most common plants in the study area. This can be related with the study of Friis (1992) in highlands of Ethiopia indicating dominacey of these plants in similar highland areas of the country.

Of the total species encountered across all plots, the result of frequency distribution revealed that some plant species were most frequent within churches and the others were least frequent within the study areas.

4.2.3 Species diversity, evenness and richness of the study sites

The churches Enda abune Teklehaymanot qoyetsa and Enda Abune Aregawi Adi wenfito had 2.77 and 2.76 Shannon's index of diversity respectively and they possess the highest species richness while, Enadamariyam sew Sekel, Endamariam Semema and Enda banew kelakl churches exhibited the least species richness. Wiener (1949) index of species diversity was applied to quantify species diversity and species richness. The churches Enda Abune Teklehaymanot Koyetsa and Enda Abune Aregawi Adi Wenfito had 32, and 29 plant species. The church Enda abune Teklehaymanot qoyetsa was the richest from the other study sites. This is due to the thought and convince of the priests to the local communities and due to the presence of keeper monks. This can be associated with grazing and human disturbance levels. Similarly, some plant species were most frequent within church areas and the others were least frequent (Table 2)., *Olea europaea* was recorded in 35 plots, out of 40 plots, followed by *Calpurnia aurea* and *Grewia trichocarpa* which occurred in 31 and 29 plots respectively out of these 40 plots were among the most frequent species in the study area. On the other hand *Cordia Africana*, *Croton macrostachyus*, and *Acacia abyssinica*, were with least frequency and the recorded frequency were 3.04%, 3%, and 0.6% respectively.

4.2.4 Conservation practice of the local community

As the result indicates, the community members in the study area keep the church rule more than government rule. Based on the interviewees, local indigenous knowledge on plant diversity and ethnobotanical practices of conservation strategies were documented and described. Most of the respondents (92.85%) understood the relationship of plants and human being taken long time ago and this situation was started from the time of the first father (Adam). Adam was lived in the forests (Genesis 1). Those forests were well flourished and pleasant. This place called Genet. Genet was full of fruits and flowers. Several respondents (89.28%) responded that, when we cut a tree from the holy place that is the church, the Angel who keeps that church can hurt our sprite and it must take our life to the bad place which is called the "Hell" the home of Saitane (devil). Tulu 2011) investigation, on the forest of Rama Kidist Kidane Miheret monastery revealed that"

the church forest lived for a century due to the commitment of holy fathers and mothers who devoted as the natural resource ambassadors without any reward for the provision of biodiversity conservation”. This showed that plants are very important for human as well as for other living organisms. Out of these twenty-eight respondents (92.85%) provide their answer; plants in the churches were very important for the followers. Plants used as shadow, food, for different furniture’s and used as medicine. Plants were also provided good odor and make respectful for the churches. The followers of the church generally agree with church belief and its rule. The idea was supported in Ethiopian church forests opportunity and challenges.

Priests and monks could learn and convince the local community to conserve the forests, even on their farm lands. The churches expect recognition of the old age church knowledge in forest conservation and protection. The plants that were found in churches are also conserved by the follower’s awareness to the religious belief and due providing education by the priests. And this was similarly to the study conducted by Alemayehu Wassie (2002) on forest churches of Gonder which “explained church forest doesn't exist by chance; it is due to the effort of Church’s rule, in which the church forest can't exist without church”. The overall survey result implies that church rule of forest conservation was most respected among followers of Ethiopian Orthodox churches in the study area than that of government rule. This result is not guaranty outside church. The spiritual interaction between tree planting, conserving and protecting is based on the Holy religious vie and church priests and monks. Most respondents believe that, the word of God is always in favor of tree and they consider trees in church forest need to be conserved and treated than that of trees in non-holy places. Contrary to this, Chandran and Ramachandra (2008) stated that, human being have the domination on everything move on the earth including plants and animals, which may jeopardize their life. Therefore, we could understood that christian followers and forests had long and intimate relationship “explained church forest doesn't exist by chance; it is due to the effort of Church’s rule, in which the church forest can't exist without church”. The overall survey result implies that church rule of forest conservation was most respected among followers of Ethiopian Orthodox churches in the study area than that of government rule. This result is not guaranty outside church. The spiritual interaction between tree planting, conserving and protecting is based on the Holy religious vie and church priests and monks. Most respondents believe that, the word of God is always in favor of tree and they consider trees in

church forest need to be conserved and treated than that of trees in non-holy places. Contrary to this, Chandran and Ramachandra (2008) stated that, human being have the domination on everything move on the earth including plants and animals, which may jeopardize their life. Therefore, we could understood that christian followers and forests had long and intimate relationships

CHAPTER FIVE

5. Conclusion and Recommendations

5.1 Conclusion

Protected areas like, churches, national parks and other enclosure places are facing high risk of forest decline, due to the presence of high human population. Most of the people who live around the protected areas disturb the activities of wildlife in their habitat. The result that the different churches have different plant species and these churches hold the same (common) plants that are native to Ethiopia. In addition to this, the church followers are well informed by the spiritual belief and they keep very well the forests around the church. So, the government and the concerning body should learn from the spiritual belief in keeping trees. The result also increases the knowledge of the local people, government and concerning body in conserving and protecting the forests around the churches. The study showed that, higher plant diversity was observed in areas where disturbance was lesser. Moreover, higher plant diversity, abundance, species composition and evenness were observed in relation to absence of disturbance and level of conservation. This in turn suggests that more conservation efforts may improve the abundance and species diversity of plants in any conservation practices.

Over all 54 species of plants were documented and recorded with their 47genera and 32 families from the study area. Of these plants 61.1% were trees, 24.07% tree/shrub and 14.8% shrubs. The family Fabaceae had the highest number of genera 10.63% followed by *Anacardiaceae* 6.3%. The distributions of these plant communities in the study area were influenced by various environmental and biotic factors which are operated in a combined way; this is why variations in species richness, composition and species diversity among communities could exist.

Most of the respondents understood the relationship of plants and human being taken long time ago and this situation was started from the time of the first father (Adam). Adam was lived in the forests. Moreover, priests and monks played a great role in controlling and saving of plants aruound the churches. Almost all the key informants suggest that the EOC will continue to play a significant role in forest preservation in the churches directly or indirectly. Therefore, ecological assessment of the existing enclosed forests is the base for meaningful planning to rationally

utilize the remaining forest resources Abate Ayalew (2007). These study of ecology and plant species diversity in response to different churches helps to generate information for a better understanding of ecological processes and in managing ecosystems. The study also has role for researchers to use outcome of the study as a base for further investigation in different part of the district.

5.2 Recommendations

Church forests comprise local as well as global “hotspots” as critical conservation areas for a large portion of Ethiopia’s remaining biodiversity. Vegetation surveys of church forests indicate that church forests house a large proportion of the endangered plant species of Ethiopia. Church forests provide important ecosystem services to local people, including fresh water, pollinators, honey, shade, and spiritual value. Awareness creation for local people on the significance of conservation area is important. The accelerating pace of species extinction is the greatest challenges facing in most part of Ethiopia. This challenge has lead to the emergence of the practice of conservation in the country. Conservation of woody plant species at the levels of ecosystems, landscapes, community, populations, individuals and genes, is essential to sustain the health and vitality of ecosystems. For sustainable use and conservation of vegetation the following recommendation are forwarded:

- ✓ Local people should keep their livestock away from the church area to prevent forest loss.
- ✓ Religious awareness creation is needed for local people on the significance of conservation of plant diversity in churches areas.
- ✓ Creating policy alignment among various sectors and integrated with religious belief in the conservation and sustainable use of forest resources is needed.
- ✓ Rehabilitating and restoring degraded ecosystems and promoting the recovery of threatened species in the churches and monasteries is relevant.
- ✓ Strengthening forestry education and training in the church areas can help for effective plant conservation.

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Appendix 1

List of plant taxa collected in the study area with corresponding code number, family, and vernacular name and habit

*	SPECIES NAME	Family	Vernacular Name (Tigregna)	Habit
021	<i>Acacia lahai</i> Steud and Hochst.ex Benth	Fabaceae	lah'ay	Tree
025	<i>Acacia abyssinica</i> Hochst.ex Benth.	Fabaceae	Chia	Tree
037	<i>Acacia albida</i> Del.	Fabaceae	Momona	Tree
003	<i>Acokanthera schimperi</i> (A.DC.) Scheinf	Acanthaceae	Mebetti	Tree
041	<i>Acacia polyacantha</i> Willd	Fabaceae	Gwmero	Tree
046	<i>Albizia amara</i> (Roxb) Boiv	<i>Fabaceae</i>	<i>Chigono</i>	<i>Tree</i>
049	<i>Azadirachta indica</i> A.Juss	Maliaceae	Nim	Tree
051	<i>Balanites aegyptiaca</i> (L.) Del	Balanitaceae	Meqi	Tree
032	<i>Bersama abyssinica</i> Fresen.	Meliantaceae	Mirkuz-zibe	Tree/Shrub
043	<i>Bridelia micrantha</i> (Hochst.) Baill	Phyllanthaceae	Ametere	Tree
036	<i>Buddleja polystachya</i> Fresen	Budlejaceae	Meterere	Tree
009	<i>Calpurnia aurea</i> (Ait) Ait.f.	Fabaceae	Hitsawits	Tree/shrub
004	<i>Carissa spinourm</i> L.	Apocynaceae	Egam	Tree/shrub
017	<i>Capparis tomentosa</i> Lam	Capparaceae	Andel	Shrub/Tree
045	<i>Calotropis procera</i> (Ait)	Asclepiadaceae	Gindae	Shrub
044	<i>Citrus limon</i> (L.) Bumf	Rutaceae	Lemin	Tree
030	<i>Clerodendrum myricoides</i> (Hochst.) Vatke.	Lamiaceae	Surbetri	Tree/shrub
007	<i>Cordia africana</i> Lam.	Boraginaceae	Awhi	Tree
027	<i>Croton macrostachyus</i> Del	Euphorbiaceae	tambuk'	Tree
050	<i>Cupressus lusitanica</i> Mill	Cupressaceae	Tsihdi-ferenji	Tree
052	<i>Diospyros mespiliformis</i> Hochst .ex.A,DC	Sapindaceae	Ayeh	Tree
019	<i>Dombeya torrida</i> (J.F.Gmel.) P. Bamps	Sterculiaceae	Buyak	Tree
013	<i>Dodonea angustifolia</i> L.f.	Sapindaceae	Tahses	Shrub
040	<i>Eucalyptus camaldulensis</i> Dehnh	Myrtaceae	bahr zaf	Tree
008	<i>Euclea racemosa</i> Murr	Ebenaceae	Kuliow	Tree/shrub
028	<i>Euphorbia abyssinica</i> , Gmel.	Euphorbiaceae	Kolqual	Tree
039	<i>Euphorbia tirucalli</i> L.	Euphorbiaceae	Kinchib	Tree
054	<i>Ficus sur</i> Forssk.	Moraceae	Sagla	Tree

*	SPECIES NAME	Family	Vernacular Name (Tigreña)	Habit
006	<i>Ficus thonningii</i>	Moraceae	Shibaka	Tree
033	<i>Ficus vasta</i> Forssk.	Moraceae	da'ro	Tree
018	<i>Grewia trichocarpa</i> (Hochst.ex. A. Rich.)	Tilaceae	Tsnquya	Tree/Shrub
015	<i>Jasminum gradiflorum</i> L.	Oleaceae	Habi-tselim	Shrub
002	<i>Juniperus procera</i> Hochst.ex.Endl.	Cupressaceae	Tsihdi-adi	Tree
034	<i>Justicia schimperiana</i> (Hochst. ex Nees) T.Anders	Acanthaceae	Shimeza	Shrub
011	<i>Maytenus obscura</i> (A.Rich) Cuf	Celastraceae	áTáT	Tree/Shrub
053	<i>Mimusops kummel</i> A.Dc(A.DC)	Sapotaceae	Kummel	Tree
012	<i>Maytenus senegalensis</i> (Lam.) Exell	Celastraceae	Argwdi	Tree/Shrub
001	<i>Olea europaea</i> (Wall.ex DC.)Cifferri	Oleaceae	Awlie	Tree
029	<i>Otostegia integrifolia</i> Benth	Lamiaceae	Chi-endog	Shrub
035	<i>Phoenix reclinata</i> (Jacq)	Arecaceae	Siye	Tree
026	<i>Phytolacca dodecandra</i> LHerit.	Phytolaccaceae	Shibti	Shrub
016	<i>Pterollobium stellatum</i> (Forssk.) Brenan	Fabaceae	Konteftefe	Shrub
048	<i>Pittosporum viridiflorum</i> Sims	Pittosporaceae	çeçenTe	Tree
014	<i>Psydrax schimperiana</i> (A.Rich.) Bridson	Rubiaceae	Selimoy	Tree/Shrub
022	<i>Rhamnus prinoides</i> L.Herit.	Anacardiaceae	Geeso	Tree/Shrub
010	<i>Rhus retinorrhoea</i> Olive	Anacardiaceae	Tetaelo	Tree
023	<i>Rumex nervosus</i> Vacl	Polygonaceae	Hehot	Shrub
031	<i>Stereospermum kunthianum</i> Cham.	Bignoniaceae	Dugdgni	Tree
020	<i>Solanum schimperianum</i> Hochst. Ex A.Rich	Solanaceae	Korenet	Tree/Shrub
038	<i>Schinus molle</i> L.	Anacardiaceae	berbere tsellim	Tree
024	<i>Senna sinqueana</i> (Del.) Lock	Fabaceae	Hambahambo	Tree/shrub
047	<i>Syzygium guineense</i> (Willd) DC	Solanaceae	li'ham	Tree
005	<i>Ximenia Americana</i> (L.var)	Olacaceae	Mulio	Tree
042	<i>Ziziphus spina-christi</i> L.Desf	Rhamnaceae	Gaba	Tree

Appendix 2

Summary of Questionnaire Survey

Dear Respondents, This questionnaire is meant to gather information for research on the contribution of Orthodox Churches in forest conservation practice and the current status of ecology and plant species diversity within the five churches.

Notice: you can write your answer in Tigrigna language.

Part-I:

Personal Information

1. Questioner Number: _____ Day _____ Month _____ Year _____
2. Sex _____, Age _____, Education _____, Family size _____
3. Farm land: Own/No _____ Economic activities _____, Religion _____

Part II: Questionnaires

1. Why do we observe many plants around the churches?
2. What is the relationship between trees and churches based on the spiritual belief?
3. Who establish and construct the church?
4. When was the church established?
5. What are the values and roles of the forests in the churches?
6. How the plants in the churches are growing? By nature or by humans?
7. Are the forests of the churches are well protected over long time?
8. What is your initiation to protect the forest in church compounds?
 - a, Bible thought
 - b, Government incentive
9. Do conservation practices in the churches differ for plants and animals?
10. Do the presence of forest and other nature in church /Monastery/ compound is religiously important? Why?
11. Why you give more care for forest in the churches than other non-religious forest areas?
12. If the diversity of the forest in the churches declining, what could be the reasons?
13. Have you ever cut the forests in the Monastery? Why?
14. How do followers of the church behave toward plants diversity, while they are in, around churches and in other areas?

15. What is the dominant plant in this church?
16. Is there any entance of livestock observed in the church?
17. Is there any support or incentive from the government?
18. Who keep this forest aroud this church?
19. Why some individuals cut trees without permission?
20. What change have you observed since tou know the place?

Appendix 3

Local name, frequency, density, Number of plots and total number individuals species

Col. No	Species name	Vernacular Name (Tigrigna)	Total number of individual species	Frequency	Number of quadrates(plot) they found
021	<i>Acacia lahai</i> Steud and Hochst.ex Benth	lah'ay	113	47.5	19
025	<i>Acacia abyssinica</i> Hochst.ex Benth.	Chia	15	27.5	11
037	<i>Acacia albida</i> Del.	Momona	27	22.5	9
003	<i>Acokanthera schimperi</i> (A.DC.) Schweinf.	Mebetti	30	17.5s	7
041	<i>Acacia polyacantha</i> Willd	Gwmero	20	20	8
046	<i>Albizia amara</i> (Roxb) Boiv	Chigono	45	17.5	7
049	<i>Azadirachta indica</i> A.Juss	Nim	3	5	2
051	<i>Balanites aegyptiaca</i> (L.) Del	Meqi	1	2.5	1
032	<i>Bersama abyssinica</i> Fresen.	Mirkuz-zibe	1	2.5	1
043	<i>Bridelia micrantha</i> (Hochst.) Baill	Ametere	4	7.5	3
036	<i>Buddleja polystachya</i> Fresen	Metere	10	15	6
009	<i>Calpurnia aurea</i> (Ait) Benth.	Hitsawits	195	77.5	31

Col. No	Species name	Vernacular Name (Tigrigna)	Total number of individual species	Frequency	Number of quadrates(plot) they found
004	<i>Carissa spinorum</i> L.	Egam	61	40	16
017	<i>Capparis tomentosa</i> Lam	Andel	7	15	6
045	<i>Calotropis procera</i> (Ait).	Gindae	2	2.5	1
044	<i>Citrus limon</i> (L) Burmf	Lemin	1	2.5	1
030	<i>Clerodendrum myricoides</i> (Hochst.) Vatke	Surbetri	30	25	10
007	<i>Cordia africana</i> Lam.	Awhi	77	62.5	25
027	<i>Croton macrostachyus</i> Del	tambuk'	76	55	22
050	<i>Cupressus lusitanica</i> Mill	Tsihdi-ferenji	2	2.5	1
052	<i>Diospyros mespiliformis</i> Hochst .ex .A.DC	Ayeh	52	17.5	7
019	<i>Dombeya torrida</i> (J.F.Gmel.) P. Bamps	Buyak	2	2.5	2
013	<i>Dodonea angustifolia</i> L.f.	Tahses	94	30	12
040	<i>Eucalyptus cmaldulensis</i> Labill	bahr zaf	37	20	8
008	<i>Euclea racemosa</i> Murr	Kuliow	121	55	22
028	<i>Euphorbia abyssinica</i> , Gmel.	Kolqual	29	25	10
039	<i>Euphorbia tirucalli</i> L.	Kinchib	180	70	28
054	<i>Ficus sur</i> Forssk.	Sagla	3	5	2

Col. No	Species name	Vernacular Name (Tigrigna)	Total number of individual species	Frequency	Number of quadrates(plot) they found
006	<i>Ficus thonningii</i> Blume	Shibaka	43	55	22
033	<i>Ficus vasta</i> Forssk.	da'ro	8	15	6
018	<i>Grewia trichocarpa</i> (Hochst.ex. A. Rich.)	Tsnquya	130	72.5	29
015	<i>Jasminum gradiflorum</i> L.	Habi-tselim	85	27.5	11
002	<i>Juniperus procera</i> Hochst.ex.Endl.	Tsihdi-adi	21	15	6
034	<i>Justicia schimperiana</i> (Hochst .ex Nees) T.Anders	Shimieza	287	30	75
011	<i>Maytenus obscura</i> (A.Rich)	áTáT	105	50	20
052	<i>Mimusops kummel</i> A.Dc(ADC)	Kummel	51	17.5	7
012	<i>Maytenus senegalensis</i> (Lam) Exell	Argwdi	4	7.5	3
001	<i>Olea europaea</i> (Wall.ex DC.)Cifferri	Awlie	230	87.5	35
029	<i>Otostegia integrifolia</i> Benth	Chi-endog	8	10	4
035	<i>Phoenix reclinata</i> (Jacq)	Siye	58	17.5	7

Col. No	Species name	Vernacular Name (Tigrigna)	Total number of individual species	Frequency	Number of quadrates(plot) they found
026	<i>Phytolacca dodecandra</i> LHerit.	Shibti	2	5	2
016	<i>Pterolobium stellatum</i> (Forssk.) Brenan	Konteftefe	10	17.5	7
048	<i>Pittosporum viridiflorum</i> Sims	çeqenTe	6	12.5	5
014	<i>Psydrax schimperiana</i> (A.Rich.) Bridson	Selimoy	115	57.5	23
022	<i>Rhamnus prinoides</i> L.Herit.	Geeso	9	10	4
010	<i>Rhus retinorrhoea</i> Olive	Tetaelo	9	15	6
024	<i>Rumex nervosus</i> Vacl	h'eh'ot	20	35	14
031	<i>Stereospermum kunthianum</i> Cham.	Dugdgni	2	5	2
020	<i>Solanum schimperianum</i> Hochst. <i>Ex A.Rich</i>	Korenet	2	5	2
038	<i>Schinus molle</i> L.	berbere tsellim	15	17.5	7
024	<i>Senna singueana</i> (Del.) Lock	Hambahambo	20	35	14
047	<i>Syzygium guineense</i> (Willd) DC	li'ham	97	30	12
005	<i>Ximenia Americana</i> (L.var)	Mulio	14	25	10
042	<i>Ziziphus spina-christi</i> , L.Desf	Gaba	23	22.5	9

Appendix 4

Family, genera, species and the corresponding percentages

No	Family Name	Genera	Percentages	Species	Percentages
1	Acanthaceae	2	4.25	2	3.70
2	Anacardiaceae	3	6.38	3	5.56
3	Apocynaceae	1	2.13	1	1.85
4	Arecaceae	1	2.13	1	1.85
5	Asclepiadaceae	1	2.13	1	1.85
6	Balanitaceae	1	2.13	1	1.85
7	Bignoniaceae	1	2.13	1	1.85
8	Boraginaceae	1	2.13	1	1.85
9	Budlejaceae	1	2.13	1	1.85
10	Capparaceae	1	2.13	1	1.85
11	Celastraceae	1	2.13	2	3.70
12	Cupressaceae	2	4.25	2	3.70
13	Ebenaceae	1	2.13	1	1.85
14	Euphorbiaceae	2	4.25	3	5.56
15	Fabaceae	5	10.64	8	14.8
16	Lamiaceae	2	4.25	2	3.70
17	Maliaceae	1	2.13	1	1.85
18	Tilaceae	1	2.13	1	1.85
19	Meliantaceae	1	2.13	1	1.85
20	Moraceae	1	2.13	3	5.56
21	Myrtaceae	1	2.13	1	1.85
22	Olacaceae	1	2.13	1	1.85
23	Oleaceae	2	4.25	2	3.70
24	Phyllantaceae	1	2.13	1	1.85
25	Phytolaccaceae	1	2.13	1	1.85
26	Pittosporaceae	1	2.13	1	1.85
27	Polygonaceae	1	2.13	1	1.85
28	Rhamnaceae	1	2.13	1	1.85
29	Rubiaceae	1	2.13	1	1.85
30	Rutaceae	1	2.13	1	1.85
31	Sapindaceae	2	4.25	2	3.70
32	Sapotaceae	1	2.13	1	1.85
33	Solanaceae	2	4.25	2	3.70
34	Sterculiaceae	1	2.13	1	1.85

Appendix 5 Pictures of the five church study areas:



Photo of. Enda Abune Teklehaymanot Koyetsa



Photo.of Enda Mariam Sewsekel



Photo of.Enda-Mariam Semema



Photo of. Enda-AbuneAregawi Addi-wenfito



Photo of. Enda-Abanew kelakil church