

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF BIOLOGY



FLORISTIC COMPOSITION AND STRUCTURE OF CHATO NATURAL FOREST IN HORO GUDURU WOLLEGA ZONE OF OROMIA REGION WEST ETHIOPIA.

BY
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ADDIS ABABA UNIVERSITY
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A thesis submitted to School of Graduate Studies of Addis Ababa University in partial fulfillment of the requirement for the degree of Master of Science in Biology (Botanical Science Stream).

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List of Acrynoms

AAU:	Addis Ababa University
CSA:	Central Statstical Authority
DBH:	Diameter at breast height
EFAP:	Ethiopia Forestry Action Plan
EMSA:	Ethiopia Meteorological Services Agency
EMA:	Ethiopia Mapping Agency
EPA:	Environmental Protection Authority
ETH:	National Herbarium of Ethiopia
EWNHS:	Ethiopia Wildlife and Natural History Society
FIV:	Family Importance Values
GPS:	Geographical Position System
H.W.R.D.O:	Horo Wereda Rural Development Office
IBC:	Institute of Biodiversity Conservation
IUCN:	International Union for the Conservation of Nature and Natural Resources
LC:	Least Concern
NBSAP:	National Biodiversity Strategy and Action Plan
NFPA:	National Forest Priority Areas
NT:	Near Threatened
SIV:	Species Importance Values
VU:	Vulnerable
WBISPP:	Woody Biomass Inventory and Strategic Planning Project
WG:	Wollega floristic region of Ethiopia

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Abstract

Structural and floristic study was carried out in Chato Natural Forest, Horo Guduru Wollega Zone, West Ethiopia, with the objectives of determining the floristic composition and structure of the vegetation found in the area. Data were collected from 40 quadrats, each with 20 m X 20 m (400 m²), for trees and shrubs. In addition, 2 m X 2 m subplots were laid within the main plot to sample herbaceous plants. Vegetation sampling sites were selected by preferential methods from Google Earth and coordinates were fed into Garmin eTrex GPS. Altitudes and geographic coordinates were recorded for each quadrat, and cover/abundance value was estimated for all species. Height and diameter at breast height of all woody species taller than 2 m and 2 cm were measured.

One hundred fifty-four species of vascular plants were identified which were grouped in to 138 genera and 67 families. Asteraceae followed by Euphorbiaceae and Fabaceae were found to be the most abundant families in the study area. Out of these, 23 species were new records for Wollega floristic region. Furthermore, Chato Natural Forest harbours 12 endemic species; one of these species was identified as a vulnerable species following the IUCN Red list criteria.

*Three plant community types were identified and named by one/ two or three species with higher indicator values. Structural analysis of the Chato Natural Forest revealed a density of 980 stems/ ha and a total basal area of 65 m²/ ha. The most dominant tree species relatively with the highest importance values recorded in the area were *Pouteria adolfi-friederici*, *Podocarpus falcatus*, *Celtis africana*, *Mimusops kummel*, *Pyschotria orophila*, *Olea capensis* subsp. *macrocarpa*.*

Analysis of population structure for majority of species revealed normal distribution patterns. Floristic comparisons with other similar forests in Ethiopia showed that Chato Natural Forest is more similarity to the moist montane forests.

Key Words/ Phrases: Chato Natural Forest, floristic composition, FIV, moist montane forest, plant community, SIV, vegetation structure.

1. INTRODUCTION

1.1 General Background

Ethiopia is a country of great geographical diversity with high and rugged mountains, flat-topped plateau and deep gorges, incised river valleys and rolling plains. Over the ages, erosion, volcanic eruptions, tectonic movements and subsidence have occurred and continued through millennia to accentuate the unevenness of the surface (EMA, 1988). Altitudinal variation ranges from the highest peak at Ras Dejen, 4620 m above sea level; down to the depression of the Kobot Sink (Afar Depression), which is 110 m below sea level (Demel Teketay 1999; EFAP, 1994). This gives the country a highly diversified climatic conditions and topography with a wide range of habitats and vegetation types. Most of the country consists of high plateau and mountain ranges with precipitous edges dissected by the numerous streams, which are tributaries of the major rivers. The Great Rift Valley separates the north-western and south-eastern highlands, and the highlands on each side give way to vast semi-arid low land areas in the east and west, especially in the south of the country. The physical conditions and variations in altitudes have resulted in a great diversity of climate, soil, flora and fauna (Brenan, 1978; cited in EWNHS, 1996).

The country has been regarded as one of the most important countries in Africa with respect to biological resources (flora, fauna and vegetation) (EFAP, 1994). The number of species of higher plants (flowering plants, conifers and ferns) found in Flora of Ethiopia and Eritrea Volumes 1-8 is about 6000, of which about 10% are endemic to the country (Vivero *et al.*, 2006). This high number of plant species results from the wide variation in climate, geology and terrain working on different time scales (EWNHS, 1996; Gebremarkos Woldeselassie, 1998; Sebsebe Demissew *et al.*, 2003; Mulugeta Lemenih and Demel Teketay, 2004) and past historical events.

Various authors (Logan, 1946; Breitenbach, 1963; EMA, 1988; Abate Ayalew *et al.*, 2006,) indicate that the substantial proportion of highlands of Ethiopia was once believed to have been covered with extensive forests. The extent to which the highland areas were once covered with dense forests can be used as indicator by numerous isolated mature forest trees or small patches

of forest and/or woodlands of approximately the same species composition found in the remaining closed forests (Friis, 1986).

However, the forest cover of Ethiopia has been diminishing over times due to an ever increasing demand for uncontrolled farmlands, the increasing livestock population, and an increasing demand for fire wood and charcoal with illegal harvesting of the forest and its products (Chaffey, 1980; Shibiru Tedla, 1995; Feyera Senbeta and Demel Teketay 2003; Million Bekele and Leykun Berhanu, 2001; Teshome Soromessa *et al.*, 2004). Loss of such forest resources would have great implication for the environment, biological diversity and socio-economic setup of the communities.

The forest cover of Ethiopia has been variously estimated over years. Historical sources indicate that about 35-40% of the land surface of the country has been covered with forest and woodlands (EFAP, 1994). The same source has shown that the size has exhibited diminishing trend over years, i.e., about 16% was left by early 1950s, 3.1 % by 1982, 2.6 % by 1989 and less than 2.3 % in 1990 forest cover was remaining before the completion of the study that led to (EFAP, 1994) establishment.

According to recent estimates by Reusing (1998 & 2000) who used LANDSAT/MSS and showed, for the first time, the extent of forest/vegetation cover of Ethiopia based on density classes, i.e., closed high forest (80% of the polygon is covered by forest), slightly disturbed high forest and heavily disturbed high forest. He found the percent coverage of these different categories of forests in 1996-1997, i.e, 0.16% of closed high forest, 0.65% of slightly disturbed high forest and 0.92% of heavily disturbed high forest. Therefore, the forest cover of Ethiopia (including all the three types) was 1.41% in 1996 – 1997.

Most of the remaining forests in Ethiopia are confined to the south and the south-western parts which are less accessible (Kumilachew Yeshitela and Tamrat Bekele, 2002 and Reusing, 1998). However, now a days the remnant natural forests in these areas are also continuously threatened by anthropogenic activities and the existing ones are in a secondary state of development (Reusing 1998 & 2000; Friis and Mesfin Tadesse, 1990; Tamrat Bekele 1994).

Deforestation and degradation are the causes of forest cover loss in Ethiopia which has its root in a cascade of events. Geometric population growth resulted in rural demand for agricultural lands. This in turn led to expansion of cultivated fields at the expense of the forest.

The annual rate of deforestation in Ethiopia was found to be extremely high (Reusing 2000 and Shibru Tedla, 2003). The major causes of deforestation were reported elsewhere (TewoldeBerhan G. Egziabher, 1990; WBISPP, 1997; Desta Hamilto, 2001; Tadesse Woldemariam, *et al.*, 2001 & 2002; NBSAP, 2005). This unprecedented deforestation rate is considered a major threat to the Ethiopian biodiversity (Demel Teketay, 1992; Tadesse Woldemariam and Demel Teketay, 2001; Tadesse Woldemariam *et al.*, 2002; Tadesse Woldemariam, 2003; Feyera Senbeta and Denich, 2006, IBC, 2009) and the habitats of the 120 threatened endemic plant species of Ethiopia (Vivero *et al.*, 2005).

This apparent forest resources degradation is alarming and the establishment and reinforcement of stringent forest resources conservation measures should be put in place. The inclusion of local communities in conservation activities is also equally useful for forest resource conservation.

In view of this, generation of sound biodiversity and ecological data on the remaining natural forest of Ethiopia is deemed necessary for their subsequent conservation activities.

Chato Natural Forest is part of the Chato – Zangi – Dangeb National Forest Priority Area (EFAP, 1994). The floristic composition and ecology of this forest is not in a record to date.

Its geographical position in relation to the main road contributed to the poor botanical and ecological knowledge of this high closed forest of Ethiopia in the terminology of Reusing (1998 & 2000). Therefore, the current study presents the floristic composition and structure and evaluates the status of the forest in the framework of other studied natural forests of Ethiopia.

1.2 Statement of the Problem

Chato Natural Forest is one of the few forest patches in Ethiopia where one finds high number of plant species diversity and remarkable vegetation stands. This forest is highly valued for its high economic and other ecological services. Despite all these services, forest vegetation removal will apparently continue for some time to come for the simple reason that forests are still the principal sources of construction and timber materials for the rural and urban population. Therefore, detailed biodiversity and ecological studies are desirable to draw the attention of policy makers to understand the ecosystem services of this biodiversity assemblage and undertake appropriate conservation measures. The absence of any previous ecological botanical studies is also equally vital to call for immediate and timely scientific interventions to uphold the conservation of this natural high forest.

1.3 Objectives of the Study

1.3.1 General objective

The general objective of the current study is to assess the floristic composition and structure of the forest vegetation of Chato Natural Forest:

1.3.2 Specific objectives

- To assess the floristic composition and structure of the forest;
- To identify and evaluate the plant community types in terms of:
Species richness, evenness and species diversity among different plant community types;
- To make phytosociological comparisons with other related forests in Ethiopia; and
- To recommend conservation measures that enhances future intervention strategies to maintain the remnant forest.

2. LITERATURE REVIEW

2.1 Vegetation Types in Ethiopia

Various authors have been attempted to study the Ethiopian forests and woody vegetation resources employing different systems, among which Logan (1964), Von Breitenbach (1963), White (1983), Zerihun Woldu (1985), Lisanwork Nigatu (1987), Zerihun Woldu *et al.*, (1989) Friis (1986 and 1992), Friis and Mesfin Tadesse (1990), EFPA (1994), Tamrat Bekele (1993 & 1994), Demel Teketay and Tamrat Bekele (1995), Sebsebe Demissew *et al.*, (1996), Friis and Sebsebe (2001), Kumilachew Yeshitila and Tamrat Bekele (2002) and Tadesse Wolde Mariam (2003) have made considerable contributions toward understanding the vegetation of the country and proposed their conservation strategies.

Recent studies (Abate Ayalew *et al.*, 2006; Simon Shibru and Girma Balcha, 2004 ; Genebe Bekele, 2005; Motuma Didta, 2007; Alemu Abebe, 2007 and Dereje Denu, 2007; Kitessa Hundera *et al.*, 2007; Haile Yineger *et al.*, 2008 and Ensermu Kelbessa and Teshome Soromessa, 2008) provided general description of the vegetation types and their floristic composition in different parts of Ethiopia. Based on the works of these and other authors the various vegetation types of Ethiopia have been grouped in to different categories.

Accordingly, the various natural vegetation types of the Flora area of Ethiopia have been divided into eight major ecosystems which are described as follows: Desert and semi-desert scrubland, *Acacia- Commiphora* woodland, Moist Montane rainforest (which includes the Afromontane-rainforest and the Transitional rainforest), Lowland semi-evergreen forest, *Combretum-Terminalia* woodland and Savannah, Dry evergreen montane forest and Grassland complex, which can also be divided into four subtypes namely: Undifferentiated Afromontane forest, Dry single-Dominant Afromontane of the Ethiopia Highlands, Afromontane woodland, wooded grassland and grassland, Afro alpine and sub-afro alpine vegetation and Riparian and Swamp vegetation.

From these vegetation types, the current study area, Chato Natural Forest, might fit the characteristics of the moist evergreen montane forest in the country (Friis, 1992; EFAP, 1994;

Kumilachew Yeshtila and Taye Bekele, 2003; NBSAP, 2005; Alemu Abebe, 2007; Woldeyohannes Enkossa, 2008) as it has similar climatic and physical features to the southwestern parts of the country.

2.1.1 Moist Evergreen Montane forest

The moist evergreen montane forest consists of high forests of the country mainly the southwest forests, wettest and also humid forest in the southeastern plateau known as the Harena forest (Ermias Lulekal, 2005). Many other researchers for example, Lisanwork Nigatu and Mesfin Tadesse, 1989; Zerihun Woldu *et al.*, 1989; Friis, 1992; Kumilachew Yeshitila, 1997; Woldeyohannes Enkossa 2008, Ensermu Kelbessa and Teshome Soromessa, 2008) have also studied the composition and structure of this forest type.

This forest occurs mainly in the southwestern part of the country (Wollega, Illubabor and Kafa) with altitudinal ranges of 1500-2500 m a.s.l., average annual temperature of 18-20 °C and annual rainfall between 1500-2000 mm sometimes even higher than 2000 mm, with rain all the year round, but a maximum in April-October (Friis *et al.*, 1982; Friis, 1992; Tadesse Woldemariam, 2003; NBSAP, 2005; Feyera Senbeta, 2006).

The moist forest ecosystem is the most diverse ecosystem in composition, structure and habitat types (NBSAP, 2005), consequently it is rich in biodiversity with a number of endemic species.

The characteristic plant species in this vegetation type include the largest and commercially most important trees associated with broad-leaved species of which the most frequent emergent species and also the most upper canopy trees such as *Pouteria adolfi-friederici*, *Podocarpus falcatus*, *Celtis africana*, *Schefflera abyssinica*, *Mimusops kummel*, *Millettia ferruginea*, *Croton macrostachyus*, *Albiza gummifera*, *Ficus ovata*, *Ficus thonningii*, *Syzygium guineense* subsp. *afromontanum*, *Ekebergia capensis* and *Olea welweitschii* . .

The lower storey trees and shrubs include: *Maesa laceolata*, *Bersama abyssinica*, *Ehretia cymosa*, *Clausena anisata*, *Cordia africana*, *Matyenus gracilipes*, *Teclea nobilis*, *Trema orientalis*, *Nuxia congesta*, *Cassipourea malosana*, *Allophylus abyssinicum*, *Coffee arabica*, *Dracaena steudneri*, *Calpurnia aurea*, *Phoenix reclinata*, *Psychotria orophila*, *Olea capensis* subsp. *macrocarpa*, *Carissa spinarum* and *Rytigynia neglecta*.

Lianas are common and include: *Jasminium abyssinicus*, *Landolphia buchananii*, *Commobretum paniculatum*, *Urera hypselodendron*, *Embelia schimperii*, *Hippocratea goetzei*, *Periploca linearifolia*, *Tiliacora troupinii* and *Clematis hirsuta*.

Acanthaceous species such as *Thunbergia alata*, *Hypoestes* spp., *Justicia ladanoides*, etc predominate in the herb layer within the forest and the grass species are common on the ground vegetation mainly *Oplismenus hirtellus*. Several ferns and epiphytes are found, some of which are Orchids, *Peproma abyssinica*, *Loxogramme abyssinica*, *Adiantum poiretii*, *Dryopteris* spp and *Asplenium* spp.

Therefore, the vegetation cover in a given area has definite structure and composition developed as a result of long term interaction with biotic and abiotic factors. The pattern of distribution and vertical stratification change attributed to varied climatic conditions, soil types, latitude and topography of the area which in turn influence the distribution and types of plant and animals in the forest (Mueller-Dombois and Ellenberg, 1974:)

2.2 Plant Biodiversity and Threats in Ethiopia

Owing to the diversity in climatic variations, Ethiopia is one of the richest centers of biological diversity and genetic resources in the world (EWNHS, 1996; EPA, 2003; NBSAP, 2005). A loss in biodiversity due to degradation of environment and other threats to the components of ecological systems is the most serious environmental problems facing Ethiopia at present. Biodiversity resources along with their habitats are rapidly disappearing in the country (Demel Teketay, 1992; Tadesse Woldemariam and Demel Teketay, 2001; Tadesse Woldemariam *et al.*, 2002; Tadesse Woldemariam, 2003; Feyera Senbeta, 2006; Feyera Senbeta and Denich, 2006).

In addition, Ensermu Kelbessa *et al.*, (1992) mentioned that environmental degradation in Ethiopia, limitations to the opportunities for income generation caused by ecological and socioeconomic constraints exacerbated by a mounting population pressure have, over the years, forced people to cultivate marginal lands and allow over grazing and feeling of trees, thus catalyzing spiral environmental degradation and deforestation.

This loss in biological diversity ultimately results in economic losses of the country and the world as a whole, including reduction in the quantity of carbon that can be sequestered from the atmosphere (EFAP, 1994). Most highlands have felt the impacts of fundamental changes, as a result of the vegetation deteriorating in its biological potential from the effects of human pressure (Sebsebe Demissew, 1980). Although biodiversity has valuable importance and services in terms of economic, ecological and other benefits, humans have a bad record of misuse of these resources.

Generally, there are close connections between poverty, population growth, economic development, and the use of the environment (Woldeyohannes Enkossa, 2008). If present trends in population growth continue, deterioration of natural resources will be even more rapid in the future. This rapid depletion of the forest associated with other pressing problems such as land degradation, soil erosion, and water resource degradation (EFAP, 1994; NBSAP, 2005), also caused by an increased demand for construction inputs, over grazing, fuelwood and clearing for agricultural expansions (Alemu Abebe, 2007; Million Bekele and Leykun Berhanu, 2001; Simon Shibru and Girma Balcha, 2004; NBSAP, 2005). The recognition of these loss/threats to biodiversity has led to draw conservation strategies at global, regional and national levels.

2.3 Plant Community Types

Plant communities are conceived as types of vegetation recognized by their floristic composition. The species compositions of the communities better express their relationships to one another and environment than any other characteristics (Kent and Cooker, 1992). It can be defined as the collection of plant species growing together in a particular location that show a definite association or affinity with each other (Kent and Cooker, 1992).

Plant community can be understood as combination of plants that are dependent on their environment, influence one another, and modify their environment (Mueller-Dombois and Ellenberg, 1974). As stated in Mueller-Dombois and Ellen berg (1974), the floristic composition of vegetation includes all species occurring within a plant community. However, most plant communities consist of many different species which are not particular to discover all species within a community. Hence, it is common to use the dominant species in naming plant

communities (Kent and Cooker, 1992). Information on plant population structure analysis helps to respect the healthy regeneration of the tree species under utilization. It indicates the history of forest disturbances to that species and environment and hence used to forecast the further trend of the population of that particular species (Peters, 1996).

Vegetation classification attempts to define discrete, repeatable classes of relatively homogenous vegetation communities /association about which reliable statements can be made. Classification assumes either that natural vegetation groupings do occur, or that it is reasonable to separate a continuum of vegetation composition and/or structure in to a series of arbitrary classes (Kimmins, 1997).

2.3.1 Species diversity, species richness, evenness and similarity

The description of plant community involves the analysis of species diversity, evenness and similarity. Diversity and equitability of species in a given plant community are used to interpret the relative variation between and within the community and help to explain the underlying reason for such a difference. The two main factors taken into account when measuring diversity are richness and evenness.

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 (Zerihun Woldu, 1985). Species richness refers to the total number of species in a community whereas evenness is the relative abundance of species within the sample or community making up the richness of an area (Kent and Cooker, 1992; Krebs, 1999). Species richness index is of great importance in assessing taxonomic and ecological values of habitats.

A number of indices of diversity have been devised, each of which seeks to express the diversity of a sample or quadrat by a single number. Of the various indices, the most frequently used is the simple totality of species numbers to give species richness (Magurran, 1988). Among many species diversity indices, probably the most widely used to calculate the diversity and evenness includes Shannon-Wiener diversity index, which naturally varies between 1.5 and 3.5 and rarely

exceeds 4.5 (Kent and Cooker, 1992). It is widely used index that combines richness and evenness (Krebs, 1999).

Species diversity could be viewed from different approaches in terms of alpha, beta and gamma diversity (Rosenzweig, 1995). Alpha diversity (α) refers to the diversity of species within a particular habitat or community. Beta diversity (β) is a measure of the rate and extent of change in species along a gradient from one habitat to another. It is between habitat diversity that measures turnover rates. Beta diversity is sometimes called habitat diversity (Kent and Cooker, 1992). Gamma diversity (γ) on the other hand is the diversity of species in comparable habitats along geographical gradients and is independent of the two (Kent and Cooker, 1992; Buley, 2001). Similarity index measures the degree to which the species composition of the quadrats/ samples is alike, whereas dissimilarity coefficient assesses which two samples/ quadrats differ in composition. It can be used to assess the similarity between different habitats with reference to the composition of species.

Jaccard and Sorensen are the most common binary similarity coefficient, because they rely on probability data, except that Sorensen gives more weight to the species that are present in both quadrats and therefore less weight to species that are present in only one quadrat (Kent and Cooker, 1992). Patterns of plant species diversity have often been noted for prioritizing conservation activities because they reflect the underlying ecological processes that are important for management (Lovett et al., 2000; cited in Feyera Senbeta, 2006).

2.3.2 Abundance and frequency

Abundance is the number of plant per unit area. Measurement of plant abundance requires the counting of individual plants by species in a given area. It can be used to show spatial distribution and ranges over time.

Frequency is the proportion of plots in which a species occurs. 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)

2.3.3 Species important value index (SIV) and dominance

SIV permits a comparison of species in a given forest and reflects the dominance, occurrence and abundance of a given species in relation to other associated species in an area (Kent and Coker, 1992). Therefore, for setting priority, it is a good index for summarizing vegetation characteristics and ranking species for management and conservation practices. Whereas species with lower SIV need high conservation efforts, those with higher SIV need monitoring management.

2.4 Vegetation Patterns along Environmental Gradients

Natural vegetation may respond to environmental gradients in many ways (Desalegn Wana and Zerihun Woldu, 2005). Globally, Patterns of plant species diversity are influenced by latitudinal, altitudinal and soil gradients (Huston, 1994). Altitude is one of the most important environmental factors that determine species diversity and distribution patterns. Species diversity generally tends to decrease with increasing altitude (elevation) (Whittaker, 1975). The interacting influences of climate, topography and soil are primary determinants of plant distribution so that variables such as vegetation structure and productivity also exhibit complex patterns along environmental gradient (Brown, 2001). Altitude affects temperature, moisture, radiation and atmospheric pressure thereby influencing the growth and development of plants and the distribution of vegetation (Zerihun Woldu *et al.*, 1989; Getachew Tadesse *et al.*, 2005). Zerihun Woldu *et al.* (1989) indicated that altitude is the main factor that orders the tree-shrub layer into respective vegetation types because it is positively correlated with some environmental factors like organic matter and negatively correlated with pH, clay and calcium.

In general, the distribution, abundance and diversity patterns of species can result from the interaction between biotic and abiotic factors at different spatial and temporal scales (Brown, 2001; Feyera Senbeta 2006). Variations in climate, temperature and rainfall distribution are generally reflected in the variations of the species composition and structure of communities (Brown, 2001, Grytnes and Vetaas, 2002).

3 MATERIALS AND METHODS

3.1. Description of the Study Site and Location

The study was undertaken at Chato Natural Forest which is located in the Horo -Guduru Wollega Zone of Oromia National Regional State, Ethiopia. This forest is part of National Forest Priority Areas (NFPAs) and has been known by the name Chato-Sangi-Dangab Forest in the country (EFAP, 1994). The forest lies approximately between 9° 40' - 9°42' N latitudes and 36° 59' -37° 00'E longitudes (EMA, 1988) in the Horo District 30 km north-west of Shambu which is located at about 314 km west of Addis Ababa (Fig. 1).

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 (Oromia Agricultural Bureau personal Communication).

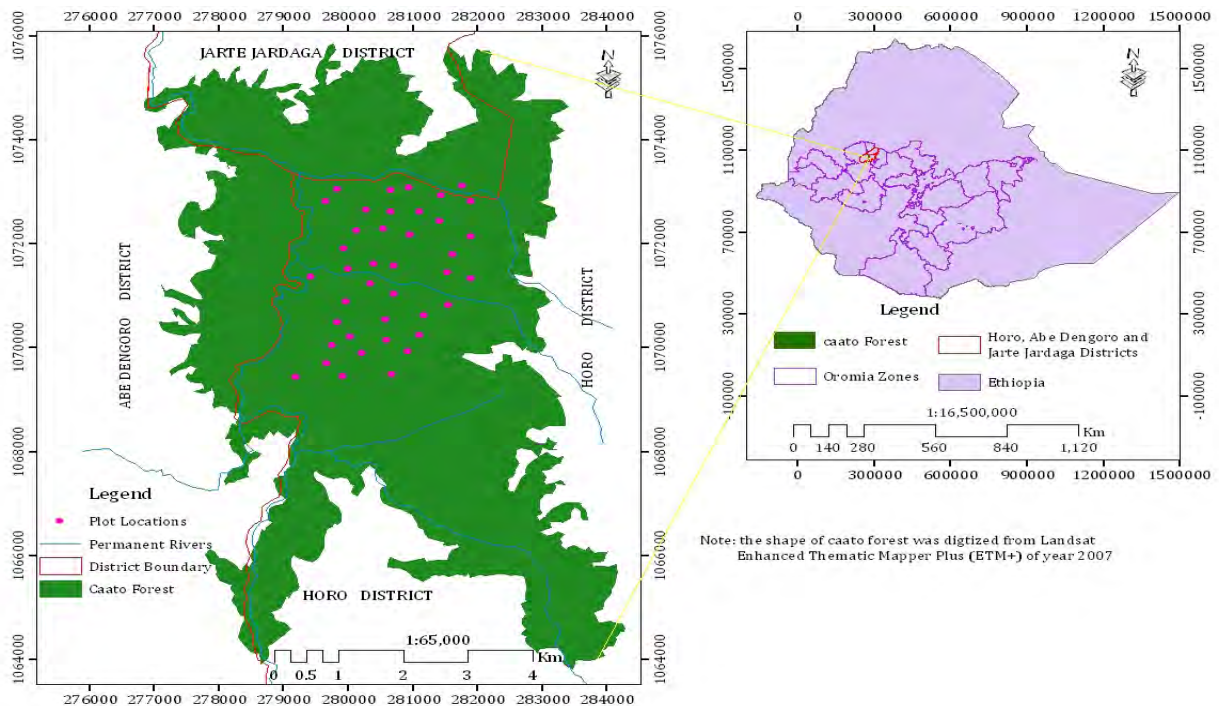


Figure 1: Location map of the study area (Chato Natural Forest)

3.1.1 Topography

Topographically, the forest is generally characterized by rough topography with undulating plain, hills, slopes, deep valley, gorges, escarpments and dissected plateaus (Plate 1).

Several perennial rivers such as Yamalagi River, Badessa River, Chiracho River, Jaba River and Gabar River are flowing into Garchi River by crossing the forest, all of which emerge from the highlands. It is bounded in the north by Jaba River (Jardega-Jarte Wereda) in the west by Garchi River (Abe Dongoro Wereda), in the southeast by Bafo-Gabar River and in the east direction by plantation (Horo Wereda).

Because of topographic nature, the forest area is not easily accessible as it is surrounded by steep hill slope and escarpments - it is relatively less disturbed by human actions.



Plate 1: Topography of the forest area

3.1.2 Climate

3.1.2.1 Temperature and rainfall

The temperature and rainfall data for this study were obtained from Shambu Meteorological Station from 1992- 2006 (EMSA, 2010). Shambu station is located at 9⁰34'N latitudes and 37⁰ 06'E longitudes with altitude of 2430 m a.s.l

The distribution of rainfall is unimodal, characterized by a prolonged wet season from June to September (big rain) and a short dry spell showers from mid February to April. There is a long dry period from October to the end of February (H.W.R.D.O., 2009; Woldeyohannes Enkossa, 2008).

Climate diagram was computed by using R for windows version 2.10.1 statistical package (R-Development Core Team, 2007). The climate of the study area is illustrated by Shambu (Fig. 2).

Based on 15 years data, the mean annual rainfall in the study area is about 1566 mm, rainfall peak period between May to October, and decreasing in November and December with little or no rainfall in January and February. The mean annual temperature is about 16.6⁰C and the mean minimum temperature is 10.78⁰C whereas the mean maximum temperature is 22.32⁰C. There is slight temperature difference throughout the year. The hottest months are from February to May maximum temperature recorded is about 24.6⁰C (in April/May) and the coldest months are from July to December with the mean minimum temperature 9.8⁰C (in December).

Based on altitudinal variations, Horo District has three Agro-Climatic Zones which correspond to the traditional classification systems: 43% Dega (2500-3500 m) 55.56% Woina Dega (1500 - 2500 m), and 1.24% Kola (500-1500 m) (EFAP,1994) (Horo District Agricultural Office, 2009).

They are generally found on landscape that is undulating and one of the wettest in the country. According to (HWRADO, 2009) the type of soil in the District is sandy-loam type. However, as visually observed the Soils of the forest area are darker-reddish in color with concentrated humus as there is no strong eroding forces along vegetation cover.

3.1.4 Population and Land Use

According to population and housing census reported by the CSA (2007), the total population of Horo District was 76,162 of these 73,983 and 2,179 were rural and urban population respectively. Similarly, 38,256 are females and 37,906 are males in District. In each, 36,811 are males and 37,172 are female in rural, whereas 1,095 are males and 1,084 are females in urban area.

Like other parts of the highlands of the country, mixed cultivation of livestock rearing and crop production, subsistence agriculture is the main economy development of the community (H.W.R.D.O., 2009). Coffee and honey production is also practiced in the forest area. The traditional farming systems enforce the population to exploit the forest, particularly at the marginal areas for agricultural expansions and settlements. Based on the data obtained from the (H.W.R.D.O., 2009), the land cover categories of the District include about 45% account for potential arable land including land under crops and land reserved 12.29% goes for pasture land/grazing land, 11.05% accounted for forest land, 2% for swampy land and 29% for other purposes.

Major crops grown in this wereda are cereal crops (tef, wheat, maiz, barely), pulses (peas and beans) and oil crops (noug and rape seed).

During the 1999-2000 E.C. livestock populations in the district were 362,507 cattle, 118,389 sheep, 29,214 goats, 85,557 poultry, 38,523 horses, 4,007 mules and 18,545 donkeys as reported by (H.W.R.D.O., 2009).

3.1.5 Vegetation

As it is indicated by several authors the vegetation of Ethiopia is extremely complex. This complexity derived from the great variation of altitude implying equally great spatial differences in moisture regimes as well as temperature within horizontal distances. The south-western forests of Ethiopia are characterized as moist montane forest ecosystems (Friis, 1992; Kumilachew Yeshitila, 1998; NBSAP, 2003).

The main species of plants found in this forest vegetation include broad-leaved and evergreen with important tree species such as *Pouteria adolfi-friederici*, *Mimusops kummel*, *Millettia ferruginea*, *Teclea nobilis*, *Podocarpus falcatus*, *Celtis africana*, *Croton macrostachyus*, *Dracaena steudneri*, *Allophylus abyssinicum*, *Albiza gummifera*, *Prunus africana*, *Polyscias fulva*, *Cordia africana*, *Warburgia ugandensis*, *Diospyros abyssinica*, *Macranga capensi*, *Nuxia congesta*, *Ekebergia capensis*, *Ficus* spp., *Syzygium guineense* subsp. *afromontana*, *Olea capensis* subsp. *macrocarpa* and *Pittosporum viridiflorum* (Plate 2).

Although, Chato Natural Forest has been designated as a NFPA, little conservation attention was given. Apparently new settlers, who settled there from other parts of the country, cleared the forest for other types of land uses, particularly at marginal area of the forest. This is one of the existing threats to the forest vegetation by expansion of farmland surrounding the forest and illegal logging.

3.1.6 Wild life

The vegetation of Chato Natural Forest also contains a variety of wildlife including Colabus monkey, wild pig, various species of birds and mammals and reptiles. Some of the common wild life include Anubis baboon, Verbeit monkey, Porcupine, Common warthog, Africana civet cat, Leopard, Common bushbuck, Platypus. Thus, the forest is rich in fauna diversity.



Plate 2: A) Vegetation of Chato Natural Forest B) *Landolphia buchananii* scrabbling over *Podocarpus falcatus*

3.2 METHODS

3.2.1 Reconnaissance survey and sampling site selection

Reconnaissance survey of the Chato Natural Forest was made in the first week of October, 2009 in order to obtain an impression of the site conditions, to collect information on accessibility and to identify sampling design. Following this, samplings (preferential methods) for vegetation sites (coordinates) were selected from Google Earth. This Google Earth was used to provide information and effort was made to make the samples as representative as possible by uniformly distributing the sites over the study area. These coordinates were fed into Garmin eTrex GPS. Each sampling site was identified on the ground by using the navigation facility of this GPS apparatus and later modified accordingly in the area of investigation.

3.2.2 Vegetation data collection

A total of 40 plots of the Chato Natural Forest were sampled to the current study. Woody species were sampled in 20 m x 20 m sample plot while herbaceous species were measured in cover abundance using subjectively laid 2 m x 2 m subplot within the main plot in five places where four plots placed at each corner and one was at center (Mueller-Dombois and Ellenberg, 1974). The data were collected from October 26 -November10/2009.

A complete list of trees, shrubs and herbs was made for each plot. Plants were collected following standard herbarium technique and identified at the National Herbarium of Ethiopia, Department of Biology, Addis Ababa University. Herbarium specimens housed at ETH and volumes 1 – 8 of the Flora of Ethiopia and Eritrea and (Azene Bekele, 2007) were used to aid identification. Plant species occurring outside the plot were also collected and identified to produce a comprehensive list of the plant species diversity of the study area.

All individuals of trees and shrubs with a diameter at breast height (DBH) > 2 cm and height > 2 m were measured following Abate Ayalew *et al* (2006). Individuals with DBH less than 2 cm, and height less than 2 m were counted as seedling and sapling. DBH of all woody plants were measured and recorded using diameter tape and heights were estimated visually.

3.2.2.1 Estimation of % covers value

Transformations of the Braun-Blanquet cover-abundance scale into a new numerical scale has been introduced by Maarel (1979). This new cover-abundance scale is an effective, easy to use directly in the field and the raw data can be easily entered into the data-processing system for vegetation community classification.

Therefore, the percent cover-abundance value was estimated visually for each species within the sample plot and recorded. These were later used for the estimation of cover/abundance values and converted to the Braun-Blanquet 1-9 scale as modified by van der Maarel (1979) as follows:

- 1= rare generally one individual,
- 2= occasional < 5% cover,
- 3=abundant < 5% cover,
- 4= very abundant <5% cover,
- 5= cover values between 5-12%,
- 6= cover values between 12-25%,
- 7= 25-50% cover;
- 8= 50-75% cover and
- 9= 75-100% cover of the total plot area.

3.2.3 Data Analysis

3.2.3.1 Vegetation data

In vegetation ecology, many studies have pointed out that among the multivariate approaches ordination and classification are the two main methods. The choice of the method to be used depends on the ecological question to be answered (Gauch and Whittaker, 1972; Gauch, 1982).

It is now generally accepted that the choice between the two methods depends on the objectives of the data analysis and the structure of the data set being examined, rather than on preconception about the nature of the vegetation (Grieg-Smith, 1997) and there is no prior reason to accept either a classification or an ordination as an inherently correct technique (Anderson, 1965). Bearing this in mind, classification technique is employed to study the ecology of Chato

Natural Forest. Classification by means of cluster analysis is the most common multivariate technique to analysis community data and for mapping ecological community (Kershaw, 1973).

Hierarchical cluster analysis in PC-ORD for windows version 5.0 (McCune and Mefford, 1999; McCune and Grace, 2000) was used to classify the vegetation into plant community types following (Feyera Senbeta and Demel Teketay, 2003; Tadesse Woldemariam, 2003; Feyera Senbeta, 2006; Woldeyohannes Enkossa, 2008). The floristic and structural data analysis was based on 108 species that were recorded and collected within the sampled plots.

The analysis was based on the abundance data of the species (number of individuals). The Indicator Species Analysis was used to compare the species present in each group. The Relative Euclidean Distance (RED) measures using Ward's method was used in the current study to eliminate the differences in total abundance among sample units. In addition, the Ward's method minimizes the total within group mean of squares or residual sum of squares (Van Tongeren, 1995; McCune and Grace, 2000). The identified plant community types or groups were tested for the hypothesis of no difference using the Multi-response Permutation Procedures (MRPP).

Species indicator values were calculated by using Dufrene and Legendre's (1997). These values obtained by combining the relative abundances and relative frequency of each species. Indicator values are measures of the fidelity of occurrence of a species in a particular group (McCune and Mefford, 1999) and its values ranges from zero (no indication) to 100 (perfect indication). Indicator values were also tested for statistical significance using Monte Carlo technique. Indicator species are the characteristic species of each group found mostly in a single group of typology, and present in the majority of sites belonging to that group. A species is considered as an indicator of a group when its indicator value is significantly higher at $p < 0.05$ (Tadesse Woldemariam, 2003; Feyera Senbeta, 2006). The plant community types were named after one; two or three dominant indicator species selected using the relative magnitude of their indicator values.

3.2.3.2 Diversity Indices

Diversity indices measure the degree of uncertainty that is if the diversity is high in a given habitat, the certainty of observing a particular species is low. They are simple mathematical expressions that summarize a lot of data recorded in one or sets of figures.

Of the various indices, Shannon-Wiener diversity index (H') is the most applicable index of diversity (Grieg-Smith, 1983). It was used to compute for both species richness, species evenness and species diversity of the plant community types in the vegetation (Magurran, 1988).

- i. **Diversity index** was calculated according to Shannon-Wiener (1949) by using the following formula:

$$H' = -\sum_{i=1}^s p_i \ln p_i \text{ Where,}$$

H' = Shannon diversity index

\sum = Summation symbol;

S = the number of species;

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

\ln = log base n (natural logarithm)

- ii. **Shannon's Equitability** (E), Evenness is calculated from the ratio of observed diversity to maximum diversity using the equation

$E = H' / H'_{\text{max}}$, or

$E = H' / \ln s$, Equitability assumes a value between 0 and 1 with 1 being complete evenness (Kent and Cooker, 1992).

The higher the value of evenness index, the more even the species is in their distribution within the given area.

- iii. **Similarity coefficient** - The similarity of forest types with regard to species composition was assessed using Sorensen's coefficients as described by Grieg-Smith (1983) and computed from the formula below.

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

Where: S_s = Sorensen's similarity coefficient

a = is number of species shared by the two forests/ samples;

b = is the number of species in forest/ sample 1 (community1);

c = is the number of species in forest/ sample2 (community2) Kent and Coker (1992)

3.2.3.3 Analysis of the vegetation structure

In this study, the structural analysis of the vegetation was described by using the following components: frequency, DBH and height class distribution, Important Value Index (IVI), basal area, and the stem density. Tree/shrubs density and basal area values were analysed on a hectare basis. Nine DBH classes (i.e. 1= 2.1-10, 2= 10.1-20, 3= 20.1-30, 4=30.1-40, 5= 40.1-50, 6= 50.1-60, 7= 60.1-70, 8= 70.1-80, 9= >80cm) were constructed following Kitessa Hundera *et al* (2007). In addition, the percentage distribution of individuals in each class was calculated.

Tree height (m) was also classified into eleven classes based on the method established by Kitessa Hundera *et al.* (2007) i.e. 1=2-6, 2=6-10, 3= 10-14, 4= 14-18, 5= 18-22, 6= 22-26, 7= 26-30, 8 = 30-34, 9= 34-38, 10 = 38-42, 11= >42 and the percentage distribution of individuals in each class was computed for each species.

3.2.3.4. Species Importance Value (SIV)

SIV is considered by ecologist as the most realistic aspect in vegetation study because it combines data of the three parameters (Curtis and McIntosh, 1951). SIV was calculated for species of the study area following Mueller-Dombois and Ellenberg (1974). The expression of the relative dominance of all woody species in the community followed Kent and Cooker (1992). As a result, SIV can be calculated by using the following formula.

$SIV = \text{Relative Density (RD)} + \text{Relative Dominance (RDO)} + \text{Relative Frequency}$

$$RD = \frac{\text{number of all individuals of a species}}{\text{total number of all individuals of the sample}} \times 100$$

$$\text{RDO} = \frac{\text{basal area of a species}}{\text{total basal area of the sample}} \times 100$$

$$\text{RF} = \frac{\text{the number of plots where a species occur}}{\text{total occurrence for all species of the sample}} \times 100$$

Family Importance Value (FIV) was calculated based on the formulae given below Mori *et al.* (1983); cited in Nebel *et al.* (2001).

$$\text{Relative diversity (RDV)} = \frac{\text{number of species of a family}}{\text{total number of species of the sample}} \times 100$$

$$\text{Relative density (RD)} = \frac{\text{number of individuals of a family}}{\text{total number of individuals of the sample}} \times 100$$

$$\text{Relative dominance (RDO)} = \frac{\text{basal area of a family}}{\text{total basal area of the sample}} \times 100$$

FIV= relative diversity (RDV) + relative density (RD) +relative dominance (RDO).

Frequency is the number of times a particular species is recorded in the sample area. The frequency distribution of tree species was calculated as follow:

$$\% \text{ frequency of species} = \frac{\text{No. of quadrats in which species A occurs}}{\text{total No. of quadrats examined}} \times 100$$

Importance Value Index (IVI) is useful to compare the ecological significance of the species (Dereje Denu, 2007). High value of IVI indicates that the species sociological structure in the community is high.

Total basal area is the sum of the stem cross-sectional area at breast height on a per- hectare basis. Generally, it is a measure of dominance where the term “dominance” refers to the degree of coverage of a species as an expression of the space it occupies and calculated by using DBH; In turn, DBH values were calculated from circumference measurements by using the formula as follows: $d = C/\pi$

Therefore, **Basal area** = $\pi d^2 / 4$ where: d = diameter at breast height (DBH) $\pi = 3.14$

Basal area was computed for all trees and shrub species with a DBH > 2 cm. The population structure of all tree species in the sample plots was analyzed by using stems with a DBH > 2 cm and the pattern that emerged were interpreted as indication of variation in population dynamics in the forest (Kumelichew Yeshitila and Taye Bekele, 2003).

Phyto-geographical comparison was carried out in order to evaluate the relationships between Chato Natural Forest with other Dry/ moist montane forests of Ethiopia. Sorensen's similarity coefficient was used to evaluate woody species composition (tree/shrubs) and species distribution.

4. RESULTS AND DISCUSSIONS

4.1 Floristic composition

A total of 154 species of vascular plants belonging to 138 genera and 67 families and were identified from 40 quadrats examined from the study area. These plant species are comprised of the following growthform/habit, i.e., 103 species (66.9%) are woody species [50 tree species (32.46%), shrub species 39 (25.32%) and 14 species of lianas (9.09%)] and 51 (33.1%) species of herbs, ferns and epiphyte (Appendix 1).

With regards to species number, the most dominant family is Asteraceae (10 species). This is followed by Euphorbiaceae (9 species), Fabaceae and Acanthaceae (each with 8 species), Lamiaceae (7 species), and Rubiaceae (6 species) and Oleaceae (4 species). On the other hand, the remaining families of the study area are comprised of 3, 2 and 1 species each (Appendix 3). When the plant species are viewed at a larger taxonomic rank of vascular plants, there are fifty two families (77.6%) of dicots, eight families (11.9%) of monocots, six families (8.95%) of pteridophytes and one family (1.49%) of gymnosperm. A complete list of scientific name, family, habit and vernacular name of the species are given in Appendix 1.

The families Euphorbiaceae and Fabaceae had 8 woody species each followed by Oleaceae with 5, the remaining families had from 1-4 woody species each. This pronounced family hierarchy is one of the most important characteristics of the evergreen montane forests.

This forest contains 12 (50%) of the 24 national priority tree species (EFAP, 1994). These are *Podocarpus falcatus*, *Pouteria adolfi-friederici*, *Celtis africana*, *Ekebergia capensis*, *Albizia gummifera*, *Syzygium guineense* subsp. *afromontanum*, *Cordia africana*, *Croton macrostachyus*, *Prunus africana*, *Diospyros abyssinica*, *Warburgia ugandensis* and *Olea welwitschii*.

4.1.1 Endemic plant species

Chato Natural Forest also contains 12 endemic species of vascular plants (Table 1). Noteworthy is that one of these endemic plant species (Table 1) was listed as vulnerable (IUCN, 2001; Vivero *et al.*, 2005; Vivero *et al.*, 2006).

The presence of these vulnerable endemic plant species signifies that Chato Natural Forest houses and provides critical habitats for important gene pools of national value.

Table 1: Endemic plant species of Ethiopia occurring in Chato Natural Forest.

Key: LC = Least Concern; NT = near threatened; VU = Vulnerable.

Scientific name	IUCN Category	Family
<i>Lippia adoensis</i>	LC	Verbenaceae
<i>Laggeteria tomentosa</i>	NT	Asteraceae
<i>Kalanchoe petitiiana</i>	LC	Crassulaceae
<i>Vepris dainellii</i>	LC	Rutaceae
<i>Millettia ferruginea</i>	NT	Fabaceae
<i>Pycnostachys abyssinica</i>	LC	Lamiaceae
<i>Echinops longisteus</i>	LC	Asteraceae
<i>Phyllanthus dewildiorum</i>	NT	Euphorbiaceae
<i>Mikaniopsis clematoides</i>	LC	Asteraceae
<i>Justicia diclipteroides</i> subsp. <i>aethiopica</i>	LC	Acanthaceae
<i>Tiliacora troupinii</i>	VU	Mersipermaceae
<i>Phragmanthera macrosolon</i>	LC	Loranthaceae

4.1.2 New Records for Wollega (WG) Floristic Region of Ethiopia

The current study reports 24 plant species as new records for WG Floristic Region of Ethiopia (Table 2). These species represent 19 families and 24 genera. This finding demonstrates a high taxonomic richness relative to other montane forests of Ethiopia. Regarding floristic richness Chato Natural Forest is comparable with Masha-anderacha (146 species), but less than Alata-Bolale, (165 species), Gendo forest (168), Gura Ferda (174 Species), Denkoro (174 species), Sigo-Setema (196 species), Magada forest (194 species) and Harenna (202 species).

Table 2: New plant species recorded for Wollega Floristic Region of Ethiopia.

Keys:* = No local name, F =ferns, E =Epiphyte =Herbs, S =Shrubs, T =Trees, C=climbers

L= Lianas.

Scientific name	Family	Habit	Vernacular Name
<i>Kalanchoe petitiata</i> A.Rich.	Crassulaceae	H	Bussuqqee
<i>Acacia brevispica</i> Harms.	Fabaceae	S	Harangamaa
<i>Andropogon abyssinicus</i> Fresen.	Poaceae	H	Ballammii
<i>Myrsine africana</i> L.	Myrsinaceae	T	Qacamaa
<i>Olea capensis</i> subsp. <i>macrocarpa</i> (C.H. Wright) Verdc.	Oleaceae	T	Gaagama
<i>Warburgia ugandensis</i> Sprague	Canellaceae	T	Beftii
<i>Euphorbia ampliphylla</i> Pax	Euphorbiaceae	T	Hadaamii
<i>Tiliacora troupinii</i> Cufod.	Menispermaceae	L	Hidda Liqimee
<i>Loxogramme abyssinica</i> (Baker) M.G.	Polypodiaceae	E/F	*
<i>Mikaniopsis clematoides</i> (A. Rich.) Milne-Redh.	Asteraceae	C	Hidda Hantuttaa
<i>Caesalpinia decapetala</i> (Roth)	Fabaceae	L	Harangamaa
<i>Dovyalis abyssinica</i> A.Rich.	Flacourtaceae	S	Koshomii
<i>Plumbago zeylanica</i> L.	Plumbaginaceae	C	Ameeraa
<i>Dryopteris inaequalis</i> (Schltdl.) Kuntze.	Dryopteridaceae	F	Tirimmi
<i>Asplenium aethiopicum</i> (Brum.f.) Beckerer	Aspleniaceae	F	*
<i>Pteris catoptera</i> Kunze	Pteridaceae	F	*
<i>Cystopteris fragilis</i> (L.) Benth.	Athyriaceae	F	*
<i>Aspilia gilletti</i> Wild.	Asteraceae	S	*
<i>Laggera tomentosa</i> (Sch.Bip.ex A.Rich) Oliv.and Hiern.	Asteraceae	H	*
<i>Pycnostachys abyssinica</i> Fresen.	Lamiaceae	S	Doroomii
<i>Solenstemon autranii</i> (Briq.) J.K.Moore	Lamiaceae	H	Fakkii siqaqibee
<i>Oresoschimperella verrucosa</i> (A.Rich.) Rauschert	Apiaceae	H	*
<i>Commelina foliacea</i> Chiov.	Commelinaceae	H	Gorora Fardaa

4.2 Vegetation Community Classification

Three plant community types were recognized using hierarchical cluster analysis of PC-ORD 5.0 window versions (Fig. 4). The vegetation analysis was derived from the abundance data of species. The data matrix contained 40 samples by 108 species from Chato Natural Forest. The clusters were significantly different ($P < 0.000$) using the Multiple Response permutation Procedure (MRPP) test. The decision on the number of groups was based on the MRPP technique and the ecological interpretation of the groups. The three clusters occupying different region of space as shown by strong chance –correlation within the group (A) and (T). The test statistics T-value for the three groups were -12.65 ($P < 0.0000$) and A statistic was 0.067. The test statistics T, described the separation between/ among groups, with more negative T value was the stronger separation. The agreement A describes within group homogeneity and falls between 0 and 1, when all items within groups are identical $A=1$ and 0 when the groups are heterogeneous. In community ecology, values of A (agreement) are commonly below 0.1 (McCune and Mefford, 1999).

In the results, one or a combination of dominant or characteristic species having high indicator values ($p^* < 0.05$) was considered as an indicator species for a particular group and was/were used to name these plant community types (Table 3). The description and altitudinal distribution that could shape the distribution of identified community types is given along with. Unlikely other possible environmental variables that could affect the outcomes were not used in this study because of financial limitations. Based on the present analysis, the three plant communities identified from the study area were *Carissa spinarum* - *Justicia schimperiana* (Community1), *Matyenus gracilipes* (community 2) and *Podocarpus falcatus* – *Pyschotria orophila*-*Landolphia buchananii* (Community 3).

4.2.1. *Carissa spinarum* – *Justicia schimperiana* community type

The dominant species (mainly based on cover abundance value) in this type is *Justicia schimperiana* and *Carissa spinarum*. This community type consists of nine sample plots and 68 species. This community experienced a high level of antropogenic disturbance. It is located at an

altitudinal range of 1714 – 2111 m a. s. l. Altitude is one of the environmental gradients that could shape the species composition and distribution of the plant communities. This species-plot clustered was relatively located along the hill slopes and extend toward the flat bottom with narrow gradients between respective plots.

The main associated characteristic tree and shrub species to this community included *Pouteria adolfi-friederici*, *Clausena anistata*, *Ekebergia capensis*, *Macaranga capensis*, *Diospyros abyssinica*, *Croton macrostachyus*, *Cordia africana*, *Nuxia congesta*, *Premna schimperi*, *Embelia schimperi*, *Maesa lanceolata*, *Vernonia ampygdalina* and *Argomuelera macrophylla*. The herbaceous and the grass species are dominated by *Hyposetes forskali*, *Setaria megaphylla*, *Hyparrhenia anthistiriodes*, *Achyrospermum schimperi*, *Kalancheo petitiana*, *Cyathula cylindrica* and *Achyranthes aspera*. Lianas of this community included, for example, *Jasmiium abyssinicum* and *Clematis hirsuta*.

4.2.2 *Matyenus gracilipes* community type

This community type is located at an altitudinal range of 1705-2055 m. This community resulted from 21 plots and 84 species. Noteworthy is that this community is also under intense human impacts such as logging trees for timber and construction purposes. Although PCORD given *Matyenus gracilipes* to be an indicator species of this community, this species itself has the least indicator species compared to those of the remaining two communities reported in this study. Different species of the community co-exist together and have similar affinity for specific environmental conditions (e.g. altitudinal gradients and topographic factors). Herbaceous species, *Oplismenus hirtellus*, is also very dominant in the herb layer while *Commobretum paniculatum*, a liana, was found to be the second dominant species of this community.

The associated trees and shrubs of this plant community are: *Prunus africana*, *Ficus thonigii*, *Ochna holstii*, *Olea welwitschii*, *Allophylus abyssinicus*, *Clusia abyssinica*, *Rothmannia urcelliformis*, *Myrsine africana*, *Dracaena afromontana*, *Ehretia cymosa*, *Polyscias fulva*, *Euclea divinoroum*, *Acacia brevispica*, *Gardenia ternifolia* and *Vernonia auriculifera*. Several lianas were also recorded, e.g., *Periploca linearifolia*, *Taccaza apiculata*, *Commobretum paniculatum*, *Mikaniopsis clematoides*, *Helinus mystacinus* and *Plumbago zeylanica*.

The herbaceous layer was comprised of *Cyperus fischerianus*, *Commelina foliacea*, and *Oplismenus hirtellus*.

4.2.3 *Podocarpus falcatus* - *Pychotria orophila*-*Landolphia buchananii* community type

This community had seven indicator species (cf. Table 3), namely, *Teclea nobilis*, *Pychotria orophila*, *Podocarpus falcatus*, *Millettia ferruginea*, *Landolphia buchanani* and *Olea capensis* subsp. *macrocarpa* and *Mimusops kummel*. This community type is located between 1834-2144 m a.s.l. and comprised of 10 plots and 61 species. This community is located in the wettest parts of the forest and in the inner parts of Chato Natural Forest. *Podocarpus falcatus*, *Mimusops kummel*, *Schefflera abyssinica*, *Olea capensis* subsp. *macrocarpa*, *Celtis africana*, and *Cassipourea malosana* are the dominant tree species.

Additional characteristic tree species in this community type include *Pittosporum viridiflorum*, *Ficus vasta*, *Millettia ferruginea*, *Albizia gummifera*, *Acacia abyssinica*, *Phoenix reclinata*, *Warburgia ugandensis*, *Chionanthus mildbraedii* and *Olinia rochetiana*. The associated shrub species in this community type include *Calpurnia aurea*, *Ocimum lamiifolium*, *Bersama abyssinica*, *Rubus steudneri*, *Solanum giganteum*, *Pycnostachys abyssinica* and *Lepidotrachelia volkensii*. Lianas include *Tiliacora troupinii*, *Hippocratea goetzei*, *Urera hypselodendron* and *Landolphia buchananii*. High coverage of epiphytes like *Peperomia abyssinica*, *Diaphanandra tenuicalcar* and *Drynaria volkensii* were found on most of the tree species. There was no visible species of herbaceous layer. Exceptions are few individuals of *Carduus schimperi* which were observed in one sample plot.

In all communities, species with high indicator values (mainly based on cover values) are those that were easily observed by repeating themselves in associations. Results of the indicator species analyses for determining the degree to which the species are associated with different groups are presented in (Table 3).

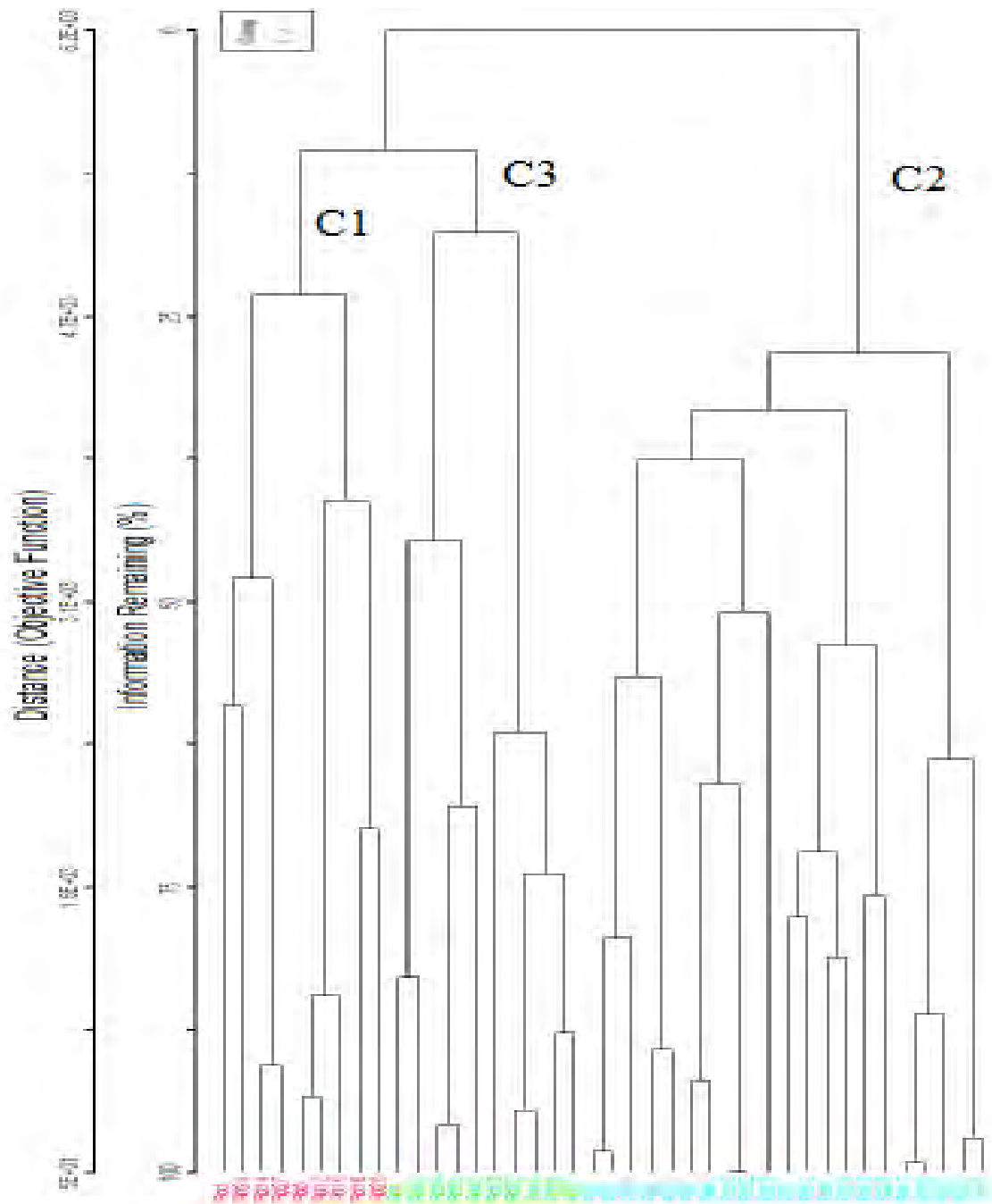


Figure 3. Dendrogram output of the vegetation data obtained from hierarchical cluster analysis.

The cut level of grouping was based on 20% information remaining.

The plot code and arrangement of plot along the dendrogram from left to right are as follows:

C1: (plots 1, 5, 12, 14, 16, 18, 20, 24 and 27)

C2 : (Plots 2, 3, 6, 7, 8, 9, 11, 13, 15, 17, 19, 21, 25,26, 29, 30, 32, 33, 37, 38, 39)

C3: (Plots 4, 10, 22, 23, 28, 31, 34, 35, 36, 40)

Table 3. Indicator values of each species for each community and Moute Carlo test of significance observed for each species.

Community/Group	1	2	3	
No.of Plots	9	21	10	P*
<i>Acanthus eminens</i>	0	12	15	0.4457
<i>Hypoestes forskoolii</i>	14	0	4	0.2304
<i>Justicia schimperiana</i>	52	2	27	0.0022
<i>Carissa spinarum</i>	57	0	18	0.0006
<i>Adiantum poiretii</i>	11	0	0	0.2238
<i>Achyranthes aspera</i>	12	0	9	0.4173
<i>Cyathula cylindrica</i>	11	0	0	0.2258
<i>Landolphia buchananii.</i>	1	3	74	0.0002
<i>Polyscias fulva</i>	3	4	3	1.0000
<i>Schefflera abyssinica</i>	0	2	14	0.3627
<i>Phoenix reclinata</i>	5	3	11	0.7261
<i>Periploca linearifolia</i>	0	5	0	1.0000
<i>Taccazzea apiculata</i>	0	5	0	1.0000
<i>Carduus schimperi</i>	0	0	10	0.4867
<i>Echinops longisetus</i>	0	6	3	0.5939
<i>Mikaniopsis clematiodes</i>	0	5	0	1.0000
<i>Vernonia amygdalina</i>	18	1	0	0.0960
<i>Varnonia auriculifera</i>	0	14	0	0.3605
<i>Vernonia purpurea</i>	0	10	0	0.3723
<i>Cordia africana</i>	19	1	0	0.1692
<i>Ehretia cymosa</i>	3	3	0	1.0000
<i>Warburgia ugandensis</i>	0	0	10	0.4767
<i>Hippocratea goetezi</i>	0	2	31	0.0286
<i>Matyenus gracilipes...</i>	6	37	1	0.0410

Table 3 con...

Group	1	2	3	P*
<i>Maytenus undata</i>	2	15	2	0.4071
<i>Combretum paniculatum</i>	10	30	4	0.1822
<i>Commelina foliacea</i>	0	10	0	0.3653
<i>Kalanchoe petitiiana</i>	11	0	0	0.2238
<i>Cyperus fischerianus</i>	0	17	3	0.2565
<i>Dracaena afromontana</i>	5	11	0	0.5971
<i>Dracaena steudneri</i>	37	2	0	0.0082
<i>Diospyros abyssinica</i>	21	9	7	0.4205
<i>Euclea divinorum</i>	0	5	0	1.0000
<i>Argomuelera macrophylla</i>	23	3	0	0.1090
<i>Clutia abyssinica</i>	0	19	0	0.1432
<i>Croton macrostachyus</i>	7	3	9	0.8852
<i>Erythrococca trichogyne</i>	11	10	0	0.5457
<i>Euphorbia ampliphylla</i>	0	0	10	0.4775
<i>Macaranga capensis</i>	12	3	2	0.4697
<i>Phyllanthus dewildiorum</i>	14	12	25	0.4783
<i>Acaccia abyssinica</i>	3	2	17	0.2749
<i>Acacia brevispica</i>	0	10	0	0.3733
<i>Albiza gummifera</i>	11	12	13	0.9698
<i>Calpurnia aurea</i>	5	15	16	0.7942
<i>Millettia ferruginea</i>	1	9	42	0.0164
<i>Dovyalis abyssinica</i>	0	0	10	0.4815
<i>Arisaema schimperiana</i>	6	1	2	0.7259
<i>Ocimum lamiifolium</i>	0	5	5	0.8072
<i>Achyrospermum schimperii</i>	30	0	0	0.0178
<i>Leucas martinicensis</i>	0	5	0	1.0000

Table 3 cont...

Group	1	2	3	P*
<i>Pycnostachys abyssinica</i>	0	0	10	0.4775
<i>Premna schimperi</i>	11	0	0	0.2238
<i>Nuxia congesta</i>	11	0	0	0.2238
<i>Ekebergia capensis</i>	21	0	0	0.0466
<i>Lepidotrichilia volkensis</i>	2	4	15	0.3979
<i>Bersama abyssinica</i>	4	0	25	0.0582
<i>Stephania abyssinica</i>	8	3	0	0.4823
<i>Tiliacora troupinii</i>	0	1	35	0.0136
<i>Ficus sur</i>	2	4	4	0.9620
<i>Ficus thonningii</i>	0	14	0	0.3429
<i>Ficus vasta</i>	0	0	10	0.4791
<i>Embelia schimperi</i>	11	0	0	0.2238
<i>Maesa lanceolata</i>	6	1	3	0.6015
<i>Myrsine africana</i>	0	10	0	0.3819
<i>Syzygium guineenses</i>	4	4	2	0.9328
<i>Ochna holistii</i>	2	20	16	0.4997
<i>Jasminum abyssinicum</i>	9	3	7	0.8094
<i>Olea capensis</i> subsp. <i>macrocarpa</i>	9	19	49	0.0036
<i>Olea welwitschii</i>	2	15	0	0.2869
<i>Chionanthus mildbraedii</i>	18	3	18	0.5355
<i>Olinia rochetiana</i>	0	0	10	0.4713
<i>Diaphananthe tenuicalcar</i>	0	0	10	0.4713
<i>Phytolacca dodecandra</i>	11	0	0	0.2224
<i>Peperomia abyssinica</i>	0	0	10	0.4763
<i>Pittosporum viridiflorum</i>	0	0	20	0.1028
<i>Plumbago zeylanica</i>	0	5	0	1.0000
<i>Hyparrhenia anthistiriodes</i>	22	0	0	0.0474

Table 3 cont...

Group	1	2	3	p*
<i>Setaria megaphylla</i>	34	34	32	0.9042
<i>Podocarpus falcatus</i>	15	8	54	0.0012
<i>Psychotria orophila</i>	1	6	64	0.0002
<i>Clematis hirsuta</i>	7	2	0	0.8174
<i>Helinus mystacinus</i>	0	5	0	1.0000
<i>Rhamnus prinoides</i>	0	5	0	1.0000
<i>Cassipourea malosana</i>	0	0	36	0.0128
<i>Prunus africana</i>	0	14	0	0.3639
<i>Rubus steudneri</i>	0	5	5	0.8104
<i>Coffea arabica.</i>	8	1	0	0.6075
<i>Gardenia ternifolia</i>	0	5	0	1.0000
<i>Rothmannia urcelliformis</i>	3	8	6	0.9972
<i>Rytigynia neglecta</i>	7	0	4	0.6787
<i>Teclea nobilis</i>	6	4	60	0.0002
<i>Clausena anistata</i>	18	11	0	0.3233
<i>Allophylus abyssinicus</i>	0	12	3	0.4139
<i>Mimusops kummel</i>	20	6	36	0.0862
<i>Pouteria adolfi-friederici</i>	12	7	7	0.8504
<i>Solanum giganteum</i>	0	0	10	0.4713
<i>Dombeya torrida</i>	11	0	0	0.2238
<i>Grewia ferruginea</i>	0	0	10	0.4763
<i>Triumfetta rhomboidea</i>	0	5	0	1.0000
<i>Celtis africana</i>	1	9	35	0.0436
<i>Trema orientalis</i>	11	0	0	0.2224

4.3 Species richness, species evenness and species diversity of plant community types

Species richness, evenness and diversity of the plant communities are given in Table 4.

Table 4: Shannon-Wiener Diversity Index.

Community	Richness	Diversity index(H')	Evenness
1	68	3.63	0.56
2	84	3.77	0.53
3	61	3.52	0.55

Of the three community types, community 2 has the highest species richness and diversity with the least species evenness values and followed by community 1 with the highest evenness. Community 3 has the lowest species richness and diversity but has an intermediate evenness value compared to communities 1 and 2. There was not a big difference in Shannon diversity index and evenness among the three communities but a greater difference in species number. The reason for closeness of diversity and evenness of these three communities could be attributed to relatively comparable altitudinal ranges.

From this result, one may infer that the study area is rich in floristic diversity and richness with high similarity indicating the forest is more complex and diverse.

In this study, the highest Shannon diversity indices were recorded for plots 40, 19, 22, and 20 with corresponding values of $H' = 3.19, 3.13, 3.01$ and 3.00 respectively. Corresponding numbers of species were 28, 26, 24 and 22 demonstrating that many species occur at these plots. On the other hand, the lowest diversity index was observed for plot 26 ($H' = 2.09$) having only 9 species (Appendix 2). The reason for this low diversity could be due to anthropogenic factors, topographic and/or biological, whereas high species diversity was probably attributed to the existence of preference of environmental gradients/ecological to which the biotic community interacts

4.4 Similarity between the three community types

Sorensen's coefficient similarity index of the three communities is presented in Table 5.

Table 5 Sorensen's Coefficient of similarity index among communities.

Community types	1	2	3
1	-	0.63	0.60
2		-	0.61
3			-

Based on Sorensen's similarity coefficient among the three communities, communities 1 and 2 have high number of species composition in common (63%) followed by communities 2 and 3. A relatively low similarity was observed between communities 1 and 3.

4.5 Analysis of vegetation structure

4.5.1 Stem density

The density of tree and shrub species of the sampled area is given in Table 6.

A total of 1568 individuals (980 individuals/ha) were counted with the DBH > 2 cm within sampled quadrats. Of these, *Mimusops kummel*, *Podocarpus falcatus*, *Diospyros abyssinica*, *Celtis africana*, *Pouteria adolfi-friederici* and *Olea capensis* subsp. *macrocarpa* contributed to the largest proportion of individuals.

The total density was 333 stems per ha for DBH > 10cm and 194 individuals per ha for DBH > 20 cm. The ratio of the density of individuals with DBH >10 cm to those greater than 20 cm showed the distribution of size classes (Grubb *et al.*, 1963). This ratio is 1.71 for the Chato Natural Forest, indicating slight variation between the small-sized and large –sized stems. When this ratio was compared with other forests in the county (Table 6), it is greater than that of Wof-Washa and Dodolla, but exhibited a strong variability with those of Chilmo, Masha-Andercha,

and Menagesha Forests. However, it is almost comparable to Alata-Bolale, Magada and Denkoro forests

Table 6. Reported stem density of other montane forests of Ethiopia. Note: a=Individuals with DBH >10 cm, and b=individuals with DBH >20 cm.

Forest	DBH between 10-20 cm	DBH >20 cm	Ratio (a/b)	References
Denkoro	526	285	1.84	Abate Ayalew <i>et al</i> (2006),
Chilmo	638	280	2.55	Tamrat Bekele (1993&94),
Menagesha	484	208	2.33	Tamrat Bekele (1993&94)
Marcha-Anderacha	385	160	2.4	Kumelachew Yeshitela & Taye Bekele (2003),
Wof-Washa	329	215	1.53	Tamrat Bekele (1993)
Magada	608	332	1.83	Genene Bekele(2005),
Gura Ferda	500	263	1.9	Dereje Denu (2007),
Dodola	521	351	1.48	Kitessa Hundera (2003),
Alata-Bolale	365	219	1.67	Woldeyohannes Enkossa (2008)
Chato	333	194	1.71	Present study

4.5.2 Diameter at Breast Height (DBH)

The general pattern of DBH class distribution of tree species was calculated based on the sampled area and showed an inverted J-shape which is typically observed in natural undisturbed montane forests (Fig. 4), with many small stems compared to few large ones (Nebel *et al.*, 2001). This pattern has good reproduction and recruitment potential. Similar results were reported by AbateAyelew *et al.*, (2006); Feyera Senbeta, (2006); Haile Yinger *et al.*, (2008).

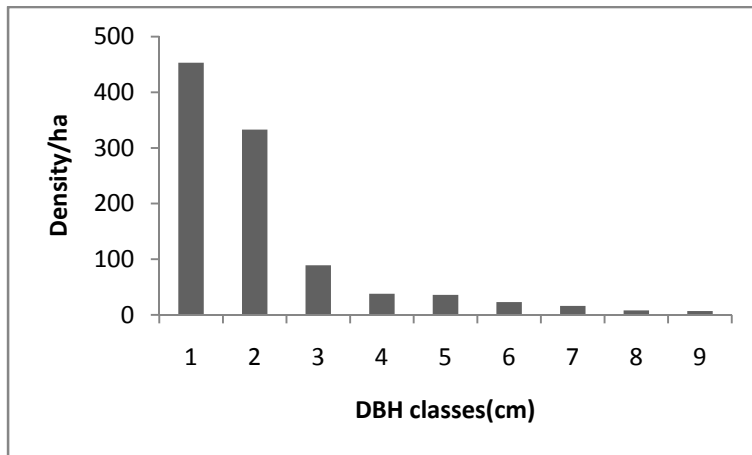


Figure 4: Size class distribution of stem density across diameter classes in Chato Forest

Of all the individuals sampled in Chato Natural Forest, about 1.6% that attained a DBH greater than 80 cm belonged to the species of *Podocarpus falcatus*, *Pouteria adolfi-friederici* and *Celtis africana*. In addition, individuals of the above mentioned three species with a DBH of 175 cm, 140 cm and 101 cm, respectively, were recorded in the Chato Natural Forest.

The percentage distribution of DBH classes was 46.2%, 33.98% and 19.79% for the individuals (density) with DBH between 2-10 cm, 10-20 cm and >20 cm, respectively. The large proportion of small-sized tree/shrub individuals suggest that the forest vegetation has good reproduction potential. Similar reports were made by Motuma Didita (2007) and Woldeyohannes Enkossa (2008). This forest has a similar proportion (19.79%) of tree with DBH greater than 20 cm when compared to Dodolla (20.3%) (Kitessa Hundera *et al.*, 2003). Chato Natural Forest is less

dense in trees over 20 cm DBH than Chilimo, Menagesha, Alata-Bolale and Masha-Anderacha, but it is comparable to Alata-Bolale and Wof-Washa in tree density with DBH between 10-20 cm .

4.5.3 Height

The height class distribution of the forest is shown in Fig.5. When taken together, like the frequency distribution of DBH classes, height almost attained a regular distribution pattern (normal) except the last height class that was represented by individuals exceeding heights of 42 m and forming the upper canopy of the forest. More number of individuals per ha were found in lower height classes, which contributed to larger proportion (> 40% for height <10 m). This could suggest that the Chato Natural Forest is dominated by lower stature individuals (Table 7). Such patterns commonly referred to as reverse J-shape distribution showing stable population structures but there would be variation with respect to individual species when it was analysed separately.

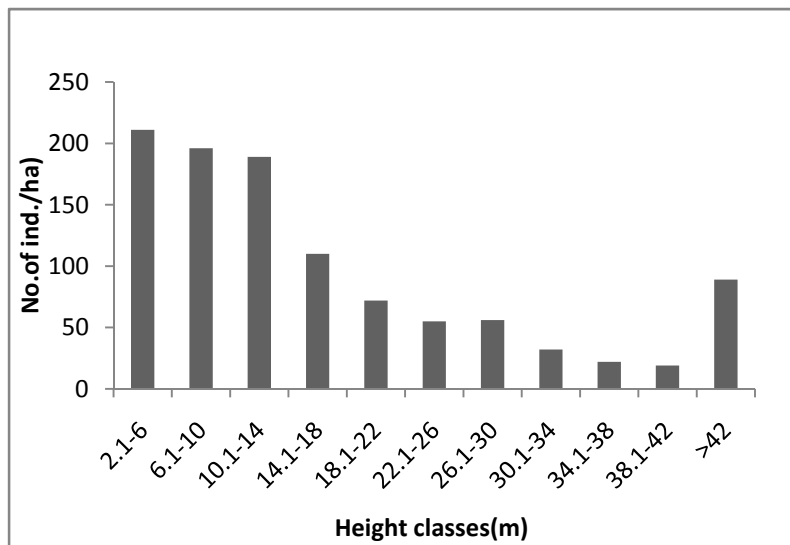


Figure 5. Height class distribution of individual Trees/Srubs in Chato Natural Forest.

Generally, higher number of large-sized individuals in the upper height class in the natural forest implies the presence of a good number of adult tree species for reproduction (Getachew Tesfaye

and Abiyot Berhanu, 2002). This argument holds true for Chato Natural Forest. This is partly due to the absence of a large scale timber exploitation. Therefore, the current study exhibited a condition of primary forest development of the Chato Natural Forest. Noteworthy is that woody species with the highest DBH size were also recorded for the highest height. Although there is selective logging of tree species at certain height, Chato Natural Forest exhibited individuals of all height classes.

Height reflects something about the different growth phase or ages of tree species. It is a good indicator of the role of a species as each of them occupies a different layer and practically determines the vertical structure of the stand (Pascal *et al.*, 1996). Variation in tree height is an important ecological phenomenon which affects the microclimate and distribution of epiphytes and climbers (Tamrat Bekele, 1993).

The emergent tree species which had the highest height in this forest are *Podocarpus falcatus*, *Pouteria adolfi-friederici*, *Albizia gummifera*, *Celtis africana* and *Ekebergia capensis* are represented by about 15% (> 30 m). There are enough individuals in the lower classes to replace the old individual plants (Table 4). The last two height classes, the 10th and 11th i.e. 38-42 m and > 42 m, had about 108 individuals which contributed to about (10.26%) of the total species of upper canopy layer and they are also the dominant groups in the forest under study.

In Chato Natural Forest, the middle forest layer (15-30 m) comprises about 22 species. Examples are *Dracaena steudneri*, *Allophylus abyssinicus*, *Croton macrostachyus*, *Mimusops kummel*, *Olea welwitschii*, *Terminalia macroptera*, *Polyscias fulva*, *Cordia africana* and *Diospyros abyssinica*. On the other hand, the lower forest layer (< 15 m) are dense and formed by small trees and shrubs such as *Teclea nobilis*, *Vepris dainellii*, *Chionanthus mildbraedii*, *Cassipourea malosana*, *Psychotria orophila*, *Rytigynia neglecta*, *Olea capensis* subsp. *macrocarpa*, *Dracaena afromontana*, *Coffee arabica* and *Bersama abyssinica*.

4.5.4 Vertical structure

The vertical structure of the woody species occurring in Chato Forest was described following the International Union Forstery Research Organization(IUFRO) classification scheme as used by Lamprecht (1989).

Therefore, according to this study, three vertical structures were recognized. These are upper storey (tree height > 2/3 of the top height; > 30 m), middle storey (tree height between 1/3 and 2/3 of the top height; 15-30 m) and lower storey (<1/3 of the top height; <15 m) (Table7). Such structural variations could be mainly attributed to differences in the properties and nutritional values of the soils.

Table 7. Vertical layer of the Chato Natural Forest.

Storey	Height (m)	No.of stem/ha	%	No. of species	%	Ratio of Ind. /ha to species
Lower	2-15	596	56.76	33	47.8	18:1
Middle	15-30	292	27.80	22	31.9	13:1
Upper	>30	162	15.42	14	20.3	11:1

Table 7 indicates that the proportion of individuals to species number in the three storeys is relatively closer to each other. Such a similarity does perhaps show that Chato Natural Forest is considered at a primary forest development stage. Therefore, the profiles of 20 m x 20 m quadrats in sampled forest and the height class distributions showed that there were marked variation in the vertical structure of the stands in the study area.

4.5.5 Basal area and dominance

The total basal area calculated for the study area was about 65.8 m²/ha for woody plants > 2 cm in DBH. This is further partitioned into 2.9 m²/ ha for individuals with DBH between 2-10 cm (small-sized), 4.9 m²/ ha for DBH 10-20 cm (medium-sized) and 58 m²/ ha for DBH > 20 cm (large-sized). There is a considerable decrease in number of individuals with increasing DBH size and basal area. Individuals that attained higher DBH classes are fewer in number while they

contributed over 61% to the total basal area. Noteworthy is that a basal area of 40 m²/ha (Table 8) was accounted for by four important tree species, i.e., *Podocarpus falcatus* (12.9 m²/ha), *Pouteria adolfi-friederici* (13.5 m²/ha), *Celtis africana* (7.7 m²/ha) and *Mimusops kummel* (5.9 m²/ha). The relative importance of tree species in a forest can better be depicted from measurements of basal area than stem counts (Cain and Caston, 1959; cited in Tamrat Bekele, 1993). Therefore, species with the largest contribution in basal area can be considered the most important woody species in the forest. Accordingly, the most dominant species of Chato Natural Forest are presented in Table8.

Table 8. Basal area and density distribution of four dominant tree species in the Chato Forest

Species	Basal area (m ² /ha)	%	Density
<i>Pouteria adolfi-friederici</i>	13.5	20.76	78
<i>Podocarpus falcatus</i>	12.9	19.60	115
<i>Celtis africana</i>	7.7	11.70	80
<i>Mimusops kummel</i>	5.9	8.96	139

The density distribution of these four tree species does not follow the same trend as that of the basal area. For example, species with the highest basal area don't necessarily have the highest density depicting size differences as exemplified by *Mimusops kummel* and *Pouteria adolfi-friederici*.

The basal area of Chato Natural Forest is much greater than that of Chilimo, Tamrat Bekele (1993) i.e 45 m²/ ha, Menagesha, Tamrat Bekele (1993) 32.4 m²/ ha, Donkoro, Abate Ayalew *et al.*, (2006) 45.3 m²/ ha, Alata-Bolale, Woldeyohannes Enkossa (2008) 53.3 m² / ha, Jibat, Tamrat Bekele (1993) 47.5m²/ ha, Gendo, Teshome Gemechu (2009) 55.25 m²/ ha, and Jima, Fufa Kenea (2008) 33.3m²/ ha. Forests but much less than that of Wof Washa, Tamrat Bekele (1993) 101.8 m²/ ha, Dodolla, Kitessa Hundera *et al.*,(2007) 129 m²/ ha, Masha-Anderacha, Kumelachew Yeshitela and Taye Bekele (2003) 81.9 m²/ ha. On the other hand, it is more close to figures reported for Magada Forest, Genene Bekele (2005) 68.5 m²/ ha. Such a close affinity could be attributed to occurrence at similar altitudinal gradients.

Individuals in the DBH classes greater than 60 cm have a density of about 3.16% of the total but they contributed about 51.6% to the total basal area. Thus the ecological role of these large – sized individuals in this forest can be estimated.

In the Fig.6 below, the basal area distribution versus diameter classes showed an increase in the higher diameter classes. This result was similar to what was observed for natural conditions in Wof-Washa (Tamrat Bekele, 1993), Masha-Anderacha, (KumelachewYeshitela and Taye Bekele, 2003) and Dodolla (Kitessa Hundera *et al.*, 2007). From this result, the basal area slightly declined at DBHs 30 - 60 cm (i.e. 5.7m²/ha, 5.5 m²/ha, and 4.7 m²/ha) and then abruptly increased after DBHs beyond 60 cm which is over 10 m²/ha). A sharp decrease was noticed between DBHs of 70 - 80 cm and again an abrupt increase in basal area beyond 80 cm DBH. This result signifies selective harvesting of the medium size classes in Chato Natural Forest. This observed trend is also supported by researches made in other areas (Tamrat Bekele, 1993).

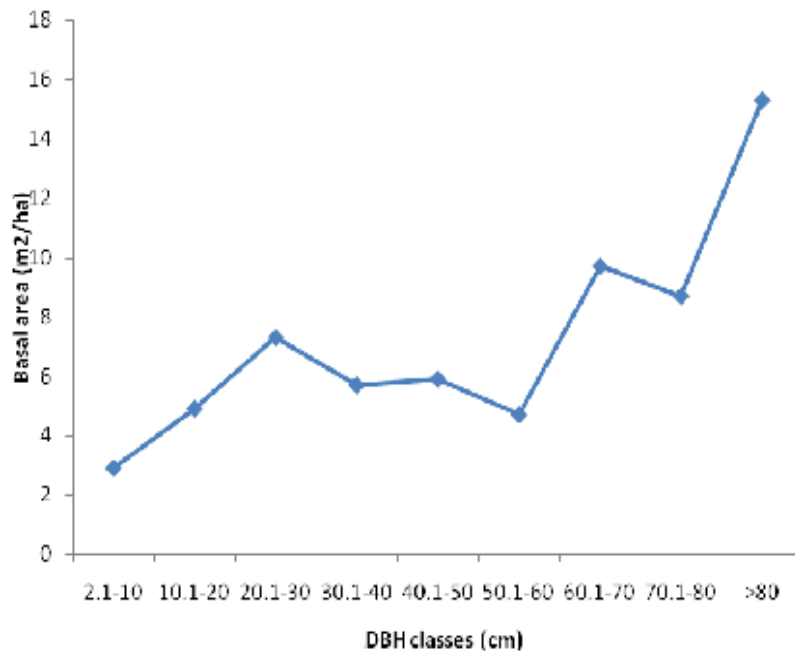


Figure 6: Distribution of basal area and its relationships to diameter class in Chato Natural Forest.

4.5.6 Species population structure

When all woody species are taken together, the population structure exhibits the reversed J-shaped (Feyera Senbeta *et al.*, 2003). However, the frequency distribution of DBH classes of some selected important tree species showed different types of population structure (Figure 8a-d). Similarly, various patterns of species population structures have been reported for different species in Afromontane forests of the country by Tamrat Bekele (1993). From the population dynamics point of view, examination of patterns of species population structure could provide valuable information about their regeneration and/or recruitment status as well as viability status of the population that could further be employed for devising evidence-based conservation and management strategies (Demel Teketay, 2005; Abrham Abiyu *et al.*, 2006).

In Chato Natural Forest, the first pattern of population structure showed a normal reversed J-shape curve (Fig. 8a). This pattern exemplifies *Pouteria adolfi-friederici*, *Mimusops kummel*, *Albizia gummifera*, *Millettia ferruginea*, and *Celtis africana*. In addition, this pattern suggests a good reproduction and recruitment capacity.

Although these species are attractive for timber production elsewhere in Ethiopia, the local community has never logged them for this use. This in a way contributed to the observed pattern of their population structure and subsequent conservation. There is also a long history of local tradition which attached a myth to the felling of trees and uses (household and commercial) of large trees in the Chato Natural Forest. This tradition promoted effective conservation of the forest resources of this Natural Forest. As a result, it is a common practice to see old tree species which are naturally dying and fallover.

The second pattern of the population structure showed some sort of unstructured pattern of some plant species at DBH class distribution from classes 3 – 7, for example, *Podocarpus falcatus* (Fig. 8b). This could be attributed to selective removal of individuals of preferred size of this species for the purpose of logging and constructions. Although the number of individuals of *Podocarpus falcatus* seemed high, many stumps were observed in the forest.

The third pattern exemplifies *Cordia africana* (Fig. 8c), *Prunus africana*, *Olea welwitschii*, *Allophylus abyssinicus* and *Pittosporum viridiflorum*. This pattern showed the absence or very few numbers of individuals in the upper DBH classes. It is to be noted that the first three species are highly exploited by the local people/ community for various uses and there is a selective logging of them. This could account for the absence of the upper DBH class of some of the species of Chato Natural Forest. In this case, there are many individuals in the lower DBH classes followed by decline in the middle and then rise again at larger size classes. *Cordia africana*, *Prunus africana* and *Olea welwitschi* exhibited good reproduction and poor recruitment. The pattern of population structure illustrated by *Cordia africana* could be termed as a U- shaped. In this species, DBH classes of the 4th and 5th are lacking and only nine individuals of it per hectare were recorded in the current study. Unless some appropriate conservation measure and management plan are put in place, *Cordia africana* will become locally extinct from Chato Natural Forest over in the near future.

On the other hand, the fourth pattern represented by small trees and they would not have upper DBH classes. Examples are *Teclea nobilis*, *Psychotria orophila*, *Vepris dainellii*, *Galiniera saxifraga* and *Rytigynia neglecta*. This pattern shows the highest frequency in the first or second DBH classes and a gradual decrease towards the bigger classes (Fig.8d).

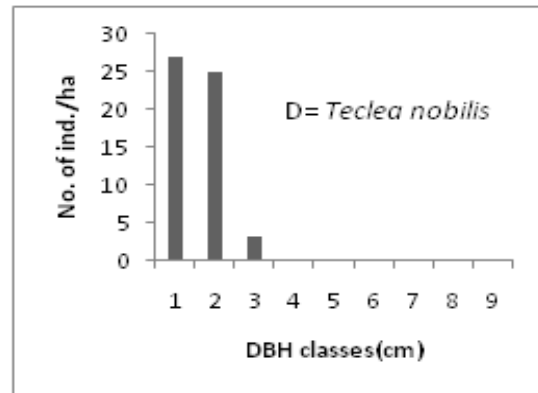
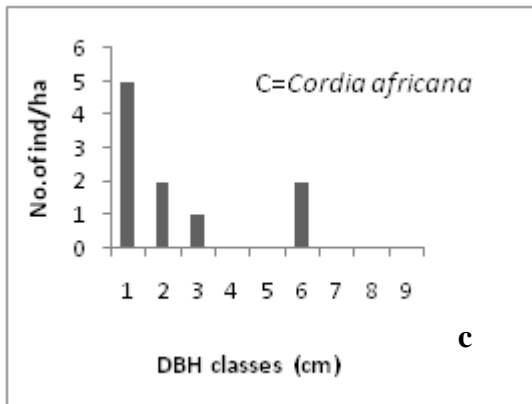
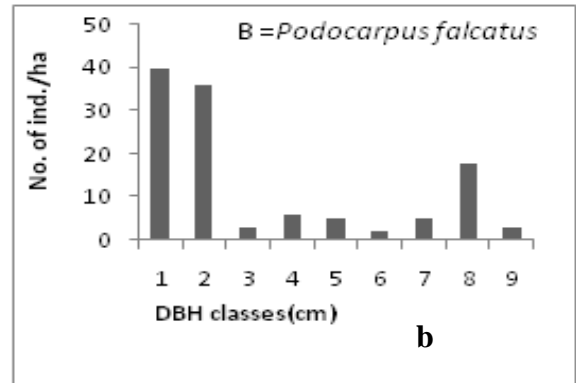
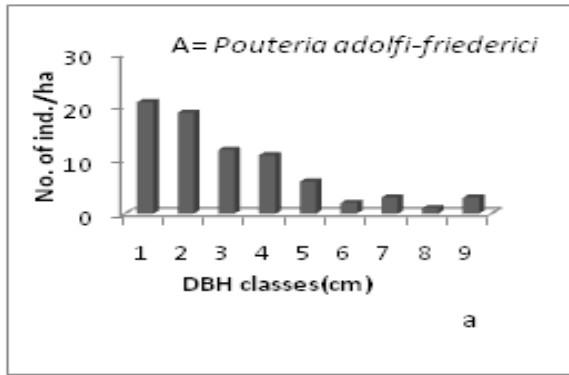


Figure 7: Four representative patterns of population structure of Chato Natural forest.

4.6 Species Importance Value (SIV) and Frequency.

The floristic structure was studied by using an index namely, Importance Value Index, derived following Curtis and McIntosh's (1951). This index is generally calculated as the sum of the RD, RF and RDO for each woody species. The relative ecological importance of the forest is expressed by SIV. High SIV is attributed to their high basal area, high relative frequency and high relative density. The greatest SIV reflects the degree of dominance and abundance of a given species in relation to the other species in the area. It is also used for setting priority /ranking species management and conservation practices and helps to identify their sociological status (structure) in a certain plant community as dominant or rare species (Kent and Coker, 1992).

In the current study, high SIV (at a cut level of 14%) was obtained for seven tree species. These species are, in descending order of SIV, *Podocarpus falcatus*, *Pouteria adolfi-friederici*, *Mimusops kummel*, *Celtis africana*, *Ochna holstii*, *Diospyros abyssinica* and *Albizia gummifera* (Table 11). These dominant species accounted for over 45% of the total SIV of the Chato Natural Forest. On the other hand, six species had less than 2% SIV values. Examples are, in descending order of SIV, *Cordia africana*, *Dracaena steudneri*, *Maesa lanceolata*, *Ficus sur*, *Polyscias fulva* and *Ekebergia capensis*.

Such low abundance may be due to either adverse environmental conditions or random distribution of available resources in the forest (Miranda *et al.*, 2002; cited in Feyera Senbeta *et al.*, 2007). The current study showed that both *Cordia africana* and *Prunus africana* exhibited very low frequency in the Chato Natural Forest. In the case of the former, it was so because illegal logging by local people has increased from time to time for their daily income. A similar observation was reported by Genene Bekele (2005) while the latter was determined by altitudinal ranges of the forest.

Olea welwitschii and *Ficus sur* which are typical species of moist montane forest were less frequent in the Chato Natural Forest, which could be attributed to altitudinal, edaphic and topographic factors or other ecological reasons.

Table 9. The SIV for 31 tree species identified in the sampled area with corresponding values for each species.

Species	RF.(%)	RD(%)	RDO(%)	SIV(%)
<i>Cordia africana</i>	0.50	0.57	0.28	1.35
<i>Dracaena steudneri</i>	0.5	0.31	0.63	1.44
<i>Maesa lanceolata</i>	0.75	0.57	0.12	1.44
<i>Ficus sur</i>	0.50	0.31	0.74	1.55
<i>Polyscias fulva</i>	0.75	0.25	0.74	1.74
<i>Ekebergia capensis</i>	1.00	0.63	0.26	1.89
<i>Syzygium guineensis</i>	0.75	0.57	1.25	2.57
<i>Nuxia congesta</i>	1.00	1.08	0.53	2.61
<i>Prunus africana</i>	0.75	1.14	0.86	2.75
<i>Schefflera abyssinica</i>	2.01	0.89	0.37	2.79
<i>Millettia ferruginea</i>	2.51	0.89	0.80	4.20
<i>Allophylus abyssinicus</i>	1.75	1.46	1.07	4.28
<i>Chionanthus milddbraedii</i>	2.76	1.40	0.24	4.40
<i>Rytigynia neglecta</i>	2.51	1.46	0.81	4.78
<i>Phoenix reclinata</i>	2.26	0.63	2.40	5.29
<i>Clausena anistata</i>	3.01	2.42	0.57	6.00
<i>Croton macrostachyus</i>	1.00	2.10	3.2	6.3
<i>Olea welwitschii</i>	2.51	1.65	3.02	7.18
<i>Rothmonnia urcelliformi</i>	3.76	3.06	0.54	7.36
<i>Psychotria orophila</i>	3.26	4.59	0.94	8.79
<i>Teclea nobilis</i>	4.52	3.5	0.99	9.01
<i>Olea capensis subsp. macrocarpa</i>	3.0	5.29	1.18	9.47
<i>Carissa spinarum</i>	3.01	6.37	1.07	10.45
<i>Albizia gummifera</i>	3.76	357	7.4	14.08
<i>Diospyros abyssinica</i>	3.51	5.10	7.04	15.65
<i>Ochna holstii</i>	2.76	16.58	.37	19.71
<i>Celtis africana</i>	4.27	4.97	11.79	21.03
<i>Mimusops kummel</i>	5.77	8.86	9.09	23.72

Species	RF (%)	RD (%)	RDO (%)	SIV (%)
<i>Pouteria adolfi-friederici</i>	3.01	4.97	20.57	28.55
<i>Podocarpus falcatus</i>	6.03	7.33	19.63	32.99
Others	25.00	6.59	0.86	32.47
Total	100.00	100.00	100.00	300.00

4.6.1 Family Importance Value (FIV)

Family importance value is also calculated for the forest trees from relative density, relative diversity and relative dominance as given by Mori *et al.* (1983); cited in Nebel *et al.* (2001).

At the family level, as for the species, the stem density, relative basal area and FIV were analyzed to assess species rich family/dominant family in all sampled area of the forest. In view of this, this forest is dominated by Sapotaceae, 19.5 m²/ha (30% of the total basal area), followed by Podocarpaceae 12.9 m²/ha (19.9%), Ulmaceae 7.7m²/ha (11.9%) and Fabaceae 5.65m²/ha (8.7%).

The most dominant families/ species are also those which have the highest SIV (Curtis and McIntosh, 1951). This was true with the present study where the dominant families include Sapotaceae (FIV=51.1), Podocarpaceae (FIV= 30.80), Fabaceae (FIV=23.49) and Ulmaceae (FIV=20.41), these four families are distinctly dominant in term of FIV and together contributing more than 70% of the total basal area. The reason for their dominance could be they might have developed strategies like resistance, reproductive mechanisms, and conductivity, ecological and morphological adaptations which helped them to survive in the area.

The present study showed that eight families contributed about 75.8% to the total FIV. Sapotaceae and Podocarpaceae are the most dominant families in the Chato Natural Forest with 51.11% and 30.86% FIV, respectively. Families such as Fabaceae (23.49%), Oleaceae (22.72%), Rubiaceae (21.40%), Ochnaceae (21.10%) and Ulmaceae (20.41) have also exhibited relatively higher FIV compared to the remaining families of plants inhabiting Chato Natural Forest.

Table 10 The relative Family importance values (FIV) for the 21 most dominant and abundant families of tree present in the study area.

Family	Rel.de. (%)	Rel.div (%)	Rel.dom (%)	FIV (%)
Boraginaceae	0.60	3.12	0.27	3.99
Dracaenaceae	0.33	3.12	0.63	4.08
Moraceae	0.33	3.12	0.75	4.20
Loganiaceae	0.60	3.12	0.54	4.26
Myretaceae	0.60	3.12	1.26	4.98
Rosaceae	1.22	3.12	0.88	5.22
Sapidaeeae	1.55	3.12	1.08	5.75
Arecaceae	0.68	3.12	2.44	6.24
Meliaceae	0.95	6.25	0.26	7.46
Euphorbiaceae	2.23	3.12	3.34	8.69
Araliaceae	.95	6.25	3.2	10.4
Rutaceae	6.30	6.25	1.6	14.15
Ebenaceae	5.42	3.12	7.11	15.65
Apocynaceae	8.8	6.25	1.20	16.25
Ulmaceae	5.28	3.12	12.01	20.41
Ochnaceae	17.6	3.12	0.38	21.10
Rubiaceae	9.68	9.37	2.35	21.4
Oleaceae	8.87	9.37	4.48	22.72
Fabaceae	5.42	9.37	8.7	23.49
Podocarpaceae	7.79	3.12	19.95	30.86
Sapotaceae	14.7	6.25	30.16	51.11
	100.00	100.00	100.00	300.00

Table 10 gives FIV classes recorded from the Chato Natural Forest. Based on 5% cut level, seven FIV classes are discernible. It is to be noted that there are no families which fall in FIV between 31.0% - 46%. Those families that have higher FIV were the most dominant, frequent and abundant families in the structure of the forest stand.

4.7 Phyto-geographic Comparison with other similar forests

The total species that were recorded from this study area is not believed to be complete since it was a single data collection, more species will probably be expected if other researchers continue further study on the flora of the area. The present study revealed that Chato Natural Forest consists of some of the dominant tree species like *Podocarpus falcatus*, *Mimusops kummel*, *Pouteria adolfi-friederici*, *Albizia gummifera*, *Olea welwitschii* and *Allophylus abyssinicus* which are characterized by high density and basal area placing this forest in the moist montane forest type.

From this study, a similarity analysis between Chato Forest and six dry and five moist montane forests in Ethiopia was carried out to evaluate the relationship between them based on the presence of woody species. The result shows that Chato Forest is more similar to the moist forests than to the dry forests. In fact, direct comparison of the species diversity with other forests is not feasible due to differences in size of forests, survey methods, and objective of the study (Tadesse Woldemariam, 2003). However, over all species richness of the forest can give more or less a general picture of their diversity and phytogeographical resemblances. In this respect, this forest is compared with other forests in the country to evaluate the similarity in woody species composition in the forests and indicate to which forest it is more related.

In this aspect, the similarity indices used is Sorensen's similarity Coefficient, Chato Forest showed high similarity with moist montane forests such as Gendo (55%), Masha-Anlderacha (57%) and Harena (55.8%) and relatively the highest similarity was observed with Jima (60%) and Alata-Bolale (67%) forests due to their geographical proximity, similar climatic and altitudinal factors and probably due to species migration (Table 12). On the other hand, Chato Forest shows low similarity in species composition with Menagesha Suba, Jibat, Kimphee, Sigo-Stema and Jemjem forests, 44.9%, 34.8%, 38%, 37%, and 44.6% respectively.

The reason for this low similarity could be attributed to elevation difference, geographical factors, climatic conditions and human related disturbances.

The results of similarity analysis between Chato Natural Forest (90 tree and shrub species) and other eleven forests are presented in the table 12. The similarity index used for these forests comparison is Sorensen's Similarity Coefficient Index (SI) $2a/2a+b+c$ as described earlier. Overall, similarity indices ranged between 0.26 and 0.67 for all compared forests.

Table 11. Sorensen's coefficient of similarity of woody plants between Chato Forest (90 tree species) and other related forests in Ethiopia.

Forest	Altitude(m)	a	b	c	Ss (%)	References
Harena	1500-3300	50	39	40	55.86	Lisanework Nigatu (1987)
Menagesha	2300-3000	31	17	59	44.9	Tamrat Bekele (1993)
Kimphee	1600-1750	33	50	57	38.1	Feyera Senbeta and Demel Tektay (2003)
Jibbat	2000-2950	24	24	66	34.8	Tamrat Bekele (1993)
Masha-Anderacha	1250-2700	57	50	33	57.8	Kumilachew Yeshitela and Taye Bekele (2003)
Sigmo-Setema	2194-2516	35	63	55	37.2	Alemu Abebe (2007)
Jemjem	1570-1940	35	32	55	44.58	Hailu Sharew (1982)
Alata-Bolale	2061-2360	63	34	27	67.4	Woldeyohannes Enkossa (2008)
Dodolla	2650-3250	20	40	70	26.6	Kitessa Hundera <i>et al.</i> , (2007)
Gendo	2183-2300	49	38	41	55.3	Teshome Gemechu (2009)
Jima	2166-2470	54	36	36	60	Fufa Kena (2009)

Where: Ss=Sorensen's similarity coefficient

a= is number of species shared by the two forests;

b= is the number of species in other forest and

c= is the number of species unique to the present study

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion.

This study contributes the basic data on floristic composition and structure of the woody plants to provide base line information on ecological and botanical studies. One hundred fifty four species of vascular plants were identified and assigned to 138 genera and 67 families. Of which family Asteraceae was the most dominant followed by Euphorbiaceae and Fabaceae. These dominant families might have well developed strategies and adaptations which helped them successfully to survive in the area.

Of species recorded from the forest, 12 species are endemics to Ethiopia that have been recorded in the red data list of IUCN, and 22 species were new records for the Wollega floristic region of Ethiopia and Eritrea. Structural description of the forest based on tree density /woody species implied the predominance of small-sized individuals. The densities of woody species with the highest DBH size are also the top highest heights. Based on SIV output, the most dominant species are those that have the highest SIV, as exhibited by *Podocarpus falcatus*, *Pouteria adolfi-friederici* and *Celtis africana*.

Cluster analysis of the vegetation data of the forest produced three community types each of which have its own indicator and dominant species. The distributions of these plant communities in the forest were influenced by various environmental factors and biotic stresses which are operated in a combined way; this is why variations in species richness, composition and species diversity among communities could exist.

Analysis of population structure of the most common species indicated that the majority of them showed a reversed J-shape with the exception of few economically important tree species so that regeneration and recruitment are normal. This population dynamics within the forest revealed the signs of some disturbances and assert Chato Forest to be in a stage of primary development at present. Phytogeographic descriptions and comparisons of Chato Forest with other similar forests showed that it is related more to the moist evergreen montane forests than others as it is characterized by dominant species of moist montane forests.

5.2 Recommendations

Plant species are the potential stock for future genetic resources, and would have great implications for the environment, biological diversity and socio-economic importance. The inclusion of local communities in the forest conservation activities and management is the only realistic option to reduce the forest loss and its various resources as complex and valuable natural resource system. The result of this study can contribute towards the understanding of the plant species diversity of moist montane forest of the western part of the country which is of considerable importance in its conservation. Based on the results of the study, the following recommendations were drawn.

- To conserve the biodiversity of the area detailed ecological and botanical studies are vital concerning the species composition, diversity and distribution of plant species in relation to the environmental factors such as soil type and properties.
- The future management strategy of Chato Natural Forest should focus on multiple-use conservation approaches. Some areas of the forest that are relatively undisturbed can be designated for strict conservation so that they may act as repositories of biodiversity and possibly as a source of forest genetic resources including wild coffee. Other exploited parts by local communities can sustainably be used by developing appropriate forest management plan. This forest consists of large areas that are still inaccessible, it provides various ecosystem services including nutrient cycling and CO₂ sequestration and therefore, establishment of the forest as Biosphere Reserve is recommended.
- Tree planting by local people has to be encouraged on already degraded land scapes to create a buffer for the forest.
- Potential traditional knowledge of the people on the diverse uses of plants should be strengthened for the enrichment of ethnobotanical studies of the area.

The present study is limited to species composition and structure then further studies on , environmental parameters, forest management and conservation system, soil seedbank, and regeneration of the woody species is recommended.

6. REFERENCES

- Abate Ayalew, Tamirat Bekele and Sebsebe Demissew (2006). The Undifferentiated afro-montane forest of Denkoro in the central highland of Ethiopia: A floristic and Structural Analysis. *SINET: Ethiop. J. Sci.* **29**(1): 45-56.
- Alemu Abebe (2007). *Floristic Diversity and Regeneration Structure of some National priority species in Sigmo – Setema forest*, Southwest Ethiopia. M.Sc. Thesis. AAU, Addis Ababa, Ethiopia.
- Anderson, D. J. (1965). Classification and Ordination in vegetation Science: Controversy over non-existence problem. *J. Ecol.* **53**: 521-526.
- Azene Bekele (2007). *Useful Trees and Shrubs for Ethiopia, Identification, Propagation and Management for 17 Agro-climatic Zones*. Technical manual, No. 6 Tengnas, B., Ensermu Kelebessa, Sebsebe Demissew and Maundu, P.(eds). World Agroforestry Center, English Press, Nairobi Kenya, Pp. 550.
- Breitenbach, F.V. (1963). *The Indigenous Trees of Ethiopia (2nd ed.)*. Addis Ababa, Ethiopia Forestry Association.
- Brown, J. H. (2001). Mammals on mountainsides: elevational patterns of diversity. *Glob. Ecol. and Biogeog.* **10**: 101-109.
- Buley, J. (2001). The balance between biodiversity conservation and sustainable use of tropical rainforests: policy-relevant forest research. **In: *The Balance between Biodiversity Conservation and Sustainable Use of Tropical Rain Forests***, PP. 13-18, (Hillegers, P.J.M. and de Iongh, H.H. eds.) Workshop proceedings. The tropenbos Foundation, Wageningen, The Netherlands.
- Central Statistical Authority (CSA) (2007). The 2007 population and housing census of Ethiopia result for Oromia Region. Addis Ababa.
- Chaffey, D.R. (1980). South-west Ethiopia forest inventory project; an inventory of forest at Munesa and Shashemene Project report 29, Ministry of Overseas Development Land Resource Division, London.

- Curtis, J. T. and McIntosh, R. P. (1951). An Upland Continuum in the Prairie Forest Dorder Region of Wiesconsin. *Ecol.* **32**: 476-496.
- Daniel Gamachu (1977). *Aspects of Climate and Water budget in Ethiopia*. A Technical Monograph. Addis Ababa University. 39p.
- Demel Teketay (1992). Human impact on a natural montane forest in southeastern Ethiopia. *Mount. Res. Dev.* **12**: 393-400.
- Demel Teketay (1999). Past and present activities, achievements and constraints in forest genetic resources conservation in Ethiopia. **In:** *Forest Genetic Resources Conservation: Principles, Strategies and Actions*, pp. 49-72, (Edwards, S., Abebe Demmissie, Taye Bekele and Haase, G., eds). Workshop proceedings. Institute of Biodiversity-Conservation and Research, and GTZ, Addis Ababa.
- Demel Teketay and Tamrat Bekele (1995). Floristic composition of Wof-Washa natural forest, central Ethiopia: Implication for the conservation of biodiversity. *Fed.Repret.*, **106**: 127-147.
- Dereje Denu (2007). Floristic composition and Ecological Study of Bibita Forest (Gura Ferda), Southwest Ethiopia. M.Sc. Thesis, Addis Ababa University, Addis Ababa. pp.91
- Desalegn Wana and Zerihun Woldu (2005). Vegetation of Chencha highlands in southern Ethiopia. *SINET. Ethiop. J. Sci.* **28**: 109-118.
- Desta Hamito (2001). *Research Methods in forestry, Priniciple, Practices with Particular Reference to Ethiopia*. Larenstein University of Professional Edition, Netherlan. 682 Pp.
- Dufrene, M. and Legendre, P. (1997). Species Assemblages and Indicator Species: the need for a flexible asymmetrical approach. *Ecol. Mono.* **67**: 345-366.
- EFAP (1994). *Ethiopian Forestry Action Program, Volume III*. The Challenge for Development. Ministry of Natural Resources, Addis Ababa.
- EMA (Ethiopian Mapping Agency) (1988). *Topographic map of Ethiopia: 1:50 000*. EMA. Addis Ababa, Ethiopia.
- EMS (1988). *National Atlas of Ethiopia*. Ethiopia Mapping Authority, Addis Ababa.

- EMSA (2009). *Rainfall and temperature data for Shambu town*. Ethiopiaian Meteorological Services Agency. Addis Ababa, Ethiopia.
- Ensermu Kelbessa, Sebsebe Demissew, Zerihun Woldu and Edwards, S. (1992). Some threatened Endemic Plants of Ethiopia. *NAPRECA Monograph, Series 2*:35-55.
- Ensermu Kelbessa and Teshome Soromessa (2008). Interface of Regeneration, structure, diversity and use of some plant species in Bonga Forest: a Reservoir for wild coffee gene pool. *SINET Ethiop. J. Sci.*, **31(2)**: 121-134
- EPA (2003). *State of Environment Report for Ethiopia*. Environmental Protection Authority. Addis Ababa, Ethiopia. Pp.1-40 .
- Ermias Lulekal (2005). *Ethnobotanical study of medicinal plants and floristic composition of the Menna - Angetu moist montane forest* in Menna - Angetu District, Bale Ethiopia. M.Sc. Thesis, Addis Ababa University
- EWNHS (Ethiopian Wildlife and Natural History Society) (1996). *Important Bird Areas of Ethiopia. A First Inventory*. EWNHS, Addis Ababa
- Feyera Senbeta and Denich, M. (2006). Effects of wild coffee management on species diversity in the Afromontane rainforests of Ethiopia. *Fhor. Ecol. Manag.* **232**: 68-74.
- Feyera Senbeta (2006). *Biodiversity and Ecology of Afromontane Rainforests with Wild Coffea arabica L. Populations in Ethiopia*. Ecology and Development Series No. 38. Center for Development Research, University of Bonn.
- 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. *Ethiop. J. Boil. Sci.* **2(2)**: 169-187
- Feyera Senbeta, Tadesse Woldemariam, Sebsebe Demissew and Denich, M. (2007). Floristic Diversity and Composition of Sheko Forest, Southwest Ethiopia. *Ethiop. J. Biol. Sci.*, **6(1)**:11-42

- Friis, I. (1986). The forest vegetation of Ethiopia. *Acta. Univ. Ups. Symb. Ups.* XX1: 31-47.
- Friis, I. and Mesfin Tadesse (1990). The evergreen forests of tropical Northeast Africa. Dk-1123 Copenhagen K, Denmark. *Opera Botanica* 63: 1-70
- Friis, IB. and Sebsebe Demissew (2001). Vegetation maps of Ethiopia and Eritrea. A review of existing maps and the need for a new map for the flora of Ethiopia and Eritrea. In: *Biodiversity Research in the Horn of Africa Region*, pp. 399-439 (Friis, IB. and Ryding, O. eds). Proceedings of the 3rd International symposium on the Flora of Ethiopia and Eritrea at the Carlsberg Academy, Copenhagen.
- Friis, IB. (1992). Forest and Forest Trees of Northeast Tropical Africa: Their natural habitats and distribution pattern in Ethiopia, Djibouti and Somalia. *Kew. Bull. Add. Ser.* **15**, 396 pp.
- Friis, IB., Rasmussen, F. N. and Vollesen, K. (1982). Studies in the flora and vegetation of southwest Ethiopia. Institute of systematic Botany, University of Copenhagen,
- Fufa Kenea (2008). *Remnant vegetation and population structure of woody species of Jima forest*, West Ethiopia. M.Sc. AAU, Addis Ababa.
- Gauch, H. G. and Whittaker, R. H. (1972). Comparison of ordination techniques. *Ecology* **53**: 868-875.
- Gebremarkos Woldeeslassie (1998). The forest resources of Ethiopia. Past and present. *Walia* **19**: 10-28.
- Genene Bekele (2005). *Floristic composition and structure of the vegetation of Magada forest*, Borana zone, Oromia National Regional State. M.Sc. Thesis, Addis Ababa University.
- Getachew Tadesse, Tamrat Bekele and Sebsebe Demissew (2005). Floristic analysis and anthropogenic influences on dryland Vegetation of Wello, Ethiopia. In: *Biodiversity Research for Livelihood Support and Food Security*, PP. 35-40 (Bernard, K., Meshack, M., Thomas, O. and Paul, O. (eds). Workshop proceedings. National Museum of Kenya, Nairobi.

- Getachew Tesfaye and Abiyot Berhanu (2006). Regeneration of Indigenous woody species in the understory of exotic tree species plantation in western Ethiopia. *Ethiop. J. sci.* **5(1)**:31-43.
- Grubb, P. J., Lloyd, J. R. Pennington, J.D. and Whitmore, J. C. (1963). A comparison of montane and lowland rain forest in Ecuador. I. The forest structure, physiognomy and floristics. *J. of Ecol.* **51**: 567-601.
- Grytnes, J. A. and Vetaas, O.R. (2002). Species Richness and Altitude: A comparison between Null Models and Interpolated Plant Species Richness along the Himalayan Altitudinal Gradient, Nepal. *The American Natural.* **159**: 294-304.
- Haile Yineger, Ensermu Kelbessa, Tamrat Bekele and Ermias Lulekal (2008). Floristic composition and structure of the Dry Afromontane forest at Bale mountains National Park, Ethiopia. *SINET. Ethiop. J. Sci.*, **31(2)** : 103-120
- Hailu Sharew (1982). *An ecological study of forests in Jemjem, Sidamo*. M.sc.Thesis, AAU. Addis Ababa, Ethiop
- Huston, M. A. (1994). Biological diversity. The Existence of Species on Changing Landscapes. Cambridge University Press, Cambridge, 681 Pp.
- H. W.R.D.O. (Horo Woreda and Rural development office) (2009). Socioeconomic Profile of Horo Woreda. Shambu.
- IBC (Institute of Biodiversity Conservation) (2009). Convention on Biological Diversity (CBD) Ethiopia's 4th country Report. Addis Ababa, Ethiopia.
- IUCN (2001). The Red List of Threatened Species. G. land Switzerland and Cambridge, UK.
- Kent, M. and Coker, P. (1992). *Vegetation Description and Analysis. A practical approach*. John Wiley and Sons, New York, 363 Pp.
- Kershaw, K. A. (1973). *Quantitative and Dynamic Plant Ecology (2nd ed)*. Edward Arnold publishers, LTD. London.

- Kimminis, J.P.(1997). *Forest ecology: a foundation for sustainable management 2nd ed.* Prentice Hall, Upper Saddle River, new jersey, USA. 596 Pp.
- Kitessa Hundera, Tamrat Bekele and Ensermu Kelbessa (2007). Floristic and phytogeographic synopsis of a Dry Afromontane coniferous forest in the Bale Mountains (Ethiopia): Implications to biodiversity conservation. *SINET: Etiop. J. Sci.*, **30(1)**:1-12.
- Krebs, C.J. (1999). *Ecological Methodology*. Second edition. Addison-Welsey Educational publishers, USA. 620p.
- Kumelachew Yeshitela and Tamrat Bekele (2002). Plant Community Analysis and Ecology of Afromontane and Transitional Rainforest vegetation of South-Western Ethiopia. *SINET: Ethiop. J. of sci.*, **25(2)**: 155-175.
- Kumelachew Yeshitela and Taye Bekele (2003). The woody species composition and structure of Masha Anderacha forest, Southwestern Ethiopia. *Ethiop. J. Biol. Sci.* **2 (1)**: 31– 48.
- Kumilachew Yeshitela (1997).An ecological study the afromontane vegetation of the sothwestern Ethiopia. MSc. Thesis, AAU, Addis Ababa.
- Kumilachew Yeshitela and Simon Shibru (2004). Floristic composition and Phytogeographical comparison of moist monane forests of southwest Ethiopia. In: Girma Balcha, Kumilachew Yeshitela and Taye Bekele (eds.) Proceedings of a National Conference on Forest Resources of Ethiopia: Status, Challenges, and Opportunities. 27-29 November 2002. Addis Ababa, Ethiopia.
- Lamprecht(1989). *Silviculture in the tropics. Tropical forest ecosystems and their tree species – possibilities and methods for their long-term utilization*. T2-verlagsgesells chaft Gmbbh, RoBdort, Germany.
- Lisanwerk Nigatu (1987). *An ecological study of the vegetation of the Harenna Forest*. M.SC. Thesis AAU.
- Lisanework Nigatu and Mesfin Tadesse (1989). An Ecological study of the vegetation of the Harenna forest, Bale, Ethiopia. *SINET. Ethiop. J. Sci.* **12**: 63-93.

- Logan, W. E.M.(1946). An Introduction to the forests of central and southern Ethiopia Imperial Forestry Institute, University of Oxford. Inst. Paper No. 24.
- Magurran, A.E. (1988). *Ecological Diversity and its Measurement*. Chapman and Hall. London.
- McCune B. and Mefford, M.J. (1999). *PC-ORD. Multivariate Analysis of Ecological Data*. Version 5.0 MjM Software, Glenden Beach, Oregon, U.S.A.
- McCune,B. And Grace, J.B.(2002). *Analysis of Ecological Communities*. MjM Software Design, USA, 304Pp.
- Mesfin Abebe(1997). *Nature and Managment of Ethiopian Soils*. Alamaya University of Agriculture, Ethiopia. Pp. 272.
- Million Bekele and Leykun Berhanu (2001). *State Forest Genetic Resources in Ethiopia. Sub-Regional workshop FAO/IPGRI/ICRAF on the conservation, management, sustainable utilization and enhancement of forest genetic resources in Sahelian and North-Sudanian Africa* (Ouagadougou, Burkina Faso, 22-24 September 1998). Forest Genetic Resources Working Papers, Working Paper Forestry Department, FAO, Rome.
- Mohr, P. (1971). *The Geology of Ethiopia*. HIS University Press, Addis Ababa.
- Motuma Didita (2007). *Floristic analysis of the woodland Vegetation around Dello Menna, Southeast Ethiopia*. M. SC.Thesis. AAU, Addis Ababa, Ethiopia.
- Muller-Dombois, D. and Ellenberg, H. (1974). *Aims and Methods of Vegetation Ecology*. Wiley and Sons, New York, 547pp.
- Mulugeta Lemenih and Demel Teketay (2004). Integrating natural gum and resin production with biodiversity conservation and desertification control, and adapting to climate change in drylands of Ethiopia. In: *Conservation of Genetic resources of Non-timber Forest products in Ethiopia*, PP. 37-49 (Wubalem Tadesse and Mbogga, M., eds.). Workshop proceedings. Ethiopian Agricultural Research Organization (EARO) and International Plant Genetic Resources Institute (IPGRI), Addis Ababa.

- Nadkarni, N. Matelson, T. J. and Haber, W. A.(1995). Structural characteristics and floristic composition of a Neotropical cloud forest, Monteverde, Costa Rica. *J. Trop. Ecol.* **11**: 481-495.
- NBSAP (2005). *National Biodiversity Strategy and Action Plan*. IBC, Addis Ababa.
- Nebel, G., Kvist, L. D., Vanclay, J. K., Christensen, H., Freitas, L. and Ruiz, J. (2001). Structure and floristic composition of flood plain forests in the Peruvian Amazon I. Overstoery. *Forest Ecology and Management* **150**: 27-57.
- Pascal, J. and Pelissier, R. (1996). Structure and floristic composition of a tropical evergreen forest in South-west India. *J. of Trop. Ecol.* **12**:000-000.191-214.
- Peters, C. M. (1996). *The Ecological and Management of Non -Timber Forest Resources*. World Bank Technical Paper 322, ISBN 0-8213-3619-3. Washington.
- R-Development Core Team (2007). *A language and environment for statistical computing*. R-Foundation for Statistical Computing. Vienna, Austria.
- Reusing, M. (1998). *Monitoring forest resources in Ethiopia*. Ministry of Agriculture, Addis Ababa, Ethiopia.
- Reusing, M. (2000). Change detection in natural high forests of Ethiopia using Remote Sensing and GIS techniques. *IAPR* 33: 1253 – 1258.
- Rosenzweig, H.C. (1995). *Species Diversity in Space and Time*. Cambridge University Press.Cambridge.
- Sebsebe Demissew (1980). *A study on the structure of a montane forest. The Menagesha State forest*. M.SC. Thesis, Addis Ababa University.
- Sebsebe Demissew (1998) - *A study of vegetation and floristic composition of Southern Wollo, Ethiopia*. *Journal of Ethiopian Studies* **31**(1): 118-141.
- Sebsebe Demissew, Cribb. P. and Rasmussen, F. (2004). *Field Guide to Ethiopian Orchids*. *Kew Field guide*, Royal Botanic Gardens, Kew.
- Sebsebe Demissew, Mengistu Wondafrash and Yilma Dellegne (1996). *Ethiopia's Natural Base*.Pp.36-53 in *Important Bird Areas of Ethiopia: A First Inventory*. Ethiopia Wildlife and Natural History Society, Addis Ababa, Ethiopia.

- Sebsebe Demissew, Nordal, I. and Stabbetorp, O. E. (2003). *Flowers of Ethiopia and Eritrea. Aloes and other Lilies*. Shama Books, Addis Ababa
- Shibru Tedla (1995). Protected Areas Management Crisis in Ethiopia. *Walia* **16**: 17-30.
- Simon Shibru and Girma Balcha (2004). Composition, Structure and regeneration status of woody species in Dindin Natural Forest, Southeast Ethiopia: An implication for conservation. *Ethiop. J. of Biol. Sci.* (1) 3:15-35
- Smith, P. G. (1983). *Quantitative Plant Ecology: Studies in Ecology 3rd ed.* Blackwell Scientific Publication.
- Tadesse Woldemariam (2003). *Vegetation of the Yayu forest in Southwest Ethiopia: Impacts of human use and Implications for In situ conservation of Wild Coffea arabica L. populations*. Ecology and Development Series No. 10. Center for Development Research, University of Bonn.
- Tadesse Woldemariam and Demel Teketay (2001). The forest coffee ecosystems: Ongoing crises, problems and opportunities for coffee gene conservation and sustainable utilization. In: *Imperative problems associated with forestry in Ethiopia*, pp. 131-142. Workshop proceedings. Biological Society of Ethiopia, Addis Ababa.
- Tadesse Woldemariam, Denich, M. and Demel Teketay (2002). Human impacts on the *Coffea arabica* gene pool in Ethiopia and the need for its in situ conservation. In: *Managing Plant genetic Diversity*, pp. 237-247 (Engels, J.M.M., Rao, V.R., Brown, A.H.D. and Jackson, M.T. eds.). CAB International, USA.
- Tamrat Bekele (1993). *Vegetation Ecology of Remnant Afro-montane Forests on the Central Plateau of Shewa, Ethiopia*, PHD Dissertation, Uppsala University, Uppsala, Sweden.
- Tesfaye Awas, Tamrat Bekele and Sebsebe Demissew (2001). An ecological study of the vegetation of Gambella region, Southwestern Ethiopia. *SINET. Ethiop. J. Sci.* **24**:213-228.
- Teshome Gemechu (2009). Floristic composition and structure of Gendo (Gura Tirign) moist montane forest, east Wellega East Zone. M.Sc. Thesis, AAU, Addis Ababa, Ethiopia.
- Teshome Soromessa, Demel Teketay and Sebsebe Demissew (2004). Ecological study of the vegetation in Gamo Gofa zone, southern Ethiopia. *J. Trop. Ecol.* **45**:209-221.

- Tewold Berhan G. Egziaber (1990). The importance of Ethiopia forests in the conservation Arabic coffee gene-pools. **In:** Proceeding of the 12th plenary meeting AETFAT, SymposiumI. Allg.Bot. Humburg Band 26a:65-72 (Ihenfeldt, H.D.,eds). Mill.Ins.Hamburg.
- Van der Maarel (1979). Transformation of cover/ abundance values in Phytosociology and its effects on community. *Vegetatio* **39**: 47-114.
- Van Tongeren, O. F. R. (1995). Cluster analysis. **In:** *Data Analysis in Community Ecology and Landscape Ecology*, pp. 174-212 (Jongman, R.H.G., ter Braak, J.C.F. and Van Tongeren, O.F.R. eds). Cambridge University Press, Cambridge.
- Vivero. J. L., Ensermu Kelbessa and Sebsebe Demissew (2006). Progress on the Red list of plants of Ethiopia and Eritrea: Conservation and biogeography of endemic flowering taxa. **In:** *Taxonomy and Ecology of African Plants, their Conservation and Sustainable Use*.Pp.761-778 (Ghazanfar S. A. and Beentje H. J., eds). Proceedings of the 17th AETFAT congress, Addis Ababa, Ethiopia.
- Vivero, J. L., Ensermu Kelbessa and Sebesebe Demissew (2005). *The Red list of Endemic Trees and Shrubs of Ethiopia and Eritrea*. Fauna and Flora International, Cambridge, UK, 23 Pp.
- WBISPP (1997). Digital Land Cover Classification of SW Ethiopia. Woody Biomass Inventory and Strategic Planning Project, Ministry of Agriculture, Addis Ababa, Ethiopia.
- White, F. (1983). The Vegetation of Africa. A descriptive memoir to accompany the UNESCO/AETFAT/UNSO. UNESCO, 356p.
- Whittaker, R. H. (1972). Evolution and measurement of species diversity. *Taxon* **21**: 213-251
 _____ (1975). *Community and Ecosystems*. 2nd ed. Macmillan.
- Woldeyohannes Enkossa (2008). *Floristic Analysis of Alata-Bolale Forest* in Gudaya Bila Wereda. MSC Thesis, AAU, Addis Ababa, Ethiopia.
- Zerihun Woldu (1985). Variation in Grassland Vegetation on the Central Plateau of Shewa, Ethiopia, in relation to adaphic factors and grazing conditions. Doctorial thesis, Uppsala University Dissertations Botanicae, 84, J. Cramer, Vaduz.
- Zerihun Woldu, Feoli, E and Lisanework Nigatu (1989). Partitioning an elevational gradient of vegetation from southeastern Ethiopia by probabilistic methods. *Vegetatio*. **81**:189-198.

Appendix 1: Species list for plants identified from study in the Chato Natural Forest.

C=Climbers, L=lianas, S= Shrubs, T= Trees, H= Herbs, F= Ferns, E= Epiphyte

*= No local name.

Genus and species Name	Family Name	Habit	V. Name	Coll.No
<i>Acaccia abyssinica</i> Hochst.ex Benth.	Fabaceae	T	Laftoo	FA065
<i>Acacia brevispica</i> Harms	Fabaceae	S	Harangama	FA084
<i>Acalyphia psilostachya</i> Hochst.ex A.Rich.	Euphorbiaceae	S	*	FA150
<i>Acanthus eminens</i> C.B. Clarke	Acanthaceae	S	Kosoruu	FA045
<i>Achyranthes aspera</i> L.	Amaranthaceae	H	Maxxanee	FA010
<i>Achyrospermum schimperi</i> (Hochst.exBriq.)Perkins	Lamiaceae	H	Kussayyee	FA078
<i>Acrachne racemosa</i> (Roem. & Schulf.) Ohwi	Poaceae	H	Margaa	FA168
<i>Adiantum poiretti</i> Wikstr.	Adiantaceae	F	Farnii	FA023
<i>Albiza gummifera</i> (J.F.Gmel.) C.A.S.M.	Fabaceae	T	Bribiraa	FA041
<i>Allophylus abyssinicus</i> (Hochst.) Radkofe	Sapindaceae	T	Malqaqqoo	FA088
<i>Andropogon abyssinicus</i> Fresen.	Poaceae	H	M/ balamii	FA123
<i>Argomuelera macrophylla</i> Pax.	Euphorbiaceae	S	Hanbubbu	FA136
<i>Arisaema schimperiana</i> Schott.	Araceae	H	Nitii bofaa	FA124
<i>Asparagus africanus</i> Lem.	Asparagaceae	S	Saritii	FA 120
<i>Aspilia gilletti</i> Willd.	Asteraceae	S	*	FA146
<i>Asplenium aethopicum</i> (Burm.f.) Beckerer	Aspleniaceae	F	Tirimmi	FA153
<i>Asplenium anisophyllum</i> Kunze.	Aspleniaceae	F	*	FA159
<i>Bersama abyssinica</i> Fresen.	Melanthaceae	S	Ararsaa	FA013
<i>Caesalpinia decapetata</i> (Roth.) Alston	Fabaceae	L	Harangama	FA164
<i>Calpurnia aurea</i> (Ait.) Benth.	Fabaceae	S	Ceekaa	FA092
<i>Carduus schimperi</i> Sch. Bip. ex Rich.	Asteraceae	H	Q/ Harree	FA098a
<i>Carissa spinarum</i> L.	Apocyanaceae	S	Hagamsaa	Fa061
<i>Cassipourea malosana</i> (Baker) Alston.	Rhizophoraceae	T	Qilxixuu	FA037
<i>Celtis africana</i> Burm.f.	Ulmaceae	T	Cayyii	FA009
<i>Chionanthus mildbraedi</i> (Gilg. & Schellenb.) Stearn.	Oleaceae	T	Karraa bayyuu	FA050
<i>Clausena anistata</i> (Willd.) Benth.	Rutaceae	S	Ulumaayyii	FA020
<i>Clematis hirsuta</i> Perr & Guill.	Ranunculaceae	L	Hidda feeti	FA063

Genus and species Name	Family Name	Habit	V. Name	Coll.No
<i>Clusia abyssinica</i> Jub. & Spach	Euphorbiaceae	S	Ulee foon	FA122
<i>Coffea arabica</i> L.	Rubiaceae	S	Bunaa	FA074
<i>Combretum collinum</i> Fresen.	Combretaceae	T	*	FA149
<i>Combretum paniculatum</i> Vent.	Combretaceae	L	Baggii	FA087
<i>Commelina foliacea</i> Chiov.	Commelinaceae	H	Gorora Farda	FA118
<i>Cordia africana</i> Lam.	Boraginaceae	T	Waddessaa	FA096
<i>Croton macrostachyus</i> Del.	Euphorbiaceae	T	Bakanisaa	FA044
<i>Cyathula cylindrica</i> Moq.	Amaranthaceae	H	Kobboo	FA102
<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	H	Coqorsaa	FA169
<i>Cyperus fischerianus</i> A. Rich.	Cyperaceae	H	Daggoo	FA022
<i>Cystopteris fragilis</i> (L.) Benth	Athyriaceae	F	*	FA151
<i>Dalbergia lactea</i> Vatke	Fabaceae	S	Warraa billee	FA055
<i>Diaphananthe tenuicalcar</i> Summerh.	Orchidaceae	E	*	FA091
<i>Digitaria abyssinica</i> (Hochst.ex A. Rich.) Stapf	Poaceae	H	*	FA167
<i>Diospyros abyssinica</i> (Hiern.) F. White	Ebenaceae	T	Hilkee	FA099
<i>Dissotis senegambiensis</i> (Guill & Per.) Triana	Melastomataceae	H	*	FA134
<i>Dombeya torrida</i> (J.F. Gamel.) P. Bamps.	Sterculiaceae	T	Danisaa	FA060
<i>Dovyalis abyssinica</i> (A. Rich.) Warb.	Flacourtiaceae	S	Koshommii	FA075
<i>Dracaena afromontana</i> Mildbr.	Dracaenaceae	S	Warqee Q.	FA79
<i>Dracaena steudneri</i> Engl.	Dracaenaceae	T	Marqoo/warqe	FA172
<i>Drynaria volkensii</i> J.Sm.	Polypodiaceae	E	Sookokee	FA145
<i>Dryopteris anthamantica</i> (Kunze) Kuntze.	Dryopteridaceae	F	Tirimii	Fa027
<i>Dryopteris inaequalis</i> (Schldl.) Kuntze	Dryopteridaceae	F	Tirimii	FA113
<i>Duranta repens</i> L.	Verbenaceae	S	Gachanafulliis	FA108
<i>Echinops longisetus</i> A. Rich.	Asteraceae	H	Qoree Harree	FA 021
<i>Ehretia cymosa</i> Thonn.	Boraginaceae	T	Ulaagaa	FA116
<i>Ekebergia capensis</i> Sparrm.	Meliaceae	T	Somboo	FA101
<i>Embelia schimperi</i> Vatke	Myrsinaceae	L	Hanquu	FA062
<i>Eragrostis superba</i> Peyr	Poaceae	H	Gosa xaafii	FA166
<i>Erythrococca trichogyne</i> (Muell. Arg.) Prain	Euphorbiaceae	T	Caakkoo	FA070
<i>Euclea divinorum</i> Hiern.	Ebenaceae	S	M'eessaa	FA105
<i>Euphorbia ampliphylla</i> Pax.	Euphorbiaceae	T	Hadaamii	FA094
<i>Ficus sur</i> Forssk.	Moraceae	T	Harbuu	Fa059

Genus and species Name	Family Name	Habit	V. Name	Coll.No
<i>Ficus thonningii</i> Blume	Moraceae	T	Dambii	FA104
<i>Ficus vasta</i> Forssk.	Moraceae	T	Qilxuu	FA098
<i>Flacourtia indica</i> Burm.f. Merr.	Flacourtiaceae	T	Akuukkuu *	FA119
<i>Galiniera saxifraga</i> (Hochst.) Bridson	Rubiaceae	S/T	Mixoo	FA046
<i>Gardenia ternifolia</i> Schumach. & Thonn.	Rubiaceae	T	Gambelloo	FA130
<i>Grewia ferruginea</i> Hochst.ex. A.Rich.	Tiliaceae	L	Dhoqonuu	FA051
<i>Helichrysum splendidum</i> (Thumb.) Less.	Asteraceae	H	*	FA144
<i>Helinus mystacinus</i> (Ait) E. Mey.ex Steud.	Rhamnaceae	L	Kobbituu	FA110
<i>Hibiscus macranthus</i> Hochst.ex A.Rich.	Malvaceae	S	Hincinnii	FA148
<i>Hibiscus ovalifolius</i> (Forssk.) Vahl	Malvaceae	S	Hinicinnii	FA90b
<i>Hippocratea goetzei</i> Looes.	Celastraceae	L	H/qolalafesa	FA018
<i>Hyparrhenia anthistiriodes</i> (Hochst.ex A.Rich.) Stapf	Poaceae	H	Dagalla	FA071
<i>Hyparrhenia arrhenobasis</i> (Hochst. ex Stued.) Stapf.	Poaceae	H	*	FA112
<i>Hypoestes forskalii</i> (Vahl) R. Schult.	Acanthaceae	H	Darguu	FA026
<i>Jasminum abyssinicum</i> Hochst. ex DC.	Oleaceae	L	H/ ilichimme	FA064
<i>Justicia diclipteroides</i> Lindau subsp .aethiopica Hedrén	Acanthaceae	H	Darguu	FA152
<i>Justicia ladanoides</i> Lam.	Acanthaceae	H	Darguu	FA141
<i>Justicia schimperiana</i> (Hochst. ex Nees) T. Anders	Acanthaceae	S	Dhumugga	FA012
<i>Kalanchoe petitiana</i> A.Rich.	Crassulaceae	H	Bussuqqee	FA072
<i>Kalanchoe lanciata</i> L. DC.	Crassulaceae	H	Bussuqqee	FA171
<i>Lagenaria abyssinica</i> (Hook.f.) C.Jeffrey	Cucurbitaceae	C	Buq/ sexanaa	FA170
<i>Laggera tomentosa</i> (Sch.Bip.ex A.Rich.) Olive. & V.	Asteraceae	H	*	FA155
<i>Landolphia buchananii</i> (Hall.f.) Stapf.	Apocyanaceae	L	Hida geeboo	FA017
<i>Lepidotrichilia volkensis</i> (Gurke.) Leory.	Meliaceae	T	Qoomonyoo	FA057
<i>Leucas martinicensis</i> (Jacq.) R. Br.	Lamiaceae	H	Dalee	Fa047
<i>Lippia adoensis</i> Hochst.ex Walp.	Verbenaceae	S	Kussayyee	FA121
<i>Loxogramme abyssinica</i> Baker M. G. Price	Polypodiaceae	E	*	FA024
<i>Macaranga capensi</i> (Bail.) Sim.	Euphorbiaceae	T	Ho'aa	A127
<i>Maesa lanceolata</i> Forssk.	Myrsinaceae	T	Abayyii	FA053
<i>Matyenus gracilipes</i> (Welw.ex Oliv.) Excell	Celastraceae	S	Hacaacii	FA038

Genus and species Name	Family Name	Habit	V. Name	Coll.No
<i>Maytenus arbutifolia</i> (A .Rich) Wilczek	Celastraceae	S	Hacacaa	FA 137
<i>Maytenus undata</i> (Thunb.) Blakelock	Celastraceae	S	Muka ilka	FA069
<i>Mikaniopsis clematoides</i> (A.Rich.) Miln-Redh	Asteraceae	C	H/ Hantuuta	FA082
<i>Millettia ferruginea</i> (Hochst.) Bak.	Fabaceae	T	Sotalloo	FA054
<i>Mimulopsis solmsii</i> . Schweinf.	Acanthaceae	H	Darguu	FA162
<i>Mimusops kummel</i> A. DC.	Sapotaceae	T	Qolaadii	FA001
<i>Myrsine africana</i> L.,	Myrsinaceae	S	Qcaqmaa	FA015
<i>Nuxia congesta</i> R.Br.ex Fresen	Loganiaceae	T	Nafuroo	FA073
<i>Ochna holstii</i> Engl.	Ochnaceae	T	Lookoo	FA007
<i>Ocimum lamiifolium</i> Hochst. ex Benth.,	Lamiaceae	S	Waancabbi	FA036
<i>Ocimum Urticifolium</i> Roth	Lamiaceae	S	Gosa wancbii	FA160
<i>Olea capensis</i> L. subsp. <i>macrocarpa</i> (C.H.Wright) Verdc.	Oleaceae	T	Gaagama	FA005
<i>Olea welwitschii</i> (Knobl.) Gilg & Schellenb.	Oleaceae	T	Bahaa	FA085
<i>Olinia rochetiana</i> A. Juss.	Oliniaceae	T	Noolee	FA090a
<i>Oplismeunus hirtellus</i> (L.) P. Beauv.	Poaceae	H	Marga Boyyee	FA077
<i>Oresoschimperella verrucosa</i> (A.Rich.) Rauschert	Apiaceae	H	gosa dimbilala	FA135
<i>Osyris quadripartita</i> Decn.	Santalaceae	S	Waatoo	FA125
<i>Pavonia urens</i> Cav.	Malvaceae	S	Hiniccinni	FA140
<i>Pennisetum sphacelatum</i> (Nees) Th. Dur. & Schinz.	Poaceae	H	Migira/ sutaa	FA126
<i>Peperomia abyssinica</i> Miq.	Piperaceae	E	*	FA056
<i>Periploca linearifolia</i> Kurt. Dill. & A.Rich.	Asclepiadaceae	L	Anannoo	FA111
<i>Phaulopsis imbricata</i> (Forssk.) Sweet.	Acanthaceae	H	*	FA157
<i>Phoenix reclinata</i> Jacq.	Arecaceae	T	Mexxii	FA052
<i>Phragmanthera macrosolon</i> (Steud. ex A. Rich.) Balle	Loranthaceae	E	Ertoo	FA128
<i>Phyllanthus dewildiorum</i> M.Gilbert.	Euphorbiaceae	S	H/ billaachaa	FA002
<i>Phytolacca dodecandra</i> L'Herit	Phytolaccaceae	S	Handoodee	FA115
<i>Pittosporum viridiflorum</i> Sims	Pittosporaceae	T	Qasamee	FA040
<i>Plantago lanceolata</i> L.	Plantaginaceae	H	Qorxobbii	FA163
<i>Plumbago zeylanica</i> L.	Plumbaginaceae	C	Ameeraa	FA106
<i>Podocarpus falcatus</i> (Thunb.) R. B. ex Mirb.	Podocarpaceae	T	Birbirsaa	FA003
<i>Polyscias fulva</i> (Hiern) Harms	Araliaceae	T	Hombolxoqa	FA080

Genus and species Name	Family Name	Habit	V. Name	Coll.No
<i>Pouteria adolfi-friederici</i> (Engl.) Baehni	Sapotaceae	T	Sooqee	FA011
<i>Premna schimperi</i> Engl.	Lamiaceae	T	Urgeessaa	FA068
<i>Protea gaguedi</i> J. F. Gamel.	Proteaceae	T	Yubdoo	FA133
<i>Prunus africana</i> (Hook.f.) Kalkam.	Rosaceae	T	Homii	FA081
<i>Psychotria orophila</i> Petit	Rubiaceae	T	M/ Gurrachaa	FA008
<i>Pteris catoptera</i> Kunze.	pteridaceae	F	Tirimmi	FA142
<i>Pteris pteridiodes</i> (Hook.) Ballard.	pteridaceae	F	Tirimmi	FA143
<i>Pycnostachys abyssinica</i> Fresen.	Lamiaceae	S	Doroomii	FA083
<i>Rhamnus prinoides</i> L.'Herit.	Rhamnaceae	S	Geeshoo	FA109
<i>Rothmannia urcelliformis</i> (Hiern.) Robyns	Rubiaceae	T/S	Buruurii	FA058
<i>Rubus steudneri</i> Schweinf.	Rosaceae	S	Goraa	FA034
<i>Rytigynia neglecta</i> (Hiern.) Robyns.	Rubiaceae	T	Mixoo dhalaa	FA067
<i>Schefflera abyssinica</i> (Hochst.ex. A.Rich.) Harms	Araliaceae	T	Gatamaa	FA076
<i>Setaria megaphylla</i> (Steud.) Th. Dur.	Poaceae	H	Jajjabaa	FA033
<i>Solanum giganteum</i> Jacq.	Solanaceae	S	Hiddii Saree	FA089
<i>Solenstemon autranii</i> (Briq.) J. K.Moore.	Lamiaceae	H	*	FA132
<i>Sparmannia ricinocarpa</i> (Eckl. & Zehy.) O.Ktze.	Tiliaceae		Burkutuu	FA086
<i>Stephania abyssinica</i> Dillon & A. Rich Walp.	Menispermaceae	C	Hida Kalalaa	FA117
<i>Syzygium guineense</i> (Willd.) DC. subsp. <i>afromontanum</i> F. White.	Myrtaceae	T	Badeessaa	FA042
<i>Syzygium guineense</i> subsp. <i>guineensis</i> (Willd.) DC.	Myrtaceae	T	Gossuu	FA156
<i>Taccazzea apiculata</i> Oliv	Asclepiadaceae	L	GuraHantuta	FA043
<i>Tactaria gimmifera</i> (Fee) Alston.	Tectariaceae	F	*	FA154
<i>Teclea nobilis</i> Del.	Rutaceae	T	Hadhessa K.	FA006
<i>Terminalia macroptera</i> Giull & Perr.	Combretaceae	T	Dabaqqaa	FA129
<i>Thunbergia alata</i> Bojer. ex Sims	Acanthaceae	H	*	FA161
<i>Tiliacarpa troupinii</i> Cufod.	Menispermaceae	L	H/ liqimnee	FA049
<i>Tragia brevipes</i> Pax.	Euphorbiaceae	C	gurgubee	FA165
<i>Trema orientalis</i> (L.) Bl.	Ulmaceae	T	Fofoo	FA114
<i>Triumfetta rhomboidea</i> Jacq.	Tiliaceae	S	*	FA156
<i>Urera hypselodredon</i> (A. Rich.) Wedd.	Urticaceae	L	Lanqisaa	FA097
<i>Girardinia bullosa</i> (Steud.)Wedd.	Urticaceae	H	Dobbii	FA100
<i>Vepris dainelli</i> (Pichi-serm.) Kokwaro.	Rutaceae	T	Hadheessa	FA04

Genus and species Name	Family Name	Habit	V. Name	Coll.No
<i>Vernonia amygdalina</i> Del.	Asteraceae	T/S	Ebbichaa	FA066
<i>Vernonia auriculifera</i> Hiern.	Asteraceae	S	Reejjii	FA125
<i>Vernonia purpurea</i> Sch. Bip.ex Walp.	Asteraceae	S	Soyyomaa	FA131
<i>Vernonia wollastonii</i> S.Moore	Asteraceae	H	Gosa reejjii	FA158
<i>Warburgia ugandensis</i> Sprague	Canellaceae	T	Beftii	FA 039

Appendix 2: Shannon diversity indices, altitudes and geographic co-ordinates of Chato Natural Forest.

plot	Richness	Shannon Index(H')	Latitude(N)/ Longitude(E)	Altitude
1	21	2.85	9° 42' 10 /36° 59' 27	1726
2	17	2.73	9° 42' 08 /36° 59' 36	1742
3	15	2.59	9° 42' 01 /36° 59' 30	1705
4	18	2.78	9 41' 39 /37° 00' 44	2144
5	15	2.62	9° 41' 16 /37° 00' 32	2045
6	15	2.63	9° 41' 16 /36° 59' 52	1861
7	20	2.93	9° 41' 54 /37° 00' 17	1962
8	13	2.48	9° 41' 40 /37° 00' 13	1935
9	22	2.95	9° 40' 50 /36° 59' 55	1920
10	22	2.99	9° 40' 47 /37° 00' 01	1980
11	15	2.58	9° 41' 03 /37° 00' 05	1916
12	12	2.41	9° 41' 09 /36° 59' 53	1866
13	19	2.87	9° 41' 22 /36° 59' 54	1884
14	20	2.80	9° 41' 31 /36° 59' 39	1851
15	12	2.39	9° 41' 17 /37° 00' 10	1919
16	11	2.23	9° 41' 54 /37° 00' 03	1882
17	12	2.41	9° 41' 55 /36° 59' 50	1830
18	17	2.71	9° 42' 05 /37° 00' 28	2046
19	26	3.13	9° 42' 09 /37° 00' 12	1905
20	24	3.00	9° 40' 50 /37° 00' 20	2111
21	15	2.50	9° 40' 25 /36° 59' 49	1962
22	22	3.01	9° 40' 30 /36° 59' 34	1834
23	18	2.82	9° 40' 45 /36° 59' 36	1855
24	12	2.40	9° 41' 04 /36° 59' 37	1822
25	10	2.23	9° 41' 34 /36° 59' 58	1876
26	9	2.07	9° 41' 42 /36° 59' 46	1847
27	15	2.59	9° 41' 13 /36° 59' 23	1714
28	15	2.62	9° 41' 28 /37° 00' 35	2079
29	18	2.79	9° 41' 48 /37° 00' 18	2055
30	15	2.58	9° 42' 10 /37° 00' 39	2035
31	12	2.40	9° 42' 01 /37° 00' 44	2101
32	13	2.43	9° 42' 07 /37° 00' 03	1878
33	18	2.78	9° 40' 58 /37° 00' 18	2033
34	21	2.93	9° 40' 17 /36° 59' 54	1992
35	21	2.93	9° 40' 34 /37° 00' 01	2036
36	17	2.69	9° 40' 12 /37° 00' 04	2063
37	14	2.59	9° 40' 19 /36° 59' 31	1825
38	11	2.37	9° 40' 11 /36° 59' 39	1871
39	17	2.76	9° 41' 20 /37° 00' 05	1906
40	28	3.19	9° 40' 27 /37° 00' 12	2131

Appendix 3: Plant families with their genera and species distribution in Chato Forest.

Family name	No. of genera	No. of species
Aspleniaceae	2	2
Boraginaceae	2	2
Crassulaceae	2	2
Dracaenaceae	2	2
Dryopteridaceae	2	2
Ebenaceae	2	2
Meliaceae	2	2
Menispermaceae	2	2
Myrtaceae	1	2
Polypodiaceae	2	2
Pteridaceae	1	2
Rhamnaceae	2	2
Rosaceae	2	2
Sapotaceae	2	2
Tiliaceae	2	2
Ulmaceae	2	2
Urticaceae	2	2
Verbenaceae	2	2
Combretaceae	2	3
Malvaceae	3	3
Moraceae	1	3
Myrsinaceae	3	3
Rutaceae	3	3
Celastraceae	2	4
Oleaceae	3	4
Rubiaceae	6	6
Lamiaceae	5	7
Acanthaceae	6	8
Fabaceae	7	8
Euphorbiaceae	9	9
Poaceae	9	9
Asteraceae	7	10
Others	1 each	1 each
67	138	154

Declaration

I, the undersigned declare this thesis is my original work; it has not been presented elsewhere in other institutions colleges or universities for seeking similar degree or other purposes. All sources of the materials used in the thesis have been only duly acknowledged.

Feyera Abdena

Signature-----

Date-----

This work has been done under the supervision of

Signature

Date

Prof. Sileshi Nemomissa

Dr. Feyera Senbeta
