PLANT DIVERSITY AND ETHNOBOTANICAL STUDY OF MEDICINAL PLANTS IN ANKOBER DISTRICT, NORTH SHEWA ZONE OF AMHARA REGION, ETHIOPIA

Ermias Lulekal Molla

Addis Ababa University

Addis Ababa, Ethiopia

June 2014

PLANT DIVERSITY AND ETHNOBOTANICAL STUDY OF MEDICINAL PLANTS IN ANKOBER DISTRICT, NORTH SHEWA ZONE, AMHARA REGION, ETHIOPIA

Ermias Lulekal Molla

A Thesis Submitted to

The Department of Plant Biology and Biodiversity Management

Presented in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

(Biology: Botanical Science)

Addis Ababa University

Addis Ababa, Ethiopia

June 2014

ADDIS ABABA UNIVERSITY

GRADUATE PROGRAMMES

This is to certify that the thesis prepared by Ermias Lulekal Molla, entitled: *Plant Diversity and Ethnobotanical Study of Medicinal Plants in Ankober District, North Shewa Zone of Amhara Region, Ethiopia*, and submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy (Biology: Botanical Science) complies with the regulations of the University and meets the accepted standards with respect to originality and quality

Signed by Research Supervisors:

Name	**Signature**	**Date**
1. ____________________	______________	__________
2. ____________________	______________	__________
3. ____________________	______________	__________
4. ____________________	______________	__________

_______________________________________ __________

Chair of Department or Graduate programme Coordinator

Abstract

Plant Diversity and Ethnobotany of Medicinal Plants in Ankober District, North Shewa Zone of Amhara Region, Ethiopia

Ermias Lulekal, PhD Dissertation
Addis Ababa University, 2014

This research aimed at providing documentation and analysis of plant diversity in Dense Forest along with the ethnobotanical knowledge associated with the medicinal plants used by the people in Ankober District, Ethiopia. Vegetation data were collected from 51, 30 m x 30 m quadrats laid for trees at every 50 m altitudinal drop along transects and 5 m x 5 m and 2 m x 2 m subplots for shrubs and herbs, respectively. Woody species with a diameter at breast height (DBH) > 2 cm were counted and cover abundance values estimated. A hierarchical cluster analysis, with PC-ORD for Windows version 5.0 software, was used to identify plant communities and synoptic values for identification of the dominant species for naming plant communities. Frequency, density, DBH, basal area and importance value indices (IVI) of woody species were also computed. Shannon-Wiener diversity index was used to assess species richness and evenness. Sorensen's similarity coefficient was used to measure similarities among communities in Dense Forest, and between Dense and other montane forests. Ethnobotanical data were collected by interviewing 352 informants (235 males and 117 females). Quantitative approaches were used to determine informant consensus factor (ICF), fidelity level (FL), use value (UV), use diversity (UD) and use equitability (UE) values. Ethnomedicinal knowledge held by different informant categories was compared using One-way ANOVA and t-tests. A total of 23 ethanol extracts of various parts of 19 most-preferred medicinal plants were also studied for potential antimicrobial activity against 12 microbial strains using broth microdilution method. The Dense Forest yielded 158 vascular plant species belonging to 143 genera and 75 families. The vegetation of the Forest was classified into five, namely Erica arborea, Maesa lanceolata-Discopodium penninervium, Podocarpus falcatus-Allophylus abyssinicus, Olea europaea-Galiniera saxifraga and Maytenus arbutifolia-Bersama abyssinica community types, based on the PC-ORD hierarchical cluster analysis. The percentage distribution of individual tree species across different DBH classes indicated relatively high proportion (27.26%) of individuals in DBH class 10-20 cm. The highest IVI values were recorded for Olea europaea subsp. cuspidata (57.63) and the next for Podocarpus falcatus (45.61). The overall Shannon-Wiener diversity and evenness values of Dense Forest were 4.07 and 0.80, respectively. Five representative woody plant population structures were identified. Results of the ethnobotanical study revealed a total of 151 medicinal plant species belonging to 141 genera and 75 families in the whole of Ankober District. The Asteraceae with 13 (9%) species and the Fabaceae with 11 (7.3%) species were families represented by more species in the District. Plants in which roots are used as medicine were more frequent than other parts in the District's ethnomedicinal lore. Significant difference ($P < 0.05$) was observed in the mean number of medicinal plants reported by respondents in different age classes, literacy levels and experiences. About 123 (81%) species of medicinal plants were cited for one or more non-medicinal uses. The highest ICF value (0.71) was recorded for livestock gastro-intestinal disease category. The highest fidelity level values were recorded for Zehneria scabra (95%) and Hagenia abyssinica (93.75%). About 17 (74%) of the ethanol extracts showed antimicrobial activity against one or more of the microbial strains tested. Extracts from Embelia schimperi showed the strongest antibacterial activity with minimum inhibitory concentration (MIC) value of 64 µg/ml against Bacillus cereus, Listeria monocytogenes and Streptococcus pyogenes. The Dense Forest and the medicinal plants in Ankober District are under pressure due mainly to ever-increasing anthropogenic influences. Thus, the declining vegetation and wild medicinal plants of the area are in need of application of complementary in-situ and ex-situ conservation. Joint management of the Dense Forest with the local people and increased participation of the local people in overall medicinal plant conservation are actions that would save and rehabilitate the fast-declining plant resources with the rich ethnomedicinal wealth in the District.

Key words*:*Ankober, antimicrobial activity, ethnobotany, floristic composition, medicinal plants

DEDICATION

This thesis is dedicated to the people of Ankober District who maintained their rich medicinal plant knowledge and practices for generations despite the tremendous environmental and socio-political changes that took place over the year.

Acknowledgments

I would like to pass heartfelt thanks to my supervisors Dr. Zemede Asfaw (AAU), Prof. Ensermu Kelbessa (AAU) and Prof. dr. ir. Patrick Van Damme (UGhent) for their unreserved guidance, support, suggestions, effective followup of the research work, and detailed reading and correcting of all my manuscripts to this end.

My heartily acknowledgment goes to Debre Berhan University (DBU) for sponsoring me for this PhD study. I would like to extend my deepest thanks to the Graduate Programmes of Addis Ababa University for funding the cost of all field expenses; the *Bijzonder Onderzoeksfonds* (BOF), UGhent, Belgium, for funding all expenses of my laboratory work and research stay at Ghent University; and the Committee for Scientific Research under the Faculty of Bioscience Engineering, Ghent University for the travel grant and fund supplied for part of the laboratory work of this project.

I am indebted to the inhabitants of Ankober District, particularly the traditional medical practitioners who unreservedly shared with me their knowledge on medicinal plants, together with their wonderful hospitality throughout my stay in the study area for field activities. I thank Shewamene Teklemariam, Zebene Haile, Ashenafi Mihrete, Abebe Shewamene, Getu Shewamene, Dawit Tewabe and Getachew Abebe for their field assistantship, Dr. Henok Lulekal from North Shewa Agriculture and Rural Development Office and Sr. Tsehay Aytenew, Hayat Hospital, Addis Ababa, for translating local names of diseases into their English equivalents based on descriptions of symptoms.

Prof. Ladislav Kokoska (head of the laboratory of Ethnobotany and Ethnopharmacology) at Czech University of Life Sciences (CULS), Johana Rondevaldova, Eva Bernaskova and Jindriska Cepkova are also heartily acknowledged for their support with various aspects of the laboratory work. Prof. Sebsebe Demissew, Prof. Zerihun Woldu, Prof. Sileshi Nemommisa, Dr. Tamrat Bekele and all other staff members of the Department of Plant Biology and Biodiversity Management (AAU) and Prof. Demel Teketay (University of Botswana) are also deeply acknowledged for their persistent encouragement during my course and research works.

I would like to pass my gratitude to Ato Getachew Tefera (President of DBU), Dr. Tamire Zewdie (Academic Vice-President of DBU), Ato Teferi Adinew (Research Vice-President of DBU) for their valuable encouragement and support during the study period. Prof. Will McClatchey, University of Hawaiʻi at Manoa, USA, is heartily acknowledged for providing useful references, and discussions on scientific concepts related to traditional knowledge dynamics. Dr. Matteo Baralado (head of Increasing Peoples Opportunity (IPO) project in Ethiopia) is also deeply acknowledged for his support and encouragement throughout the research work.

I would like to extend my deepest gratitude to the technical staff members of the National Herbarium (ETH) for their cooperation with all aspects of the herbarium work, beside their persistent and very friendly encouragements. The National Meteorological Services Agency of Ethiopia is acknowledged for providing meteorological data of Ankober station, in the study District. Staff members of the digital libraries of AAU, UGhent and United Nations Economic Commission for Africa (UNECA) are also acknowledged for their kind library services and providing valuable references for this work. W/o Fikirte Demisse and Ato Mare Addis (AAU) are also truly acknowledged for their contribution in developing the digital map of the study area.

The following people are also truly acknowledged for providing valuable information about various aspects of the study District: Ato Tadesse Fekyibelu (Administrative head of Ankober District), Liqe Kahnat Kalehiwot Habtetsedik (from Ankober Diocese of Ethiopian Orthodox Tewahdo Church), Dr. Hailegebriel Dagne (Chairman of Ankober Woreda Development Association (AWDA), Eng. Terefe Raswork (from Ankober Lodge), Ato Nigussie Lemma and Ato Giday Ambaye (experts at the District's Agriculture and Rural Development Office), Ato Geremew G/yes (secretary of AWDA), Ato Assefa Zenebe (head of the District's Tourism and Culture Office), Ato Hailegiorgis Mamo (expert at the District's Livestock Wealth Development Office), Ato Getahun Hailegiorgis (information officer at the District's Administration Office) and Ato Hailu Meshesha (expert at Ankober District Health Office).

I am very thankful to my research colleagues at UGhent: Wouter Vanhove, Céline Termote, Hannes Cosyns, Sali Bourou and Isabel Vanderissche, Sabine Van

Cauwenberghe, Jila Sagid, Arne Baert, Daniela Peñafiel Anchundia, Yolanda Beatriz, Sofie Ruysschaert, Kaat Verzelen and Doreen Rogier (BOF) for their unreserved support and encouragement during my research stay at UGhent. I am deeply indebted to Fr. Alix Cloutte and all fathers of Don Bosco in Ghent for their valuable support during my stay in Ghent. I have very special thanks to Marijke (Oma), Micha Tillaert and their family for their support and great encouragement during my study stay at Ghent University. Fr. Charles de Hemptinee, Marleen Van Stappen and Annemie Derbaix (all from Ontmoeting Buitenlandse Studenten Ghent (OBSG)) are deeply acknowledged for their unforgettable support and hospitality during my stay at OBSG.

I am very much indebted to my wife Birtukan Eshetu, and my children Nebiyu Ermias and Tinbite Ermias for their golden support, encouragement and prayers throughout the study period, and sharing all the pains and gains I faced during this study. My father Lulekal Molla, my mother Zerfe Melesse, my brothers and sisters Simret Lulekal, Esayas Lulekal, Eng. Surafel Lulekal and Serkalem Sisay, Dr. Henok Lulekal, Eyeluta Lulekal and Dilnesaw Feyissa, Soliyana Lulekal and Abiy Temesgen are truly acknowledged for their kindest support at all phases of this study. My friends Dr. Adane Assefa, Dr. Haile Yineger, Abate Bekele, Hailemariam Handino, Fekadu Mulubirhan, Solomon Mulatu, Mesfin W/Aregay, Daniel Argaw, Nigatu Balcha, Belaynesh Abehodie, Tesfaye Nafo, Azalech Mekonene, Haimanot Bichil, Alemtsehay Teka and Hussien Adal, are truly acknowledged for their support during my research period.

I would like to extend a heartfelt thanks to a number of friends, colleagues and people (whose long list of names is recorded in my diary), whom I faced during the course and research work, and from whom I received support on various aspects of this study.

Above all, I thank the Almighty God for His unspeakable gift to this end. My deepest thanks would also go to St. Mary, the mother of Lord Jesus Christ, who is with me at all aspects of my life since my childhood.

Table of Contents

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

AAU	Addis Ababa University
ADHO	Ankober District Health Office
AML	African Model Law
ANOVA	Analysis of Variance
AWDA	Ankober Woreda Development Association
AWFPEDO	Ankober Woreda Finance Planning and Economic Development Office
BA	Basal Area
CBD	Convention on Biological Diversity
CSMPP	Conservation and Sustainable use of Medicinal plants Project
CULS	Czech University of Life Sciences
DBH	Diameter at Breast Height
DBU	Debre Berhan University
DMR	Direct Matrix Ranking
EEPFE	Environmental Economics Policy Forum for Ethiopia
EFAP	Ethiopian Forestry Action Program
EHNRI	Ethiopian Health and Nutrition Research Institute
ENTMPTA	Ethiopian National Traditional Medicine Preparation and Therapy Association
EORC	Essential Oils Research Centre
ESTC	Ethiopian Science and Technology Commission
ETH	National Herbarium
ETMPA	Ethiopian Traditional Medical Practitioners Association
EWCO	Ethiopian Wild Life Conservation Organization
FAO	Food and Agricultural Organization of the United Nations
IBC	Institute of Biodiversity Conservation
ICF	Informant Consensus Factor
ITPGR	International Treaty on Plant Genetic Resources for Food and Agriculture
MIC	Minimum Inhibitory Concentration

MIDROC	Mohammed International Development Research and Organization Companies
NMSA	National Meteorological Services Agency
OAU	Organization of African Unity
OBARD	Oromiya Bureau of Agricultural and Rural Development
SNNP	Southern Nations, Nationalities and Peoples
TRIPS	Trade-Related Intellectual Property Rights
UGhent	Ghent University
UNCED	United Nations Conference on Environment and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar
WBISPP	Woody Biomass Inventory and Strategic Planning Project
WHO	World Health Organization

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Understanding diversity, distribution and extent of use of plants in a country is a basis for designing and implementing a sound resource management and utilization system in a sustainable manner (Han *et al.,* 2011). Although natural forests play important roles in providing a number of services (sources of wood, food, medicine, energy) and many other uses, they are fast-declining due to excessive anthropogenic influences (Dhillion *et al*., 2003). Deforestation and habitat fragmentation that arise largely due to the conversion of forests to other agricultural land-use types, and over-utilization of forest resources to satisfy the timber, food, medicine and energy requirements of the ever-increasing human population are mentioned as major challenges to global forest resources (FAO, 2010a).

The scenario is the same in Ethiopia where the country's high forest cover declined from 16% of the total land area in the 1950s which went down to 3% in later years (EEPFE, 2008). This scorching forest-loss is one of the major factors for environmental changes and large-scale soil degradation and/or erosion in Ethiopia, contributing to the recurrent drought and famine (EFAP, 1994). Deforestation also caused the loss of a number of traditional medicinal plants on which many people in the country rely for primary healthcare services for millennia (Dawit Abebe and Ahadu Ayehu, 1993). Thus, it is a timely endeavour to run against time so as to fully-investigate the country's flora, goods and services accessed from it, and the people's traditional knowledge associated to plant uses.

Although different floristic inventories were carried out in different parts of Ethiopia such as those by Hailu Sharew (1982), Sebsebe Demissew (1988), Zerihun Woldu *et al*. (1989), Tamrat Bekele (1993), Demel Teketay and Tamrat Bekele (1995), Kumlachew Yeshitela and Tamrat Bekele (2002), Feyera Senbeta and Demel Teketay (2003), Abate Ayalew *et al*. (2006), Ermias Lulekal *et al*. (2008b), Haile Yineger *et al*. (2008c), Abreham Assefa *et al*. (2013), etc., the country's overall floristic composition study is yet to be completed. The Dense Forest in Ankober District has never been scientifically explored for its plant diversity and thus it was targeted for investigation in this research.

Knowledge on plant use is the result of many years of human interaction with and selection of the most desirable plants present in the immediate environment at a given time (Rindos, 1984). More-specifically, the need for the well-being of a society is the ultimate driver of millennia-old interaction with and selection of the most successful medicinal plants. This has resulted in a wealth of indigenous knowledge associated with the utilization of curative plants. Traditional knowledge on plant use will be lost in the absence of continuous cultural interaction (Winter and McClatchey, 2008). Demographic, economic, socio-political, ecological, religious and cultural entities co-existing in a community are key drivers of traditional knowledge development in a given community (Cetinkaya, 2009).

Cultural acceptability, accessibility, affordability and perceived efficacy factors related to age-old use of traditional medicinal plants are factors behind the continuous use of plant remedies by many people (Jin-Ming *et al*., 2003). Traditional plant remedies are still the most important sources of therapeutics for nearly 80% of the people in the developing world (WHO, 2008). The same is true in Ethiopia where medicinal plants play a significant role in supporting the country's primary healthcare system (Dawit Abebe and Ahadu Ayehu, 1993; Mander *et al*., 2006). About 95% of traditional medicine preparations in Ethiopia are said to be of plant origin (Sebsebe Demissew and Ermias Dagne, 2001). The deep-rooted culture of using medicinal plants in the country led the people to be acquainted with knowledge of medicinal properties of many plants used in treating numerous ailments (Dawit Abebe, 2001).

Ethiopian traditional medicine also plays a significant role in addressing veterinary ailments affecting the country's livestock population (ranked among the highest ten livestock rich countries in the world) (FAOstat, 2011). In this country, ethnoveterinary practices were reported to be the only options to cure livestock ailments till the advent of modern veterinary service which only started as late as 1908 (Berhanu Admassu, 2011). Although income from livestock in the country is directly related to safeguarding the later's health, the conventional veterinary medical system is still very poor in Ethiopia (Fekadu Fullas, 2010). Dawit Abebe (1986) stated that traditional plant remedies are major sources of therapeutics for nearly 90% of the livestock population in the country.

Although ancient medico-religious pharmacopoeias of Ethiopian medicinal plants written on parchments in the classical Geez language (now only the working language in the Ethiopian Orthodox Tewahdo Church) had documented part of the indigenous knowledge on utilization of medicinal plants for treating human and livestock ailments, most of these documents were lost due to damage, theft and illegal selling to foreign collectors (Fassil Kibebew, 2001). The country's plant lore has also received a lot of attention from many foreign travellers as evidenced by Pearce (1831), Cecchi (1886), Griaule (1928) and Ganora (1929) who documented Ethiopian medicinal plants known from the then medico-religious writings.

Although medicinal plants play a significant role in supporting primary healthcare system in Ethiopia, only a limited attempt has been made to scientifically explore, document and promote the widely used medicinal plants and associated knowledge in the country. Scientific investigation of millennia-old community knowledge on plant use, which is not static and hence is in a state of change due to the impact of modernization, is crucial to define cultural identities of a particular community and understand links to their history, land and plant use practices and traditional environmental philosophy (Cetinkaya, 2009). In addition, it helps to design people-centred natural resource management practices which are important for biodiversity conservation (Lynam *et al.*, 2007). Moreover, documentation on traditionally useful plant species contributes much to attain target two of the revised Global Strategy for Plant Conservation (GSPC) (2011–2020), i.e. developing a preliminary assessment of all known plant species to guide conservation action (Sharrock, 2011).

Targeted investigation, particularly on indigenous knowledge of people related to traditionally used medicinal plants, can serve as a basis for the discovery of new lead compounds for use in the development of new or alternative modern drugs (Cos *et al.*, 2006). The global emergence of drug-resistant microbes made scientists to look for solutions from millennia-old ethnomedicinal knowledge of indigenous people. Theuretzbacher (2012) explained that the ever-increasing threat from drug-resistant microbes calls for a global effort to search for novel solutions based on natural products from plants selected on the basis of documented ethnomedicinal uses. Thus, it is important to run as many ethnomedicinal researches as possible to address the unexplored useful knowledge on medicinal plants held among diverse ethnolinguistic groups, and subsequently run focused bioactivity-testing on plants most-agreed for their curative role (Verpoorte *et al.*, 2005).

In Ethiopia, the knowledge on traditional medicinal plants which was developed for millennia is now subjected to loss since it has mainly been stored in the memories of elderly persons and handed down mostly by word of mouth, which is prone to loss at each point of transfer

(Dawit Abebe, 2001). Moreover, deforestation, overexploitation, overgrazing, habitat loss and degradation, agricultural land expansion and acculturation continuously threaten Ethiopian traditional medicinal plants and linked knowledge (Zemede Asfaw, 2001). Hence it is a timely endeavour to investigate, document and analyze traditional knowledge on medicinal plants, associated knowledge drivers, and the reservoirs of curative plants which are typically the remnant natural forests. Such research provides the opportunity for recognition, promotion, management and protection of indigenous knowledge of a community on medicinal plants as vital part of a nation's heritage, further to calling policy makers, natural resource managers, other stakeholders and cultural practitioners for conservation actions.

Recent publications on Ethiopian medicinal plants including those by Teshale Sori *et al*. (2004), Gemedo Dalle *et al*. (2005), Tigist Wondimu *et al*. (2006), Mirutse Giday *et al*. (2007), Haile Yineger *et al*. (2007), Ermias Lulekal *et al*. (2008a), Teferi Flatie *et al*. (2009), Mirutse Giday *et al*. (2010), Nasir Tajure Wabe *et al*. (2011), Girmay Zenebe (2012) and Ketema Tolossa *et al*. (2013) addressed traditional uses of medicinal plants and associated knowledge in some particular cultural groups but are insignificant when compared to the occurence of 84 different ethnic groups (Alem Habtu, 2003) in the country, most of them largely ethnomedicinally unexplored. Hence, the present research aims to fill this gap by documenting the wealth of indigenous knowledge and understanding the corresponding drivers of this knowledge related to utilization, management and conservation of medicinal plants used to treat human and livestock ailments in Ankober District, North Shewa Zone of Amhara Region, Ethiopia which has never been explored for its ethnomedicinal wealth.

Plant species in Dense Forest and the millennia-old ethnomedicinal wisdom of the community in Ankober District along with traditional medicinal plants used to treat various ailments for generations are subjected to loss due to anthropogenic and environmental threats, without being scientifically documented. Hence, this study aims at providing a comprehensive documentation and analysis of plant diversity in Dense Forest along with the ethnobotanical knowledge associated with the medicinal plants used by the people in Ankober District in order to preserve the declining resources and plant use knowledge in the area. It also aims to document the wealth of indigenous knowledge on overall use patterns and use diversity of plants known for one or more medicinal uses so as to understand conservation challenges posed on multipurpose medicinal species of the area. The work also intends to identify and document marketable traditional medicinal plants of the District. Furthermore, it investigates the antimicrobial effect of medicinal plants which are regularly used by the local people to treat infectious diseases and thereby select candidate species based on informants' consensus and fidelity level values, and carry out antimicrobial activity tests on most-preferred species. This research also integrates both floristic and medicinal plant composition study of the Dense Forest located in Ankober District so as to identify status and distribution of medicinal plants within the natural forest of the study area.

1.2. Research questions, hypotheses and objectives

1.2.1. Research questions

The following were the main research questions identified for in-depth investigation:

- What type of plant communities exist in Dense Forest in Ankober District?
- What are the traditional medicinal plants used by people in Ankober District to treat human and/or livestock ailments?
- Are there medicinal plants in Dense Forest? If yes, what is their status and distribution across plant communities?

- How do community members use traditional medicinal plants to treat ailments? Are traditional medicinal plants harvested for uses other than their medicinal role?
- How is traditional medicinal knowledge transferred among different classes of community members? What major socio-economic and cultural factors affect this traditional knowledge in the study area?
- Which of the medicinal plants used in Ankober District are best-agreed by community members on their efficacy to treat particular human or livestock ailments?
- Do traditional medicinal plants with high informants' consensus and fidelity level values show positive results when subjected to activity tests against microbial agents causing infectious diseases?
- Which of the medicinal plants used in Ankober District are available in the District's local markets? And what is their economic value for local people in the area?
- What are the main threats to medicinal plants and associated indigenous knowledge in the area? Are there local conservation practices?

1.2.2. Research hypotheses

- Natural forests have high species diversity, and are reservoirs of traditional medicinal plants;
- People of Ankober District are custodians of traditional knowledge on use and mangement of medicinal plants that they use for the treatment of human and livestock ailments;

- Dense Forest is the major source of traditional medicinal plants for people in the District;

- Traditional knowledge on use of medicinal plants varies based on social characteristics and experience of community members; and

- Traditional medicinal plants with highest informants' consensus and fidelity levels on their local uses against infectious diseases are best candidates for possible use as antimicrobial agents .

1.2.3. Research Objectives

General objective

This research is aimed at documenting and analysing plant diversity of Dense Forest, along with traditional medicinal plants and the associated local knowledge of the people in Ankober District, North Shewa Zone of Amhara Region, Ethiopia.

Specific objectives

The specific objectives of the research were to:

- Identify plant species composition and community types in Dense Forest;

- Identify availability and assess distribution of traditional medicinal plants among identified community types in Dense Forest;

- Assess and record local information on types of traditional medicinal plants used to treat human and livestock ailments;

- Document information on medicinal plant parts used, modes of remedy preparation, routes of remedy administration and dosages;

- Collect, determine and prepare an authenticated list of medicinal plants used in the area;
- Determine the effect of gender, age, literacy level or experience in traditional medicinal plant knowledge of the people;
- Determine degree of efficacy and relative healing potential of traditional medicinal plants used in the area;
- Assess marketability of medicinal plants of the study area;
- Investigate antimicrobial activity of most-preferred traditional medicinal plants selected based on the degree of informants' consensus and fidelity level values;
- Identify major threats to and local conservation practices of medicinal plant species of the study site; and
- Contribute to the efforts in building ethnobotanical database of the medicinal plants of Ethiopia.

1.2.4. Structure of the thesis

This thesis is organized in five main chapters. The first chapter starts with a general introduction encompassing brief background about the subject of investigation followed by research questions, hypotheses and objectives. Review of relevant literature makes up the second chapter. The third chapter is the materials and methods section which begins with description of the study area and continues with an in-depth presentation of research methods used in this research. Chapter four presents the results from field and laboratory researches which were published in or have been submitted to internationally peer-reviewed scientific journals. The fifth chapter deals with discussion of each result with its respective subsections, and the general conclusion and recommendation parts. Major articles published during the course of this PhD work are listed below:

1. Ermias Lulekal, Zemede Asfaw, Ensermu Kelbessa, Patrick Van Damme (2013). Ethnomedicinal study of plants used for human ailments in Ankober District, North Shewa Zone, Amhara Region, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2013, 9:63 doi:10.1186/1746-4269-9-63.
2. Ermias Lulekal, Zemede Asfaw, Ensermu Kelbessa, Patrick Van Damme (2014). Ethnoveterinary plants of Ankober District, North Shewa Zone, Amhara Region, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2014, 10:21 doi:10.1186/1746-4269-10-21.
3. E. Lulekal, J. Rondevaldova, E. Bernaskova, J. Cepkova, Z. Asfaw, E. Kelbessa, L. Kokoska, and P. Van Damme (2013). Antimicrobial activity of traditional medicinal plants from Ankober District, North Shewa Zone, Amhara Region, Ethiopia. *Pharmaceutical Biology*, Early online 1-7. DOI: 10.3109/13880209.2013.858362.

The following two articles are also in preparation:

4. Ermias Lulekal, Zemede Asfaw, Ensermu Kelbessa, Patrick Van Damme (2014). Floristic composition and vegetation structure of Dense Forest, Ankober District, North Shewa Zone, Amhara Region, Ethiopia. *Tropical Ecology* (In preparation)
5. Ermias Lulekal, Zemede Asfaw, Ensermu Kelbessa, Patrick Van Damme (2014). Use diversity of plants in Ankober District, North Shewa Zone, Amhara Region, Ethiopia. *Biodiversity Conservation* (In preparation)

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Overview of Ethiopian vegetation

Ethiopia ranges in altitude from the highest peak (Ras Dejen, 4,533 m a.s.l.) (http://simienpark.org/?page_id=57) down to the depression of the Kobat sink (Afar depression about 110 m below sea level) (EFAP, 1994). Extensive highland plateaux, with an altitude of over 2,500 m a.s.l., cover 40% of the country (Zerihun Woldu, 1999). The great African Rift Valley runs from north to south bisecting the plateaux, and in conjunction with the surrounding lowlands, this feature isolates and separates Ethiopian plateaux from other parts of the continent. The varied topography, the rift valley and the surrounding lowlands have given Ethiopia a wide spectrum of habitats, and a large number of endemic plants and animals (EFAP, 1994; Demel Teketay, 1999; Zerihun Woldu, 1999).

Attempts to describe plant diversity and vegetation types of Ethiopia by various authors including Pichi-Sermolli (1957), Hedberg (1951;1978) and White (1983) made a considerable contribution towards understanding the country's vegetation. The oldest overall survey of the vegetation of Ethiopia made by Pichi-Sermolli (1957), recognized 24 vegetation types (for the Horn of Africa, 22 of which occur in Ethiopia), laid the foundation for systematic studies of the vegetation and environmental factors in Ethiopia (Zerihun Woldu, 1999). Studies made by Friis *et al.* (1982), Hailu Sharew (1982), Sebsebe Demissew (1988), Zerihun Woldu *et al*. (1989), Zerihun Woldu and Mesfin Tadesse (1990), Tamrat Bekele (1993), Tesfaye Awas *et al*. (2001), Kumlachew Yeshitela and Tamrat Bekele (2002) represent some of the main vegetation surveys in different parts of Ethiopia aimed at describing community types and their relationship with some natural and anthropogenic features.

Friis *et al*. (2011) described twelve major vegetation types in the present Atlas of the potential vegetation of Ethiopia. These vegetation types are: desert and semi-desert scrubland; *Acacia-Commiphora* woodland and wooded grassland of the Rift valley; wooded grassland of the western Gambella Region; *Combretum–Terminalia* woodland and wooded grassland; dry evergreen Afromontane forest and grassland complex; moist evergreen Afromontane forest; transitional rainforest; ericaceous belt; Afroalpine vegetation; riverine vegetation; freshwater lakes (including lake shores, marshes, swamps and floodplain vegetation) and salt water lakes (including lake shores, salt marshes and pan vegetation).

2.2. Status of forests in Ethiopia

According to Friis (1986), even though it is difficult to establish the precise cover of the past as well as the present forest vegetation in Ethiopia, it is believed that a substantial portion of the land area in the highlands of Ethiopia was covered with forests having wider coverage than at present. The presence of a number of isolated large-sized trees, even on farmlands, or patches of forests around churchyards and religious burial grounds in this country indicate the occurrence of vast expanses of earlier forests (Tamrat Bekele, 1993). About 35% of the land cover of Ethiopia consisted of high forests before human settlement took place and if savannah woodlands are included, about 66% of the country's total area was covered with forests (EFAP, 1994). By the early 1950s, high forests had been reduced to 16% of the total land area. Forests in the entire country then went to decline at a faster rate and had dwindled to 3.6% by 1980, and 2.6% by 1987 (EEPFE, 2008). The present estimate shows only about 3% of the total land area of Ethiopia is covered with high forests (EEPFE, 2008; WBISPP, 2004; cited in FAO, 2010b).

In Ethiopia, excessive exploitation of natural forests without a minimum repair effort, the extension of cultivation to marginal lands by clearing and burning fragile ecosystems, forest fires, lack of proper forest management, lack of compatible forest legislations, lack of constant and sustainable institutional organization have all resulted in almost total deforestation that led to the highest magnitude of soil erosion, exposing the country to drought and famine (EFAP, 1994). According to FAO (2010b), the annual rate of deforestation in Ethiopia between 1990 and 2010 was estimated at 141,000 ha/year. The fast rate of deforestation in this country has seriously exposed the fertile soil to the highest magnitude of erosion (EFAP, 1994).

Depletion of vegetation by anthropogenic and natural factors has also led to the decline in number and area of distribution of many plant species. About 120 threatened plant species that are in Ethiopia are documented in the work of Ensermu Kelbessa *et al.* (1992), indicating effects of natural factors and human interference on the country's vegetation. A number of medicinally useful plants and the associated indigenous knowledge are also subjected to erosion whenever there is vegetation destruction (Hamilton, 2003). Reversing long-existing trend of deforestation might be possible (though it takes a lot of time) as long as appropriate measures are taken by the concerned governmental sector and the people as a whole.

2.3. History of botanical explorations in Ankober District

Ankober District is listed among the earliest places in Eastern Africa visited by early European explorers and plant collectors during the time when Eastern Africa was known only from scraps of floristic investigations. The famous Italian explorer and naturalist called Orazio Antinori (1811-1882) was among the first to make botanical explorations, aimed at searching for 'green-gold', in Ankober District (Baldini, 2011). He was accompanied by other Italian explorers named Giovanni Chiarini, Sebastiano Martini, Odoardo Beccari, Antonio Cecchi, Leopoldo Traversi, Vicenzo Ragazzi and other members of the Italian Geographical Society (Bompiani, 1891; Gippoliti, 2005). These naturalists recieved warm welcome from Emperor Menelik II (1844-1913) of Ethiopia. Bompiani (1891) stated that '*...Four hundred horsemen came out to meet the mission led by Orazio Antinori, preceded by fantastic music. An immense crowd of people gathered to witness this triumphal entry. King Menelik II surrounded by his princes and Monsingor Massaia, the bishop, recieved them.*'

These Italian explorers were granted a station by Emperor Menelik II at Let Marefia Kebele of Ankober District in December 1876 (Bompiani, 1891). The station was 96 hectares and served as a permanent base for the Italian Geographical Society till 1895 to carry on expeditions in Ethiopia. Orazio Antinoris' note about major plant and animal diversity of Ankober District states that '... *It is there a perpetual spring the roses and jasmines, the acacias and mimosas, the bananas, cotton plants, sugar-canes, and lemons, the grain, lentils, beans and peas, the mint and sage, the wild olives and monstrous sycamores ; the monkeys, with silvery white tales and black coats ; the birds, with green bodies and red wings, or yellow bodies and black heads, are all charming...'* (Bompiani, 1891).

Antinori and his companions were busy in studying the flora, fauna and geology of Let Marefiya area too. Bompiani (1891) noted that '*...the explorers studied the animals, plants, insects, soil, people of the land and soon collected specimens that filled thirty cases, all specimen were taken to Italy when Sebastiano Martini returned to Italy...*'. Orazio Antinori kept his explorations in Ankober District for long and died at Let Marefia in 1882. His graveyard is still kept as a tourist attraction site at Let Marefia Kebele, and serves as a historical symbol of early botanical exploration in the District.

The other notable European explorer who visited Ankober District was Nicolay Ivanovich Vavilov (1887-1943). He made botanical exploration in Ankober District in 1927 (Vavilov, 1997). Vavilov was assisted by 14 men armed with rifles and light spears and using 12 mules as a means of transport in Ankober. He noted that the exploration was a kind of interesting investigation in a major agricultural region in the country (Vavilov, 1997).

Vavilov stated that *'We were in Ankober, one of the former capitals of the country. Ankober is situated at an elevation of 2700 meters.... A few hundred low houses, solidly constructed of stone, hugged the ground ... I was well-received there, forage and flat cakes made of teff and wheat appeared, together with pitchers of 'TELA', an Abyssinian bear made of barley; and small pitchers of 'TEJ', a remarkable beverage made of honey...*(Vavilov, 1997). His note explains historical aspect of the area, as well as hospitality of indigenous people in Ankober which is still maintained for generations.

Vavilov also noted major crops and other plants he encountered in the area. He stated that *'In interior Abyssinia, there are enormous crops of Abyssinian teff (Eragrostis tef (Zucc.) Trotter); interesting peculiar and variable wheat in unbelievable mixture of forms; and mixed crops of barley, including black naked ones not known elsewhere in the world. There are large quantities of peculiar local Abyssinian forms of chick peas and vetches. Large bushes, lentils and peas. Large bushes of wild castor bean plants (Ricinus communis L.) usually grow along fences. There are also peculiar cabbages and wild mustard (Brassica carinata A. Braun), producing a large quantity of seeds but at the same time used for the leaves. Emmer wheat is also abundant* (Vavilov, 1997).

Although these historical backgrounds depict early botanical explorations made by European explorers to investigate both floral and faunal diversity of Ankober District, there is neither an overall scientific study on vegetation of Ankober nor any form of ethnobotanical investigation so far. Hence, this research serves to address this gap through an integrated plant diversity study of the Dense Forest and plant use knowledge of the people in Ankober District.

2.4. Indigenous plant use exploration and the science of ethnobotany

The reliance of humans on plants to fulfil their basic needs began since time immemorial. The millennia-old reciprocal relationship between plants and local people for diverse life activities resulted in rich and nuanced botanical traditions (Voeks, 2011). Formal documentation of indigenous plant uses started with the expedition of European explorers, in search of 'green gold', to lands occupied by indigenous people (Cotton, 1996). Such expeditions were icebreakers to encounter important plant use knowledge, followed by the subsequent transfer of useful species and their associated use knowledge to different countries (Mann, 2011).

According to Voeks (2011), the world we live in today biologically, economically, and culturally, is a living legacy of earlier plant and associated knowledge discoveries, and transfers. For example, discovery of tobacco (*Nicotiana* spp.- Solanaceae) from Cuba, tea (*Camellia sinensis* (L.) Kuntze - Theaceae) from China, coffee (*Coffea arabica* L.- Rubiaceae) from Ethiopia, and their subsequent transfer to Europe and other countries initiated more interest in the study of native plant uses (Hobhouse, 1992). Thus, the benefits obtained from earlier plant use discoveries and transfers triggered many scholars worldwide to take part in indigenous plant use explorations, that paved the way to the start of the then 'aboriginal botany' as an academic discipline (Cotton, 1996).

It was in 1873 that an American botanist called Steven Powers coined the term 'aboriginal botany' for the first time to describe the study of all forms of traditional uses of plants by aborigines for medicine, food, textile fabrics, etc. (Castetter, 1944). The phrase 'aboriginal botany' had been in use by the academic community for more than 20 years to describe studies related to indigenous plant uses (Cotton, 1996). It was in 1895 that the term ethnobotany was coined for the first time by Dr. Harshberger, a botanist/anthropologist at the University of Pennsylvania, to describe aboriginal people's use of items of food, dress, household utensils, and agricultural tools of plant origin (Cotton, 1996).

Many scholars who got involved in indigenous plant use exploration gave different elucidations on the subject of ethnobotany since Harshberger's coining of the term. As an academic discipline, it was in 1900 that the first doctoral dissertation in ethnobotany, ‘The ethnobotany of the Coahuilla Indians of Southern California’, was written by David Barrows at the University of Chicago (Cotton, 1996). The widely recognised definition of the subject, coined by Martin late in 1995, states that "ethnobotany refers to all studies (concerning plants) which describe local peoples interaction with the natural environment" (Martin, 1995).

The principal objective of all ethnobotanical studies involves documenting, analyzing and disseminating knowledge on the interaction between people and plants (Martin, 1995). Ethnobotanical investigation explores not only how a specific group of people uses plants but also how that group perceives them, how it interprets these perceptions, how these perceptions influence the activities of members of that society, and how these activities influence the ambient vegetation and the ecosystem on which the society depends (Hamilton *et al.*, 2003). Moreover, the scope of ethnobotany extends to investigate the degree to which local peoples knowledge promotes or undermines resource conservation and contributes to the solution of global challenges, such as community health, nutrition, and cultural heritage (Vandebroek *et al*., 2011).

Generally, the cornerstones for any ethnobotanical research are traditional knowledge and plant diversity (Ford, 1994; Thomas, 2008). However, both traditional knowledge and plant diversity are being lost at an alarming rate by apparently inevitable forces such as economic globalization, climate change, habitat destruction and 'human progress' (Hamilton, 2003). Thus, research in ethnobotany has to run against time by all possible means to identify problems, and search for solutions so as to save the fast-eroding resources of the subject. This indeed makes ethnobotany 'a science in struggle with time' (Thomas, 2008).

2.5. Ethnobotanical researches and their applications

Many early researches in ethnobotany, as some still are today, were largely or entirely descriptive, being concerned essentially with documenting local names and plant uses (Cunningham, 1997). In recent years, ethnobotany has tended to become more analytical, quantitative, cross-disciplinary and applied (Höft *et al*., 1999). The scientific rigour of ethnobotanical research has increased dramatically due to the adoption of quantitative methods (Alexiades, 2003). Nowadays, integrating qualitative and quantitative approaches is becoming very popular and considered a good indicator of modern ethnobotanical research.

One of the applications of ethnobotany is its functional role in conservation and sustainable development activities. According to Hamilton *et al*. (2003), ethnobotanical research allows the knowledge, wisdom and practices of local people to play fuller roles in identifying and searching for solutions to their own problems of conservation and sustainable development. In addition, involvement of local people in scientific investigation creates a better chance of ‘buy-in’ or sense of ownership to develop with every activity that gears towards conservation and sustainable development.

The other, more applauded application of ethnobotany in recent years is its potential to provide preliminary information for further screening and extraction of bioactive chemicals and lead compounds from plants (Cos *et al*., 2006). The assumption here is that careful integration of ethnobotanical research on medicinal plants with other disciplines such as pharmacology would lead to successful development of pharmaceutical products (Tsekpo, 1997). The developments of useful drugs for instance like aspirin from meadowsweet (*Filipendula ulmaria* (L.) Maxim. - Rosaceae), reserpin from snakeroot (*Rauvolfia serpentina* Benth. ex Kurz - Apocynaceae), and quinine from cinchona tree (*Cinchona pubescens* Vahl - Rubiaceae) all started from ethnobotanical information (Cox and Balick, 1994). Ethiopian medicinal plants have also been reported as source of modern drugs for example; bioactive compounds of four multipurpose traditionally used medicinal plants of Ethiopia namely, *Hagenia abyssinica, Ruta chalepensis, Glinus lotoides* and *Millettia ferruginea* are extracted by (and patented to) a researcher in Tennessee (USA) for their use in treating breast cancer, leukemia, melanoma, and myeloma or viral infection, diabetes, Parkinson's disease, tuberculosis, and fungal infections (McGown, 2006). Through ethnobotanical surveys marketable and economically useful non–timber forest products can also be thoroughly investigated and hence be used as alternative sources of income on a larger scale (Balick and Cox, 1996; Subedi *et al*., 2013).

The science of ethnobotany has also become useful in identification and application of sustainable harvesting methods of non-timber forest products, promotion of ecotourism and biodiversity prospecting. Moreover, it plays a role in development of new drugs and optimization of mixed remedies as formulated dosage forms, development of plant propagation techniques and marketing of local products in given communities (Hamilton *et al.*, 2003). Generally, beside documenting, analyzing and disseminating knowledge on the interaction of plants and human society, ethnobotanical studies are useful sources of information on healthcare, conservation of local plant resources, indigenous knowledge, culture and development of new plant products (Hamilton *et al*., 2003).

2.6. Indigenous knowledge, traditional medicinal plants and healthcare

2.6.1. Indigenous knowledge

The term indigenous knowledge stands for the unique traditional or local knowledge existing within, and developed around the specific conditions of men and women indigenous to a particular geographic area (Grenier, 1998). This knowledge includes rules, standards, skills and mental sets, which are possessed by local people in a specific geographic area (Quanash, 1988). According to Martin (1995), indigenous knowledge is a result of many generations long years of experiences, careful observations, and trial and error experiments. This knowledge helps people to adapt and survive challenges from their environment. According to Hareya Fassil (2003), development efforts which 'build on indigenous knowledge', would result in a more self-reliant pattern of development, one that is more harmonious with people's needs and preferences, more congruent with available resources, more dependable, as well as more economical.

One of the widely used indigenous knowledge systems in many countries is the knowledge on and application of traditional medicinal plants. Such knowledge, known as ethnomedicinal knowledge involves traditional diagnosis, collection of raw materials, preparation of the remedies and their prescription to patients (Farnsworth, 1994). In ethnomedicinal studies, such as the present work, terms like 'indigenous', 'traditional', 'local' or 'cultural' knowledge are used synonymously (Cotton, 1996) to discern the fundamental bodies of knowledge pertaining to health and systems of therapy which existed prior to the introduction of 'modern', 'allopathic' or 'Western' medicine to a particular area.

Indigenous knowledge on plant remedies in many countries, including Ethiopia, passes from one generation to the other verbally with great secrecy (Jansen, 1981). Such crude and secrete transfer makes indigenous knowledge or ethnomedicinal knowledge vulnerable to distortion. In most cases, some of the lore is lost at each point of transfer (Amare Getahun, 1976). Hence, there is a need for systematic understanding, documentation and promotion of such useful knowledge through ethnobotanical research.

2.6.2. Traditional medicinal plants and healthcare

2.6.2.1. A historical overview of the use of traditional medicinal plants

The World Health Organization (WHO) defined traditional medicine as " the sum total of all the knowledge and practices, whether explicable or not, used in diagnosis, prevention and elimination of physical, mental or social imbalance and relying exclusively on practical experience and observation handed down from generation to generation, whether verbally or in writing" (WHO, 1976). It also refers to traditional medicine as 'a local health treatment system which existed long before the arrival of 'modern' or 'Western' medicine' (WHO, 1996). Plants used for treatment of ailments through the traditional medicine system are referred to as traditional medicinal plants (WHO, 1996).

Human wisdom in medicinal plant use is the result of a millennia-old fight against deadly diseases instinctively and/or trial and error experiments to cure oneself using therapeutic plants (Petrovska, 2012). According to Stojanoski (1999), early humans did not have sufficient information about the probable causes of illnesses or the corresponding medicinal plant which would be used to cure diseases. Hence, it would seem that therapeutic knowledge using plants may have developed through coincidence. Some paleontological evidence allows us to hypothesise that medicinal plants were in use by Neanderthal humans 60,000 years ago, i.e. during the Middle Palaeolithic age (Solecki, 1975).

According to Jin-Ming and co-investigators (2003), the oldest pharmacopeia estimated to be as old as 4,600 years, is the one found on a Sumerian clay slab from Mesopotamia. The document was mentioned to comprise 12 recipes of traditional drug preparation referring to over 250 medicinal plants (Kelly, 2009). Another early document on the use of medicinal plants is *'Pen TS'ao'* which was written by the legendary Emperor Shen Nung of China around 2,500 BC (Cotton, 1996). *'Pen TS'ao'* listed about 366 medicinal plant remedies some of which, such as ginseng (*Panax ginseng* C. A. Meyer - Araliaceae) and *ephedra* (Jointfir), (*Ephedra sinica* Stapf - Ephedraceae) are still in use for therapeutic purposes. Ancient Egyptian pharmacopeia, the *'Ebers Papyrus'*, which dates back to 1,550 BC was also found with lists and application methods of more than 700 traditional plant remedies including opium (*Papaver somniferum* L. – Papaveraceae), garlic (*Allium sativum* - *Alliaceae*) and castor bean plant (*Ricinus communis* - Euphorbiaceae) (Gurib-Fakim, 2006). The Holy Bible also documented a number of traditional medicinal plants used in earlier times (Duke *et al*., 2008).

Hippocrates (460-370 BC) who is also known as 'the father of Western medicine' had also documented 300 different medicinal plants and their corresponding therapeutic roles. He reported the use of centaury (*Centaurium umbellatum* Gilib - Gentianaceae) against fever, *Allium sativum* against intestinal parasites and as diuretics, and *Papaver somniferum* as narcotic (Petrovska, 2012). Classification and use of more than 500 medicinal plants was also found noted on '*De Causis Plantarium*' and '*De Historia Plantarium*' written by Theophrastus (371-287 BC). The book *'De re medica'* written by Celsus (25 BC-50 AD) also comprised the remedial uses of about 250 medicinal plants (Kelly, 2009).

A marked contribution to the study of medicinal plants was made by the Greek physician Dioscorides (ca. 40-90 AD), 'the father of pharmacognosy'. His book, written in 77 AD, *'De Materia Medica'* was the first of its kind documenting on 944 drugs of which 657 were entirely of medicinal plant origin. In addition, Dioscorides described morphology, locality, mode of collection and preparation, local name as well as therapeutic effect of each medicinal plant in his book. Some of the medicinal plants mentioned in *'De Materia Medica'* such as camomile (*Matricaria chamomilla* L.- Asteraceae) and garlic (*Allium sativum*) are still in use for their curative role. Dioscorides's work remained as the standard medical reference in Europe until around the fourteenth century AD (Balick and Cox, 1996).

The book '*Historia naturalis*' by Pliny the Elder (23-79 AD) was also a notable reference documenting uses of about 1,000 medicinal plants (Kelly, 2009). Galen (131-200 AD), contributed to the study of medicinal plants by recording some more therapeutic plants and identifying medicinal drugs which have curative role (Petrovska, 2012). Charles the Great (742-814 AD), in his book '*Capitularies*', quoted around 100 different medicinal plants including sage (*Salvia officinalis* L. - Lamiaceae) and *Papaver somniferum* (Petrovska, 2012). Over 1,000 traditional medicinal plants used for treating a number of ailments were also found recorded in books entitled '*De Re Medica'* by Johannitus Mesue (850 AD), *'Canon Medicinae'* by Avicenna (980-1037 AD), and *'Liber Magnae Collectionis Simplicum Alimentorum Et Medicamentorum'* by Ibn Baitar (1197-1248) (Petrovska, 2012).

Other scholars quoted for contributing to the study of medicinal plants were Paracelsus (1493-1541 AD) and Jakob Boehme (1575-1624 AD), both known for their writings advocating a theory called the 'Doctrine of Signatures' (Kelly, 2009). The book by Jakob Boehme (1575-1624 AD) entitled '*Signatura Rerum*' stated that physical characteristics of plants provide a clue, or signature, which serves as an indication of their beneficial medicinal use. There were a number of proponents of the 'Doctrine of Signatures' theory who searched for and even used plant remedies based on the physical appearances of specific plant parts that matched the shapes of some human body parts.

Generally, as investigations and utilizations of traditional medicinal plants developed based on earlier experiences and written works of numerous contributors, the need for searching for more curative plants and their active components emerged (Gurib-Fakim, 2006). The early 19th century then got marked with discovery, substantiation, isolation and testing of bioactive principles from medicinal plants (which continued until present). This meant a turning point in the knowledge and use of medicinal plants, i.e. the beginning of a scientific pharmacy based on accumulated plant knowledge.

2.6.2.2. Role of traditional medicinal plants in contemporary healthcare practices

Nowadays, traditional medicinal plants have reached paramount importance in supporting primary healthcare systems in different countries, especially of developing nations. Jin-Ming and co-investigators (2003) stated that more than 35,000 species of higher plants are in use for traditional treatments worldwide. According to WHO (1996), an increasing number of nations, including China, India, and Mexico, have integrated traditional medicine into their primary healthcare systems. In most developing countries traditional healers are knowledgeable about identification and treatment of common diseases (Schultes, 1979). At the same time, they are also experienced traditional 'botanists' who have a great talent for locating the required curative plants from the green vastness that makes up their natural pharmacy. Hence, using their own indigenous knowledge on medicinal plant use to support primary healthcare practices is profitable (Schultes, 1979).

According to WHO (2008), about 80% of the developing world population relies on traditional plant remedies to meet its primary healthcare needs. The reliance on traditional medicinal plants in developing countries may relate to failure of governments to ensure provision of 'modern' health services at an affordable price to everyone, and especially to the most vulnerable groups in society (Dawit Abebe, 2001). According to Hamilton *et al*. (2003), high dependence on medicinal plants emanate not only from economic reasons but also from a high cultural acceptance which meets psychological needs of people, in most cases the modern ones cannot do.

The continued use of traditional medicine even in healthcare systems of developed nations, where modern medicine is fairly accessible, reflects efficacy, affordability and cultural acceptability of the traditional medical system (Jin-Ming *et al*., 2003). Demand for traditional medicinal plants in North America, Europe and Asia, has been reported to increase by 8 to 15% per year (Grünwald & Büttel, 1996). Developed countries such as the United Kingdom, Germany and Russia have their own well-developed and usable herbal pharmacopeia (Petrovska, 2012).

In 2005, it was reported that about 85% of allopathic doctors in Japan and 85% in Germany had prescribed traditional medicine to their patients (Elujoba *et al*., 2005). In the United Kingdom also almost 40% of all general allopathic practitioners offer some form of traditional medicine referral or access (Zollman and Vickers, 2000). About 48% of the population in Australia, 70% in Canada, 42% in the US, 38% in Belgium and 75% in France were reported to have used traditional medicinal plants at least once (Fisher and Ward, 1994; WHO, 1998; Health Canada, 2001). In China, the use of traditional medicinal plants accounts for about 40% of all healthcare services (WHO, 2001).

The role of traditional medicinal plants in modern healthcare services is best-amplified in countries which practice to integrate the two systems. The World Health Organisation (WHO) formulated a policy in 1978 about integration of traditional and modern healthcare systems, the central point of which states that 'it is only through the integration of the two systems that the motto ‘Health for all’ could be turned into a global reality as the majority of the world’s populations are too poor to afford modern medical services' (WHO, 2002).

Despite theoretical and methodological differences between traditional and modern healthcare services and expensive cost-implication of integrating both activities, success stories in integrating the two systems are reported from countries like China and Republic of Korea (Jin-Ming *et al*., 2003). For instance in China, a country where 7,300 medicinal plants are in use (Jin-Ming *et al*., 2003), over 30 universities and colleges have been established for standard traditional medicine training with a yearly enrolment rate of 37,000 students. Moreover, a total of 2,522 traditional medicine hospitals equipped with 353,373 staff and 236,060 beds have also been established to treat 200 million outpatients and almost 3 million in-patients annually. About 95% of Chinese general hospitals have traditional medicine departments, which treat about 20% outpatients on a day-to-day basis (WHO, 2001). Thus, it is a good indication for a sound contribution of traditional medicine to contemporary healthcare services, and indeed a good lesson for all other countries.

2.7. Traditional veterinary medicine

Treatment of animals with traditional medicinal plants is as old as 14,000 years, and probably started with treating domesticated dogs (McCorkle, 1986). A medico-religious document on early traditional veterinary practices of Egypt was found recorded on the *Kahun Papyrus* (ca. 1,900 BC) (Wanzala *et al*., 2005). Indian Sanskrit texts are also cited for documenting the earlier traditional veterinary practices of the period (1,800-1,200 BC) (Thrusfield, 1986; cited in Wanzala *et al*., 2005). Thus, historical accounts indicate that traditional veterinary medicine is an ancient practice that emerged with the domestication of animals.

The academic circle addresses traditional veterinary medicine with the term ethnoveterinary medicine, coined for the first time by Dr. Constance McCorkle in 1986. McCorkle defined ethnoveterinary medicine as local or indigenous knowledge and methods of caring for, healing and managing livestock (McCorkle, 1986). Although the evolution and development of ethnoveterinary medicine has lagged behind that of human healthcare (Wanzala *et al*., 2005), ethnoveterinary medicine and human ethnomedicine are complementary, rather than separate, fields treated under ethnobotany (Lans, 2001).

Pastoralists and many rural livestock herders are still surviving with a continued success in traditional livestock healthcare practices due to enduring nature of their ethnoveterinary knowledge (Adolph *et al*., 1996). For instance, present-day ethnoveterinary practices implemented by pastoralist communities such as the Maasai (living in Kenya and Tanzania), Turkana (in Kenya), Borana (in Ethiopia and Kenya), Somali (in Somalia, Ethiopia, Kenya and Djibouti), Karamajong (in Uganda) have all emanated from their ancestral traditions preserved and yet in use as a cultural heritage (Mathias-Mundy and McCorkle, 1989).

According to Letchamo and Craker (1996), more than 90% of the veterinary care in rural areas of developing countries is entirely based on the use of traditional medicinal plants.

Although ethnoveterinary medicine is an ancient practice, the recognition and scientific exploration of the subject is very recent, and basically triggered in the 1980s (Wanzala *et al*., 2005). According to the latter author, the boom of ethnoveterinary works since the 1980s may relate to the resolution adopted by the 30th World Health Assembly in 1977, urging interested governments to integrate their traditional systems of medicine into their formal national health delivery systems. Nowadays, the science of ethnoveterinary medicine has got wider attention in a number of countries serving as a tool for exploring untapped medicinal plant resources and associated knowledge for possible deployment in sustainable animal health management systems.

2.8. Ethnomedicine, activity testing of medicinal plants and drug development

In-depth ethnomedicinal studies are reported as keys serving as the basis for selection and subsequent evaluation of bioactive contents of traditional medicinal plants to the benefit of mankind (Cos *et al*., 2006). Savithramma and co-investigators (2012) reported that focused bioactivity testing on plants, backed by ethnomedicinal data, often leads to discovery of new lead compounds that can play a role in plant-based modern drug development. Cox and Balick (1994) also indicated that there is more probability of getting medicinally active principles from plants that had been selected based on ethnomedicinal inventories than when using just any form of random screening.

In contemporary ethnomedicinal studies, medicinal plants with the highest informant consensus and/or fidelity level values for efficacy are targets to bioactivity investigation

(Trotter *et al*., 1986). For instance, ethnomedicinal inventory based bioactivity testing of the Egyptian traditional medicinal species Bishop's flower, *Ammi majus* L. (Apiaceae) (used by indigenous people to treat skin complications) resulted in isolation of bioactive constituents and subsequent development of a drug *(b-methoxypsoralen*) which is effective in treating skin diseases (Gurib-Fakim, 2006). Isolation of the anti-malarial drug, quinine, from the bark of *Cinchona pubescens* Vahl (Rubiaceae) was also based on information on ethnomedicinal use of the bark of *Cinchona* species gathered from indigenous people in the Amazon region for treatment of fever (Jin-Ming *et al*., 2003). Ethnomedicinal use reports of Malabar Nut tree, *Adhatoda vasica* Nees (Acanthaceaeae) as antispasmodic remedy in India and Sri Lanka, led to isolation of an antispasmodic substance named vasicin (Gurib-Fakim, 2006).

Farnsworth and co-investigators (1985) indicated that among 119 different remedial compounds identified from 90 different plants, 77% (65 compounds) were obtained as a result of examining plants based on ethnomedicinal use reports, and eventually employed in a manner that approximates that use. According to Samuelsson (2004), a boom in activity testing of medicinal plants and isolation of active principles was triggered due to successful isolation of morphine from *Papaver somniferum* by Friedrich Serturner in 1806. In addition to serving as possible sources for new drugs, chemicals obtained from medicinal plants can also be used as models for new synthetic compounds. For instance, cocaine from the coca plant, *Erythroxylum coca* Lam. (Erythroxylaceae), served as model for the synthesis of the anaesthetic procaine (Fabricant and Farnsworth, 2001).

Nowadays, many institutions are widely involved in bioactivity-testing experiments starting from and backed by ethnomedicinal research outputs (Balunas and Kinghorn, 2005). The mid-1990 estimates on institutions involved in medicinal plant research showed that there were over 200 companies and research organizations worldwide working on screening of plants for medicinal properties (Jin-Ming *et al*., 2003). However, it has to be noted that bioactivity testing and subsequent drug discovery processes are expensive and time-taking. The whole process may take as long as 10 years (Reichert, 2003) while the approximate cost of the whole process is estimated to be more than 800 million dollars (Dickson and Gagnon, 2004). Hence, most developing countries are advised to focus on development of herbal extracts (crude or semi-purified) rather than to engage into modern drug development mainly due to economic reasons (Balunas and Kinghorn, 2005).

2.9. Economic value of medicinal plants

Medicinal plants have tremendous economic significance beside their role in healthcare provision of much of the world's population (Medhin Zewdu *et al*., 2001). These plants are commonly traded in various forms, i.e. fresh, dried, powdered and processed in and between different countries (Lange, 1998). According to Pierce and Laird (2003), the main actors involved in marketing channels of medicinal plants, from the forest or farm to final consumption, include collectors, petty traders, private agents, wholesale dealers and final consumers. However, due to the complexity of actors and companies involved in medicinal plants trade, and serious hesitation to share data by most small and medium-sized companies taking part in this trade, obtaining reliable data related to this trade is most difficult (Laird, 1999). The practice of hidden cross-trading of products between companies adds difficulty of understanding the trade (Dennis, 1998). Despite such difficulties, traces of information obtained on medicinal plants trade show their important economic value.

According to Srivastava (2000), in USA and Europe alone, medicinal plant trade has typically been growing at an average of 10% per annum, partly because of the popularity of alternative treatments and partly due to official recognition of the benefits of traditional medical systems involving herbal preparations. In 1976, imports of medicinal plants worldwide were estimated to be a total value of 355 million USD, and the value rose to 551 million USD by 1980s; an increase of over 60 percent in four years time (Lambert *et al.*, 1997). According to Laird and Pierce (2002), in 1999, the global revenue from medicinal plants trade reached 19.4 billion USD, with Europe in the lead (6.7 billion USD), followed by Asia (5.1 billion USD), North America (4.0 billion USD), Japan (2.2 billion USD) and the rest of the world (1.4 billion USD) (Laird and Pierce, 2002). Recent estimates on annual revenues generated from medicinal plant trade reaches 60 to 100 billion USD (Petrovska, 2012).

According to Lange (1998), about a quarter of the global trade in medicinal and aromatic plants is exported to Europe. In 1992-1996, imports to Europe came from more than 120 countries, with 60% of materials coming from outside Europe, mainly from Africa and Asia. Between 1985 and 1995, average annual growth rate in the European market was 10%, with 440,000 tons imported in 1996 valued at 1.3 billion USD (Lange, 1998). This is likely to have risen well above 500,000 tons (Srivastava, 2000) and even beyond now.

Germany is known as the leading European importer of medicinal plant products. The country's phytomedicinal market grew at 30% in the 1990s from an initial value of 2.5 billion USD to 3.2 billion USD (Lange, 1998). The most important source country to European medicinal and aromatic plants is Bulgaria, with an average net export of 7000 tons per annum over the 1990s (Lange, 1998). At the same time, Turkey provided about 28,000 tons of medicinal and aromatic plants generating nearly 50 million USD (Ozhatay *et al.*, 1998).

Although Africa has not taken significant advantage of its medicinal plant resources, reports indicate that some African countries have made considerable progress in the export of medicinal plants (Mander *et al*., 2006). Cameroon, for instance, is the major source of *Prunus africana* bark. A French-owned company based in southwest Cameroon, *Plantecam Medicam*, processed about 11,537 metric tons of the bark between 1985 and 1999. *Prunus africana* represents 86% of the medicinal plant materials exported by this company between 1985 and 1999 (Cunningham and Mbenkun, 1993). Capsules containing extracts of *Prunus africana* bark are marketed in Europe where the annual market value of this trade was estimated to be at 150 million USD per year in the 1990s (Medhin Zewdu *et al*., 2001). Other African countries, which export this bark, include Kenya (1,923 tons per year), Uganda (193 tons per year), Zaire (300 tons per year) and Madagascar 78-800 tons per year (Cunningham and Mbenkum, 1993). Egypt, Ghana, Republic of South Africa, Senegal, Sudan, Namibia, and Madagascar are also known in exporting different medicinal plants (Cunningham *et al*., 1992; Mander *et al*., 2006).

2.10. Threats to and conservation of medicinal plants and associated knowledge

Despite the global importance of traditional medicinal plants for health support, income generation and livelihood security, they are seldom handled within an organized regulated sector, and most are still exploited with little or no attention to the future (Hamilton, 2003). Apart from a dramatic decrease in native vegetation in many countries due to agricultural expansion, deforestation and urban-associated developments; the ever-increasing demand in the international market for medicinal plants has also resulted in a considerable threat on medicinally valuable plants (Cunningham, 1993). Collecting whole plant part, ring-barking, rooting-off, gathering floral parts and seeds which are all important for the survival of a plant, have placed a serious threat on a number of medicinal plants worldwide (Cunningham, 1996).

Reports on collection of medicinal plants evidence that the overwhelming majority of plant drugs used in traditional systems of medicine are derived from the wild. For instance, in China, a country where more than 7,300 medicinal plants are in use, annual demand for medicinal plants in the 1990s exceeded 700,000 tons, 80% of which were harvested from wild sources (Pen-gen, 1991). In Indonesia, a total of 1,260 species of medicinal plants are sold in markets, most of which are collected from forests (Siswoyo *et al*., 1994). In South Africa, between 400 and 500 species are commonly sold for traditional medicinal use, of which 99% are harvested from wild sources (http://www.tradeportalofindia.com/usrdata/). Such a pressure on wild sources is now a factor threatening a number of medicinal plants. In addition, it also threatens indigenous knowledge linked with wild plants. According to Hamilton *et al*. (2003), every year the sum-total of human knowledge about the types, distribution, ecology, useful properties and methods of management and extraction of medicinal plants is decreasing, and hence continued process of loss of cultural diversity is under way.

Nowadays, sustained and coordinated efforts are needed to transform the currently unsustainable practices of medicinal plant mining from wild sources to more ecologically sustainable, socially acceptable, and economically equitable production and utilization systems (Dhar *et al.*, 2000). In fact, such activity requires appropriate action, and changes by the full range of societies and stakeholders involved in the conservation, production, management, marketing, processing and use of medicinal plants and their derivatives. Since an action on conservation and sustainable use of medicinal plants needs involvement of various sectors and important public support, it needs a continuous emphasis on raising public awareness too (Hamilton, 2003).

Conserving medicinal plants *in situ* (in their natural habitat like nature reserves and parks) or *ex situ* (e.g. in fields, gene banks and botanic gardens) is practiced in different countries. For instance, countries like Sri Lanka have implemented a strong policy of *in situ* and *ex situ* conservation to save a number of valuable medicinal plants (De Silva and Wettasinghe, 2004). In India, reserves have been established across the country to protect medicinal plants, and by so doing the country ensures their sustainable supply (Balick, 1996). An average of approximately 200 species of medicinal plants are also reported to be cultivated in China each year (Lambert *et al*., 1997) to replace the depletion of the wild stock. In Thailand, a project for cultivation of medicinal plants of known efficacy has been initiated in about 1000 villages (Desawadi, 1991).

Modern and scientific management of natural forests for conservation and sustainable utilization of medicinal plants in their natural environment (*in situ* conservation) also needs attention. Protected or sustainably managed forests are useful in supplying a great number of medicinal plants that cannot be economically cultivated, require very specific habitats, are exceptionally difficult to reproduce in nurseries or greenhouses, are highly susceptible to pests and diseases, and vary greatly in their efficacy as plant drugs in relation to soils and microclimate conditions (Parrota, 2002). However, due to high current rates of forest loss and degradation, long-term demand for particular species (beyond the capacity of natural ecosystems to produce them on a sustainable basis), *ex situ* conservation and cultivation of selected medicinal species should also be promoted (Bodeker *et al*., 1997).

Generally, to bring an all-round conservation of medicinal plants, the following major activities need prime attention: *in situ* and *ex situ* conservation of medicinal plants; enhancement of cultivation efforts; improved management of wild populations; public awareness; monitoring of trade; national and international legislation; law enforcement; selfregulation; better information about wild-harvested plants; and certification of wild-harvested plant materials from sustainable sources (Lange, 1998). Integrating these measures would have sound implication in protecting life-saving plants from extinction.

2.11. Traditional medicinal plants and the question of access, intellectual property rights and benefit sharing

Research projects related to bioprospecting of medicinal plants raise a debate related to the question of access to the plants and the related indigenous knowledge. The main issue related to this debate is primarily ownership rights (Laird, 2002). Thus, the questions of access to any element of biodiversity including medicinal plants, according to Gepts (2004) include: Who owns the earth's biodiversity? Under what circumstances is it appropriate to talk of 'ownership' of biodiversity, or of particular elements of it such as medicinal plants? How should owners be compensated? How can legal bases of research related to biodiversity and bioprospecting be established?

The presence of the bulk of the world's medicinal plants and cultural heritage in developing countries, and the presence of bioprospectors and technologies to extract biological materials from the plants in industrialised countries resulted in a number of ethical, legal and political issues (Laird, 2002). The earlier attitude towards access to biodiversity and indigenous knowledge was to consider them as the property of everybody or nobody (Gepts, 2004). In contrast, current international laws coin that national governments have a right to physical control over the biological resources and related indigenous knowledge within their country, just as they have the right to control their mineral resources (Williams *et al.*, 2003).

According to Gepts (2004), proponents of the earlier attitude which hijacked ownership rights over biodiversity and associated knowledge from local communities and considered it as a global common, deny intellectual property rights of indigenous people. This notion matches the view set in Trade-Related Intellectual Property Rights (TRIPS), which states that knowledge that is not patented is not owned and, therefore, assumed as part of a global common available for exploitation by all who wish to do so (Bodeker, 2003).

Although a number of pharmaceutical firms are engaged in bioprospecting of medicinal plants, and the global market for products and applications derived from such activity is booming, the (equitable) sharing of revenues from the source nations and traditional communities from which these products were and are derived remains a rare occurrence, and this is unethical (Christoffersen and Mathur, 2005). According to Soejarto and co-investigators (2005), reasonable compensation to indigenous people is mandatory when pharmaceutical firms make use of the local people's time, resource and expertise.

Since issues related to the question of access, intellectual property rights and sharing benefit of local people's plant resources and associated indigenous knowledge are of global concern, various attempts have been made to develop and implement international policies to address them. One of the policies enacted on this issue was the Convention on Biological Diversity (CBD) adopted at the United Nations Conference on Environment and Development (UNCED) in June, 1992 in Rio de Janeiro, Brazil, which entered into force in December 1993. The CBD is the principal international legal framework concerning the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the utilisation of the latter genetic resources (Williams *et al.*, 2003).

The CBD contains the pre-eminent international standards for bioprospecting activities. Based on the provisions contained in Articles 8(j), 15, 16 and 19, parties to the CBD have developed guidelines regulating access to and benefit sharing of genetic resources. Article 8(j) of the CBD states that knowledge, innovations and practices of indigenous and local communities must be respected, preserved, maintained and promoted for their wider application with approval and involvement of the holders of such knowledge whereas benefits arising from the utilization of such knowledge must be shared equitably (Williams *et al.*, 2003). In addition, Article 15(1) of the CBD recognizes the sovereign rights of states over their natural resources, and states that the authority to determine access to genetic resources rests with national governments and is subject to national legislation.

Pursuant to Article 16, parties are to provide and/or facilitate access for and transfer to developing countries of technologies under "fair and most favourable terms", and shall cooperate to ensure that intellectual property rights are supportive of the CBD's objectives. Article 19, which addresses the handling of biotechnology and distribution of its benefits, stipulates that measures shall be adopted to provide for the effective participation in biotechnology research by countries providing the genetic resources, and that they be given priority access to results and benefits arising from biotechnology (Williams *et al.*, 2003). The problem is that the Convention does not have a mechanism for enforcement of what is agreed by the parties. It gives the mandate to the contracting parties and hence there is no internationally agreed upon enforcement mechanism to halt action against it (Trommeter, 2005).

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGR), under the auspices of the Food and Agricultural Organization of the United Nations (FAO), is another important element of the international framework guaranteeing access to genetic resources and benefit sharing. The objectives of the treaty are "the conservation and sustainable use of plant genetic resources for food and agriculture, and the fair and equitable sharing of the benefits arising out of their use, in harmony with the CBD, for sustainable agriculture and food security”. Sovereign rights of states over their own genetic resources are recognized. It is agreed, in the exercise of these rights, to establish an open multilateral system of exchange (Laird and Wynberg, 2008).

In addition, The *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS) to the Convention on Biological Diversity* is another recent and useful supplementary agreement to the Convention on Biological Diversity (www.cbd.int/abs). It provides a transparent legal framework for the effective implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources. This Protocol on access and benefit sharing was adopted on 29 October 2010 in Nagoya, Japan and its objective is the fair and equitable sharing of benefits arising from the utilization of genetic resources, thereby contributing to the conservation and sustainable use of biodiversity.

The other effort related to establishing a legitimate bioprospecting system, especially in Africa, was defined by a legislation known as the African Model Law (AML) (http://www.eli.org/pdf/africa/adeniji.Pdf). This law was endorsed by the former Organization of African Unity (OAU), Assembly of Heads of State and Government, in June, 2000 and found consistent with provisions of the CBD. The law recognizes, protects and supports the inalienable rights of local communities over their biological resources, knowledge and technologies. The document assisted OAU's members to formulate their national legislation on bioprospecting and related issues in accordance with their national interest, economic development and political orientation.

The presence of such international treaties has forced many pharmaceutical firms to run their businesses respecting binding laws on access to and benefit sharing of resources held by local people (Trommeter, 2005). Generally, the need for legitimate research on traditional medicinal plants and associated knowledge received formal consideration worldwide. Thus, efforts from governmental and non-governmental organizations have to be integrated in developing and implementing formal principles in conducting biodiversity investigations to safeguard ownership rights of indigenous people on their resources and traditional knowledge.

2.12. Medicinal plants in Ethiopia

2.12.1. History of use

In Ethiopia, the use of medicinal plants has originated several centuries ago as reflected in various medico-religious manuscripts produced on parchments (Fassil Kibebew, 2001). For example, the ancient and very antique manuscripts from the Axumite Kingdom (7^{th} to 11^{th} centuries) contains several prescriptions of medicines that could be prepared from various plants, animals and minerals used against different diseases. This manuscript addresses about 1,500 diseases, mentioned to be treated using 8,000 plants, 90 animals and 150 minerals (Fassil Kibebew, 2001). Other examples, such as ancient manuscripts collected from the ruins of the Zagwe Kingdom (11^{th}-13^{th} C) which document 280 diseases and 2,800 plant remedies; documents of Gonder Kingdom (16^{th}-17^{th} C) collected from covenants, churches and individuals addressing 2,900 medicinal plants; a document referring to the time of Menelik II (1844-1913) written in Arabic and addressing 596 plant remedies; etc., have all evidenced that the country's use of traditional medicine is deep-rooted (Fassil Kibebew, 2001).

European explorers who visited the country from the early 16th and 17th centuries onwards have also recorded age-old practices of Ethiopian people in medicinal plant utilization. According to Pankhurst (1976), the early 16th century document by a European traveller called Francisco shows the utilization of different kinds of herbs in Ethiopia as purgatives. A written account on some Ethiopian medicinal plants of the 17th century by the Jesuit Manoel d'Almeida also showed the common use of the female flowers of KOSSO (*Hagenia abyssinica*) as cure for tapeworm infection (Pankhurst and Pearson, 1972). The famous British traveller, James Bruce, who lived in Ethiopia between 1769 and 1771, reported the wide use of a medicinal plant called WAGINOS (*Brucea antidysenterica* J.F. Miller - Simaroubaceae) against dysentery (Mesfin Tadesse, 1986). Other written accounts on the Ethiopian medicinal plant lore include that of Pearce (1831) and Ganora (1929) who both documented Ethiopian medicinal plants.

Ethiopian medical texts such as METSEHAFE FEWS and METSEHAFE MEDHANIT both written in Geez (the working language of the Ethiopian Orthodox Tewahdo Church) and *Etse Debdabe* written in Amharic are also notable traditional pharmacopoeias indicating the long history of medicinal plant use in the country. According to Pankhurst (1976), these medical texts are speculated as copies of older Ethiopian pharmacopoeias that might date back to the 13th or 14th century. Vecchiato (1993) stated that much of the Ethiopian medical heritage is indigenous, despite some indications that it might have been influenced by historical developments related to prolonged immigration from the southern Arabian Peninsula, the influence of some Greek culture, and the introduction of Christianity and Islam.

In 1942, the government of Ethiopia legalised the practice of traditional medicine, and authorized traditional healers to practice non-dangerous traditional medicine (Fekadu Fullas, 2001). Late in 1977, the Ethiopian government developed a proclamation on the formal use of traditional medicine along with the formal allopathic one. Sub-article 12 of the Proclamation No 127/1977 emphasised the need to promote and encourage the use of traditional drugs along with modern ones. This proclamation confirmed the government's commitment to integrate millennia-old knowledge on traditional medicine with the modern one (Makonnen Bishaw, 1991).

Four years after setting Proclamation No 127/1977, the Ethiopian government established an office known as the Co-ordinating Office for Traditional Medicine (Dawit Abebe, 1996), currently known as the Traditional and Modern Drug Research Directorate under the Ethiopian Health and Nutrition Research Institute (EHNRI) (now known as the Ethiopian Public Health Institute) administered under the Ministry of Health. The major objectives of the co-ordinating office were carrying out surveys and documenting traditional medical practices in Ethiopian cultural groups; running chemical screening of medicinal plants and evaluating their efficacy; and co-ordinating all activities relevant to traditional medicine in Ethiopia (Messeret Shiferaw, 1996). More than 600 medicinal plants were reported to have been collected and documented by the Drug Research Directorate until late 1996 (Dawit Abebe 1996). It was in late 1987 that the first Ethiopian Traditional Medical Practitioners Association (ETMPA) was established aiming at promotion of traditional medicine in the country. In 1990, ETMPA was replaced with the Ethiopian National Traditional Medicine Preparation and Therapy Association (ENTMPTA) (Dawit Abebe, 1996). Currently, ENTMPTA is not functioning (Tesfaye Awas and Getachew Addis, personal communication) and there is still a need to establish a fully-functioning association serving as an umbrella for all traditional medical practitioners of the country.

Generally, the history of traditional medicine in Ethiopia shows its long period of existence, and to be an integral part of the culture of Ethiopian peoples. It is now more than half a century since the practice secured more attention from the government to function complementarily with the modern one, although not complementing as fast as it could be due to limited acceptance of the traditional form in the eyes of modernists.

2.12.2. Role of traditional medicinal plants in primary healthcare services in Ethiopia

Currently, a majority of the rural population in Ethiopia plus a large number of the poor in urban centres are known to rely on traditional medicine to meet their primary healthcare needs (Birhane Mewa, 2001). Dawit Abebe and Ahadu Ayehu (1993) stated that about 80% of the Ethiopian population rely on traditional medicine for primary healthcare services, whereas more than 95% of the medical preparations in the country are of plant origin (Dawit Abebe, 1986).

According to Tessema Tanto and co-investigators (2003), more than 800 plant species are being used in the country for the treatment and prevention of various ailments of humans and their livestock. Reasons behind reliance of people in Ethiopia on traditional medicinal plants relate to factors such as incomplete coverage by the modern medical system, shortage of pharmaceuticals and unaffordable prices of modern drugs (Dawit Abebe and Istifanos Hagos, 1991).

In addition, Ethiopian traditional medicine has high acceptability and is an integral part of the local culture. Hence, people often rely on it even when there is a demonstrably efficient and less costly alternative healthcare present in an area (Dawit Abebe, 2001). It is also noted that since medicinal plants are often within easy reach compared to the more inaccessible modern health services in many Ethiopian Districts, most people rely on medicinal plants for treating themselves and their livestock (Tessema Tanto *et al.*, 2003). According to Dawit Abebe

(1996a), although many people in Ethiopia are using traditional medicine for their primary healthcare, the relationship between traditional and modern medicine in the country is yet not harmonious (Dawit Abebe, 1996).

2.12.3. Medicinal plants' trade in Ethiopia

In Ethiopia, medicinal plants are exploited for domestic use rather than for export. The economic value of medicinal plants is highly significant in the remotest areas of the country where health centres are very rare (Kloos, 1976). Indeed, most people in this country prefer herbal drugs to modern drugs for their supposed efficiency in treating some diseases such as asthma, diabetes, hepatitis, haemorrhoids, epilepsy and evil spirits (Kloos, 1976).

A study on preliminary economic evaluation of medicinal plants in Ethiopia by Dessalegn Dessissa (2001) indicated that there is an increase in demand and supply of medicinal plants in local markets and herbal clinics established in Addis Ababa and a few other regions. The same document shows that *Hagenia abyssinica*, *Embelia schimperi*, *Ximenia americana, Jatropha curcas* and *Tamarindus indica* are among the most commonly sold medicinal plants in the country. Mander and co-investigators (2006) reported that the annual harvest of medicinal plants in Ethiopia may reach around 56,000 tonnes, of which 42,260 tonnes (75%) are traded through different domestic marketing channels. The same document explains that the traditonal medicinal plants market in Ethiopia worths 2 billion Ethiopian Birr per annum (51 million USD) with about 346,000 jobs.

Nowadays, some investment groups are reporting that they are giving prime attention to cultivate and commercialise a medicinal plant known as ENDOD (*Phytolacca dodecandra*). For instance, the Gemadero Coffee Development Company, a sister company of Mohammed

International Development Research and Organization Companies (MIDROC-Ethiopia), announced that it is under preparation to widely cultivate and export ENDOD (http://allafrica.com/stories/200604110567.html). Another company, i.e. Ethio Agri-CEFT, a member company of MIDROC-Ethiopia, says it has been able to control leeches, parasitic organisms that could cause great hazard to animal health using endod, hence it works on cultivation of the plant for commercialisation (http://allafrica.com/stories/200604110567.html).

Berhane Mewa (2001) explains that the investment cost for production of medicinal plants in this country is relatively small whereas their profitability is promising. Hence, in Ethiopia incentives like farm land, long-term loans, and infrastructures should put into place to draw the private sector to this activity, and make the country to benefit from medicinal plants. Generally, eventhough Ethiopia is endowed with a number of economically useful medicinal plants, proper utilization of them for economic benefit or revenue generation is negligible.

2.12.4. Research on medicinal plants in Ethiopia

Ethnomedicinal studies on Ethiopian medicinal plants were a neglected discipline and even considered irrelevant in the past (Dawit Abebe and Ahadu Ayehu, 1993). Like in many other countries in Africa, research on Ethiopian medicinal plants was triggered after the World Health Organization (WHO) officially launched an international program to promote and develop basic and applied research on traditional medicine in 1978 (WHO, 1978; Tsige Gebre-Mariam and Kaleb Asres, 2001).

Most of the earlier studies on traditional medicinal plants of Ethiopia such as those by Amare Getahun (1976), Gelahun Abate (1989), Jansen (1981) and Dawit Abebe and Istifanos Hagos (1991), etc. were more general works that do not focus on a specific ethnic group or agro-ecological zone in the country. However, with the recently triggered development of interest in the subject, a number of ethnomedicinal studies specific to some ethnic groups or agro-ecological zone of Ethiopia started to emerge; examples include the works of Getachew Addis *et al*. (2001), Mirutse Giday and Gobena Ameni (2003), Mirutse Giday *et al*. (2003), Kebu Balemie *et al*. (2004), Haile Yineger *et al*. (2007), Ermias Lulekal *et al*. (2008a), Tilahun Teklehaymanot (2009), etc.

Most ethnomedicinal studies in the country are mainly basic researches focusing on mere documentation of species lists and corresponding uses of traditional medicinal plants. These researches are even insufficient when compared to the multiethnic cultural diversity and the diverse medicinal flora of Ethiopia. Thus, more documentation of the age-old accumulated indigenous knowledge on traditional medicinal plants addressing the different ethnolinguistic groups of the nation is yet required.

Applied ethnomedicinal studies focusing on phytochemical screening and activity testing of medicinal plants of Ethiopia are scanty (Hailu Tadeg *et al*., 2005; Yitbarek Habtamu *et al*., 2010; Getachew Belay *et al*., 2011) and hence the gap calls for more integration of basic documentation with applied research activities in the years ahead. According to Sebsebe Demissew and Ermias Dagne (2001), integrating basic and applied research on medicinal plants is essential since the basic research serves in realizing new knowledge beside its role as a basis for an in-depth applied research.

In addition, nationwide ethnomedicinal studies are still a must in Ethiopia so as to develop national policies and strategies for medicinal plants conservation, to identify potential medicinal plant species and provide baseline information for future phytochemical and biological activity studies. Tsige Gebre-Mariam and Kaleab Asres (2001) explained that research programmes in traditional medicine in Ethiopia must be realistic and be based on an objective of developing safe, effective and quality phytotherapeutic preparation, which can supplement modern healthcare practices.

A notable progress on cross-institutional research on Ethiopian medicinal plants was observed between 2001 and 2007 when a World Bank funded project (with a cost of 4.49 million USD) entitled *'Conservation and Sustainable use of Medicinal Plants Project* (CSMPP)' was launched in Ethiopia (Document of The World Bank, 2007). Major institutions involved under these project were the Institute of Biodiversity Conservation (IBC), Ethiopian Health and Nutrition Research Institute (EHNRI), Ethiopian Science and Technology Commission (ESTC), Oromia Bureau of Agriculture and Rural Development (OBARD), the former Ethiopian Wild Life Conservation Organization (EWCO), Essential Oils Research Centre (EORC) and Addis Ababa University (AAU). Major research undertakings in the project include: ethnomedicinal surveys to explore utilization of medicinal plants and traditional healthcare practices, cultivation of indigenous medicinal plants used for human and livestock diseases, phytochemical studies on preferred medicinal plants, socioeconomic benefits derived from medicinal plants in human & livestock, and development of a National Medicinal Plants Database (Document of The World Bank, 2007). The rating given by the World Bank at the completion of the CSMPP in 2007 indicated that the project outcomes were satisfactory (Document of The World Bank, 2007).

Generally, research on medicinal plants and associated knowledge in Ethiopia is still underway though inadequate when compared to wide utilization of medicinal plants across different ethnolinguistic groups. There is also no well-coordinated applied research to integrate traditional medicine into the formal components of the national healthcare system, hence launching well-coordinated applied research is a timely endeavour.

2.12.5. Threats and conservation practices of Ethiopian medicinal plants

In Ethiopia, traditional medicine as elsewhere in other developing countries is faced with a problem of sustainability and continuity mainly due to loss of taxa of medicinal plants, loss of habitats of medicinal and other category of plants, and cultures (Zemede Asfaw, 2001). An increasing demand for arable land and forest products due to the rapidly growing population, and poverty of the rural people have also been mentioned as major threats to the survival of many of the Ethiopian plant species (Ensermu Kelbessa *et al*., 1992).

According to Zemede Asfaw (2001), one of the traditional anthelmintic medicinal plants in Ethiopia, i.e. *Hagenia abyssinica* is getting more and more scarce as a result of agricultural expansion and habitat destruction. In addition, medicinal plants such as *Clausena anisata* (Rutaceae), *Taverniera abyssinica* (Fabaceae), *Warburgia ugandensis* (Canellaceae), *Clerodendrum myricoides* (Lamiaceae) and *Cucumis aculeatus* (Cucurbitaceae) are also mentioned for being threatened due to overexploitation and destructive harvesting for remedial uses (Abebe Demissie, 2001).

Efforts are underway, albeit inadequate, to conserve the fast-eroding medicinal plant species and the linked traditional knowledge in the country. For instance the IBC, being a lead institution for the then CSMPP in Ethiopia, established medicinal plants' field gene banks at Wondo Genet (in collaboration with the EORC and some traditional healers) and Goba in collaboration with OBARD. Moreover, the IBC has been collecting and preserving seeds of medicinal plants in cold storage facilities (Abebe Demissie, 2001). According to Tesfaye

Awas (2004), seeds of about 662 samples belonging to 31 medicinal plant species have thus been stored at the IBC cold room gene bank. The IBC has also reported that it has initiated *in situ* conservation of medicinal plants in different parts of the country (Tesfaye Awas, 2004).

Local people and traditional healers in Ethiopia have also a tradition of cultivating common medicinal plants in homegardens (Zemede Asfaw and Ayele Nigatu, 1995). According to Zemede Asfaw (2001), amongst the species purposely maintained in homegardens in the country, about 6% are primarily cultivated for their medicinal values. Institutional level researches are also underway to study the possibility of bringing some medicinal plants to cultivation (Legesse Wolde-Yohannes, 2001). Generally, averting existing threats on Ethiopian medicinal plants demands a nationwide effort to implement a well-coordinated *in situ* and *ex situ* conservation strategies.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Description of the study area

This study was conducted in Ankober District, located in North Shewa Zone of Amhara National Regional State in north-central Ethiopia (Figure 1). The District is perched on the eastern escarpment of the Ethiopian highlands and situated 172 km north of Addis Ababa, the Ethiopian capital, and 42 km to the east of Debre Berhan town (North Shewa Zone capital) at 9^0 22' - 9^0 45' N and 039^0 40' - 039^0 53' E. Ankober District is bordered in the north by Tarmaber, south by Asagirt and west by Basonaworana Districts of Amhara Region. The eastern part shares its border with Gachine Special District of the Afar Region (Endale Zatew and Beyene Yemane, 2007). The main administrative centre of the District is located at Ankober Town (Gorabela).

The total area of Ankober District is 78, 700 Km^2 and it has 22 Kebeles (lower administrative units in the Ethiopian administrative structure) (Endale Zatew and Beyene Yemane, 2007). The elevation of the District ranges from 1300 m a.s.l. near Addis Alem to 3700 m a.s.l. at Kundi Mountain. Plain land accounts for 8% of the District, whereas rugged terrains and valley account for 17%, and mountains 75% of the District (AWFPEDO, 2012). The District has six major rivers, namely Ayrara, Chew Bele, Dinki, Gindebel, Melka Jebdu and Zenbalit that flow year in year out (AWFPEDO, 2012). WEINADEGA (sub-tropical) agro-climatic zone covers 53% of the District, while KOLLA (tropical), DEGA (temperate) and WURCH (cool) zones cover 35%, 10.5% and 1.5% of the District (AWFPEDO, 2012).

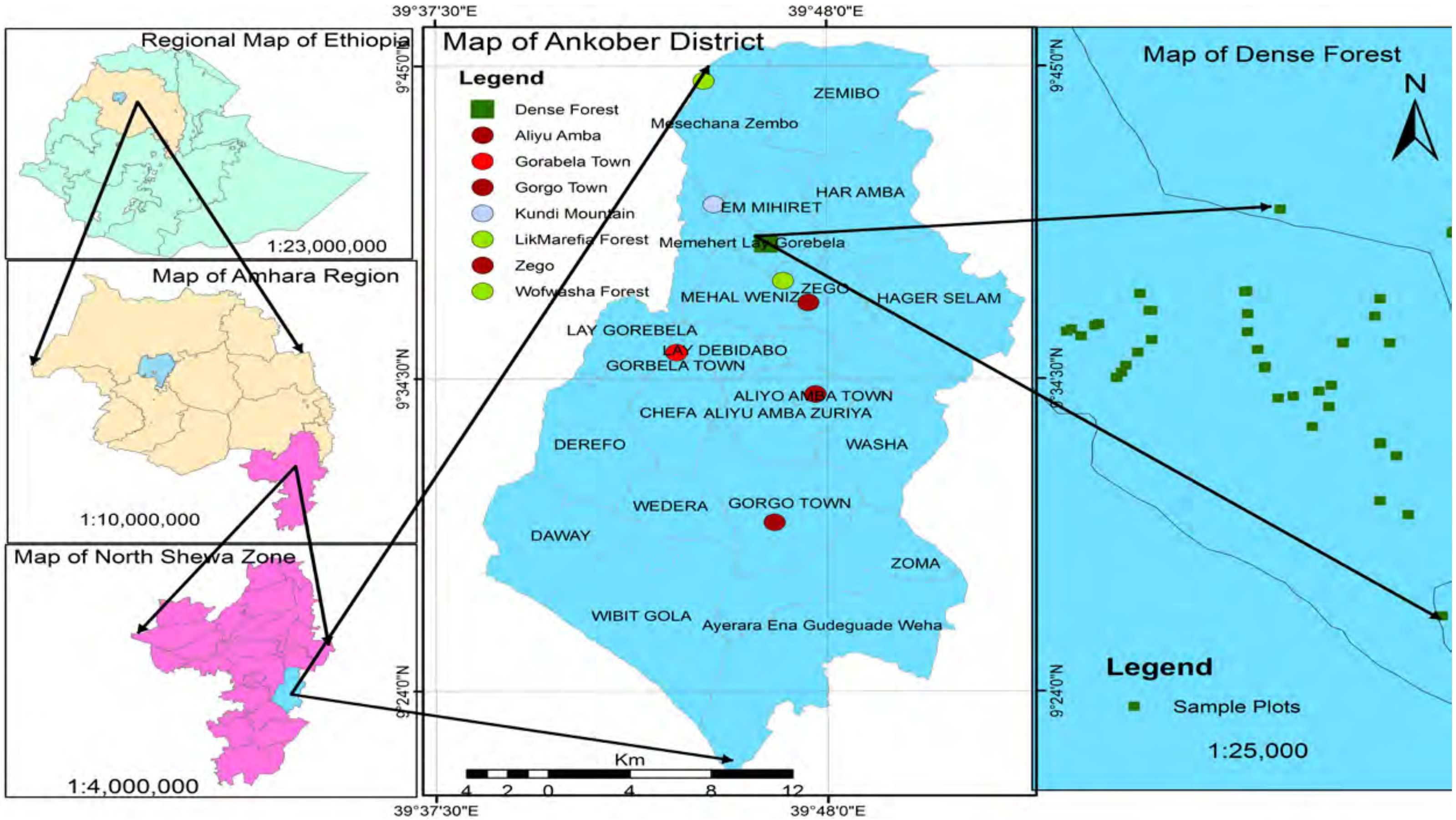
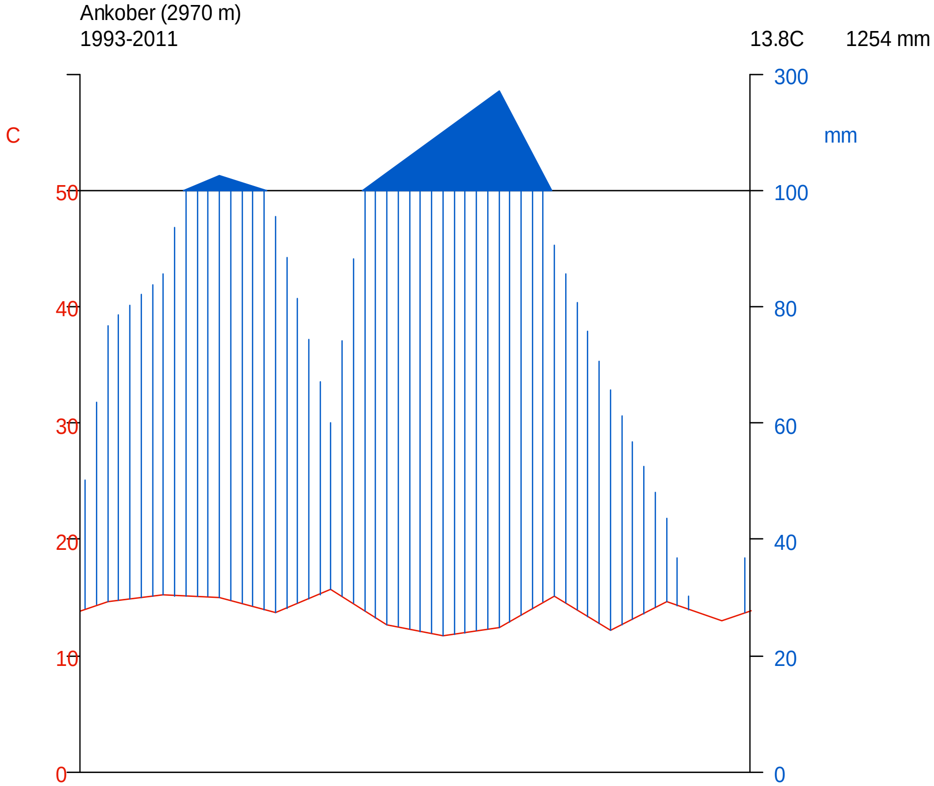


Figure 1. Map of Ethiopia showing regional states and the study area (Developed using ArcGIS 10)

3.2. Physical and biological settings of the area

3.2.1. Climate

According to the climate data (1993-2011) obtained from the National Meteorological Services Agency (NMSA), the mean annual rainfall of Ankober District amounts to 1254 mm (National Meteorological Services Agency, unpublished data, 2012). The District has a bimodal rainfall with a short rainy period in March and long rainy season which lasts from late June to September with a peak in August. Such Pattern of bimodal rain fall is also reported for other parts of central plateaux of Shewa, in Ethiopia (Daniel Gamachu, 1977). Mean annual temperature of Ankober is 13.8 ^{0}C (Figure 2). The mean minimum and maximum temperatures in the District are 22.0 ^{0}C and 8.0 ^{0}C, respectively (Figure 2).


Ankober (2970 m)
1993-2011
13.8C
1254 mm
C
mm
300
100
80
60
40
20
0
50
40
30
20
10
0

3.2.2. Geology and soils

According to Mohr (1971), Precambrian rocks that underlie the whole of Ethiopia consist of a complex of metamorphic and igneous rocks of many different grades and types. In the central plateaux of Ethiopia, Mesozoic rocks mainly made up of sandstones and limestones, which are overlain by tertiary lava, cover the Precambrian rocks (Mohr, 1971). The main rock types in Ankober District (which is part of the central plateau of the Ethiopian highlands) are rhyolites, trachytes, tuffs, ignimbrites and basalts (Mohr, 1971). The majority of soil types in the District are of volcanic origin (Logan, 1946). Black and reddish-brown soil types are mentioned as the dominant soil forms in Ankober District (Logan, 1946). According to Von Breitenbach (1961), two principal soil types, i.e. black and compact clays ('Black soil') and reddish-brown heavy loams ('Red soil'), originating from the disintegration of volcanic substrates, are known to form the central plateaux of Ethiopia. Red and Brown soils, and loams are the most common soils in the highlands, making up over 60% of plateau soils (Logan, 1946), and are also the most common forest soils. Westphal's (1975), characterization of soil regions of Ethiopia underlined that Alfisols, Vertisols and Inceptisols are the dominant soil forms in the Central Plateau of Ethiopia including Ankober District.

3.2.3. Vegetation

The District is home to Dense and Let Marefia forests, and some part of Wof-Washa Forest. Dense Forest located between 9^0 37' 44"- 9^0 39' 54" N and 039^0 45' 19"- 039^0 46' 59" E, is the largest natural forest in Ankober District. It covers a total area of ca. 625 ha. According to the current classification of Ethiopian vegetation (Friis *et al*., 2011), these forests fall in the categories of dry evergreen Afromontane forest and grassland complex. Dry evergreen montane forests are characterised by canopies usually dominated by *Podocarpus falcatus* with *Juniperus procera* as co-dominant species, followed by *Olea europaea* subsp. *cuspidata*

(Sebsebe Demissew and Friis, 2009). This forest type covers most of the highland areas and mountainous chains of Ethiopia in the Amhara, Oromia, SNNP and Tigray regions (Friis *et al*., 2011).

Ankober District is amongst the most biodiversity rich areas in the highlands of Ethiopia housing economically important tree species including *Hagenia abyssinica*, *Olea europaea* subsp. *cuspidata*, *Juniperus procera*, *Podocarpus falcatus* and *Nuxia congesta* (Demel Teketay and Tamrat Bekele, 1995). The District also bears Afroalpine species including giant lobelia (*Lobelia rhyncopetalum*) and different *Helichrysum* species at higher altitudes (> 3500 m a.s.l.) (Friis *et al*., 2011) around Kundi and Emimhret mountains. The lowlands and foothills of the mountains in the District are under cultivation and are commonly devoid of forest cover (AWFPEDO, 2012).

3.2.4. Fauna

Ankober District is also home for very diverse wildlife and bird species mainly living in natural forests. According to AWFPEDO (2012), the most common wild animals residing either on the cliffs or inside natural forests of Ankober include *Colobus guereza* Rüppell (colobus monkey), *Tragelaphus scriptus* Pallas (bushbuck), *Sylvicapra grimmia* Linnaeus (duikers), *Papio anubis* Lesson (anubis baboon), *Chlorocebus aethiops* Linnaeus (vervet monkey), *Sus scrofa* Linnaeus (wild pig), *Hystrix cristata* Linnaeus (porcupine), *Phacochoerus africanus* Gmelin (warthog), *Hyaena hyaena* Linnaeus (Stripped hyena), and *Lepus starcki* Petter (rabbit). The District also houses different bird species including the IUCN red-listed endemic bird species, *Serinus ankoberensis* Ash (Ankober Serin) (BirdLife International, 2012).

3.3. The people and socio-economic aspects

3.3.1. Brief history

Ankober District has a remarkable historical significance as it has been the seat of Ethiopian emperors since 1270 for centuries (Tekletsadik Mekuria, 1961). The name Ankober is taken from an Oromo Queen, Anko, who ruled the District during the reign of Qedami Qal (1718-1744) (Endale Zatew and Beyene Yemane, 2007). Ankober town served as the principal residence of the rulers of the Shewa kingdom, and as the former Ethiopian capital, until Emperor Menelik II moved the capital to Mount Intoto in 1878 (Tekletsadik Mekuria, 1961).

Emperors of the Shewa kingdom including King Libne-Dingil (1508-1540), Amha-Iyesus (1744-1775), Asfaw-Wossen (1775-1808), Wesen-Seged (1808-1812), Sahile-Sillassie (1812-1848), Haile-Melekot (1848-1856) and Menelik II (1857-1882) have used Ankober as their administrative capital (Tekletsadik Mekuria, 1961; Mordechai, 1969). This indicates that the District has long been inhabited by many people accompanying series of Emperors crowned in Ankober, as evidenced now that much of the land is used for settlement and cropland including the very steep slopes where cultivation is being undertaken by terracing the cliffs.

According to Endale Zatew and Beyene Yemane (2007), there were a number of traditional herbalists living in Ankober and around the Emperor's palaces who provided traditional healthcare services to the then Emperors and the rank and file. This evidences that the District was inhabited by people who have a long tradition of using medicinal plants for centuries. It is also observed that the use of medicinal plants by people in Ankober continued over generations to the present time. Circumstantial evidence suggests that the main sources of plants for traditional medicine, in the area, are the remaining forest patches, cultivated land

and field margins. Thus, historical significance of the District attracts an interest to run scientific exploration on age-old medicinal plant lore of indigenous people in the area.

3.3.2. Population, ethnographic background and land use

Ankober District has a total population of 83,260 (42,180 males and 41,080 females) of whom only 6,272 (7.5%) are urban inhabitants (AWFPEDO, 2012). The population density of the District is 113.72 individuals/km^2, which is slightly below the North Shewa Zone average of 115.3 persons/km^2 (AWFPEDO, 2012). The indigenous people inhabiting Ankober District belong to the Amhara (one of the major ethnolinguistic groups in Ethiopia). They speak Amharic language, the official working language of the government of the Federal Democratic Republic of Ethiopia. About 92.52% of the people in Ankober belong to Ethiopian Orthodox Tewahdo Christianity whereas 7.41% are Muslims (AWFPEDO, 2012). Regarding land use type, about 13.12% (10,322 ha) of the total land area of Ankober District is under cultivation, whereas 28.7% (22,588 ha) is covered with vegetation (high forests, plantations, woodland and bush lands), 13% (10,231 ha) is pasture land, and about 37% (29, 119 ha) constituted with mountain cliffs, gorges and river courses (AWFPEDO, 2012).

3.3.3. Economic activity

About 94% of the population in Ankober District depends on agriculture for livelihood (AWFPEDO, 2012). Civil servants and merchants constitute 5% of the population. The remaining 1% are handicrafts men and women (AWFPEDO, 2012). Average farm size per household ranges from 0.66 - 0.71 hectare. People in Ankober cultivate different types of crops including barley (*Hordeum vulgare*), wheat (*Triticum* spp.), faba bean (*Vicia faba*), teff (*Eragrostis tef*), sorghum (*Sorghum bicolor*) and maize (*Zea mays*) (AWFPEDO, 2012). Coffee (*Coffea arabica*), KHAT (*Catha edulis*) and buckthorn/GHESO (*Rhamnus prinoides*) are also cultivated as cash crops in the area. People in Ankober District also grow fruit trees such as avocado (*Persea americana*), mango (*Mangifera indica*), papaya (*Carica papaya*), ZEITUN (*Psidium guajava*), orange (*Citrus sinensis*) and banana (*Musa x paradisiaca*). According to AWFPEDO (2012), there are 310 modern and 2,930 traditional beehives actively used in bee-keeping for household use and market consumption.

3.3.4. Status of human health services in the District

According to the annual report of Ankober District health office (ADHO 2010/11, unpublished), the District has one health centre and 19 health posts giving service to a total of 83,260 people. There is neither a hospital nor a higher clinic in the District. There are 29 health professionals composed of four health officers, two sanitarians, thirteen senior nurses, three junior nurses, two laboratory technicians, two pharmacy technicians and three health assistants working in the District (ADHO 2010/2011, unpublished). The major human diseases in the area include internal parasites, pneumonia, eye disease, febrile diseases, diarrhoea, gastritis, dermatological diseases and rheumatoid arthritis (ADHO 2010/11).

3.3.5. Livestock population and status of veterinary services in the District

The livestock population in the District was estimated at 61,499 heads of cattle, 54,493 goats, 47,756 chicken, 33, 265 sheep, 8,802 donkeys, 395 horses, 244 camels and 221 mules in the year 2012 (AWFPEDO, 2012). At the same time, there were only seven rural veterinary clinics in the District (located at Mescha, Haramba, Gorgo, Aliyu Amba, Wedera, Derefo and Lay Gorebela kebeles). The remaining 15 kebeles did not have any veterinary clinics at all at the time of this study. Moreover, there were only eight veterinarians (1 DVM, 2 Bsc and 2 Diploma holders with 3 assistants) working in the District in 2012 (AWFPEDO, 2012). This was found insufficient to provide proper health services for a total of more than 200,000 heads of livestock present in the District (AWFPEDO, 2012). Blackleg, pasteurellosis, Newcastle disease, lumpy skin disease, foot and mouth disease, African horse sickness and various parasitic diseases are reported as the most common disease types affecting the District (AWFPEDO, 2012).

3.4. Research methods

3.4.1. Vegetation study of Dense Forest

3.4.1.1. Site selection and establishment of quadrats

A reconnaissance survey was made from 25 June to 24 July 2009 to get a general impression of the physiognomy of Dense Forest; and select sampling sites. Floristic data were collected in September 2009, 9 January to 20 February 2010, 22 May to 27 August 2010 and 14 February to 7 May 2011. Seven transects, 750 meters apart from each other were established along an altitudinal gradient, from the ridge top of the mountain (highest elevation = 2971 m a.s.l.) to the bottom (lowest elevation = 2054 m a.s.l.) where human interference is relatively low. The transects were laid from different points of the mountain where the forest is stretched and hence have different lengths. Accordingly, a total of 51, 30 x 30 m^2 quadrats (six quadrats from transect 1, six others from transect 2, 9 from transect 3, 11 from transect 4, 7 from transect 5, 5 from transect 6, and 7 from transect 7), were established for tree inventory in the manner described by Kent and Coker (1992) at every 50 m altitudinal drop. For shrub and herbaceous layers, 5 x 5 m^2 and 2 x 2 m^2 subplots were established, respectively, within the main quadrats following Kent and Coker (1992).

3.4.1.2. Vegetation data collection

In each quadrat, trees and shrubs with diameter at breast height (DBH) > 2 cm were counted and cover abundance estimated following the Braun-Blanquet scale as modified by van der Maarel (1979). Growth forms of plants were listed and voucher specimens collected. In the centre of each plot, altitude was recorded using a ‘Pretel’ digital altimeter, whereas GPS readings were taken with Garmin eTrex GPS.

Voucher specimens were collected with the help local field assistants. Specimens were dried, numbered, labelled, pressed, identified and deposited at the National Herbarium (ETH) in Addis Ababa University. Identification of specimens was performed both in the field and later at ETH using taxonomic keys in the Flora of Ethiopia and Eritrea and by comparison with authenticated herbarium specimens.

3.4.1.3. Vegetation data analysis

Vegetation data were analysed via hierarchical cluster analysis using PC-ORD for Windows version 5.0 (McCune and Mefford, 1999). Plots were grouped into clusters based on floristic similarity and species abundance in order to define distinct plant community types. Identified communities were further refined in a synoptic table where species occurrences were summarized as synoptic cover-abundance values (van der Maarel *et al.*, 1987). Synoptic values were calculated as the product of average cover abundance values of species and their frequency in a specific community type following van der Maarel *et al*. (1987). Community types were named after one or more dominating and/or characteristic species per community.

Structural analysis of the Forest was performed based on frequency, density, DBH and basal area (BA) per hectare, following Tamrat Bekele (1993). Frequency of a species was computed as the proportion of samples within which a species is found. Density was then computed by converting the count from all quadrats into a hectare basis as indicated in Kent & Coker (1992). DBH values were classified into seven classes in the manner used by Tamrat Bekele (1993) and density distribution of each tree and shrub species was then computed per DBH class (Kent and Coker, 1992). The ratio of density of individuals with DBH > 10 cm and DBH > 20 cm was computed to measure the size class distribution of species in the forest, following Grubb *et al*. (1963). Relative density of species in different DBH classes was used to get representative patterns of species population structures, following Popma *et al*. (1988). Basal area (in m^2 per hectare) of trees was computed using $(DBH/200)^2$ x 3.14 to measure dominance (degree of coverage of a species as an expression of the space it occupies) (Barbour *et al*., 1987). Importance value indices of woody species were computed by adding relative density, relative frequency and relative dominance of the respective species, following Mueller-Dombois and Ellenberg (1974).

Shannon-Wiener diversity index was calculated to measure species diversity of identified plant communities (Kent and Coker, 1992) in Dense Forest, using:

H' = - $\sum_{i=1}^{s} pi \ln pi$, whereby

H' = Shannon diversity index**,**

s = number of species,

pi = proportion of individuals or abundance of the i^{th} species expressed as a proportion of total cover in the sample; and

ln = the natural logarithm.

Shannon's evenness index (J) was also calculated using:

J = H'/H'max,

where, H' = Shannon–Wiener Diversity Index; and

H'max = ln S where s is the number of species in the sample (Kent and Coker, 1992).

Floristic similarity analysis between Dense and eight other montane forests of Ethiopia was computed using;

Sorensen's similarity coefficient (Ss), Ss = 2a/ (2a+b+c), where, a = number of species common to both forests compared; b = number of species in one forest; and c = number of species in the other forest (Kent and Coker, 1992).

The same similarity index was also used to measure the pattern of species similarity among communities identified in Dense Forest.

3.4.2. Ethnobotanical study

3.4.2.1. Informant selection

Representative general informants and knowledgeable traditional medicine practitioners of the District were selected using systematic random and purposive sampling approaches, respectively, in the manner described by Martin (1995). The total number of informants involved in the ethnomedicinal survey from the four agro-climatic zones of the District was 352 (235 male and 117 female). Informants' ages ranged from 20-89 years (122 were between 20-39, whereas 230 were $\geq$ 40 years old). Peer-recommendations from community members, elderly people and knowledgeable inhabitants helped in nominating 88 traditional herbalists (68 male and 20 female) who participated as key respondents following Davis and Wagner (2003), whereas general informants were sampled during random visits made to households in the study kebeles. Informed consent was obtained from each informant who participated in this study after explaining the purpose of the study and assuring him/her of the most responsible judicial use of information before the start of interviews.

3.4.2.2. Data collection

Ethnobotanical data were collected during five different field visits conducted between 25 June 2009 and 7 May 2011. Data were collected in different seasons over the different years with the objective of including different kebeles found in the four agro-climatic zones of the

District, and collecting plant specimens during the respective flowering seasons. Market surveys were conducted between 29 December 2012 and 9 February 2013.

Semi-structured interviews, focus group discussions, participant observation and walk-in-the-woods were used to collect ethnobotanical data as described by Martin (1995) and Cotton (1996). Informants were interviewed individually in the local Amharic language. Semi-structured interviews addressed questions regarding name, age, gender, level of education, occupation, religion and ethnic background of each informant. The individual semi-structured interviews also asked local names of medicinal plants, ailments treated, habitat of the species, seasonality and marketability of species, parts used, condition of plant part used (fresh/dried), methods of remedy preparation, dosage prescriptions and routes of remedy administration (Appendices 14 and 15) (Martin, 1995; Cotton, 1996).

In addition, the semi-structured interviews enquired about the degree of management (wild/cultivated), abundance, existing threats and traditional conservation practices (if any), distance from the house to medicinal plants' gathering sites, other ingredients or additives (if any), noticeable adverse effects of remedies, use of antidotes for adverse effects, taboos/beliefs related to collection and use of plants, source of knowledge about medicinal plants and method of indigenous knowledge transfer. Moreover, informants were asked about other (non-medicinal) uses of medicinal plant species they mentioned, so as to identify overall use values and use diversities of species (Martin, 1995; Alexiades, 1996; Cotton, 1996). The traditional healers were also asked about the number of years of practice as a healer and the amount of income earned per person/animal treated for an ailment following the methods used by other researchers (Alexiades, 1996; Balick, 1996).

The semi-structured interviews were followed by independent walks-in-the-woods, which allowed for more discussion with individual informants and the practical identification and collection of traditionally used medicinal plants in their natural environment. This method was combined with participant observation through which reliability of the information collected on medicinal plant collection methods and preparation of specific remedial parts was ascertained as described by Cotton (1996) and Alexiades (1996). In addition, focus group discussions (one focus group per KEBELE with an average number of five participants) were undertaken to gain further information on medicinal plant knowledge at the community level and to triangulate information collected through semi-structured interviews (Martin, 1995).

Data on use diversity of ten multipurpose medicinal plants was evaluated by direct matrix ranking (DMR) exercise as described in Cotton (1996). The latter involved fifteen (ten men and five women) key informants contacted at Gorabela market with purposive appointment for the task. The participants for this exercise were selected based on their long years of experience as traditional herbal medicine practitioners in the District in the manner described by Alexiades (1996). The purpose of the DMR was to identify which of the multipurpose plants is under heavier pressure in the area and to evidence the corresponding factors that threaten the plants. Participants were asked to assign values to different uses of a medicinal plant species as firewood, construction, agricultural tool, medicine, charcoal and lumbering based on the degree of uses (with 5= best; 4= very good; 3=good; 2= less used; 1=least used and 0= no value). By adding the scores, it was possible to compare the multipurpose medicinal plants so as to identify the main factor contributing to overharvesting of the respective species as recommended by Cotton (1996). The same key informants also participated in a preference ranking exercise in the manner recommended by Martin (1995) to identify the most-preferred species for treating the most commonly reported diseases affecting humans (dermatological disease) and livestock (gastro-intestinal disease) in the area. In this exercise too, informants were given respective plant species whereby they were asked to arrange the medicinal plants based on their personal perception of efficacy. The medicinal plant which participants thought to be most-effective in treating the reported ailments got the highest value (7), whereas the one with least effectiveness got the lowest value (1) (Martin, 1995). Based on the total score of each species, the rank was determined. This helped to determine the most-effective plant used by the community to treat most commonly reported diseases.

A market survey of medicinal plants of the District was conducted at six major markets, i.e. Gorabela, Aliyuamba, Gorgo, Haramba, Derefo and Zego. Availability, price and unit of measurement of each marketable medicinal plant were documented and analysed so as to identify extent of use and income-generating potential of the respective medicinal plants. Voucher specimens of medicinal plants were collected with the help of traditional healers and local field assistants. Specimen processing followed the procedure explained under 3.4.1.2.

3.4.2.3. Data analysis

Descriptive statistics and test of significance - Data on informants' backgrounds and medicinal plants used in Ankober were entered in an Excel spreadsheet (Microsoft corporation, 2007) and organised for statistical analysis. Traditional knowledge dynamics on use of medicinal plants by men and women, young to middle-aged (23-39 years) and elderly (40-89 years); literate (completed at least primary education) and illiterate; knowledgeable (key) and local (general) informants as well as those living near health centres ($\leq$ 5 km from health centres) and far (> 5 km distance from health centres) was compared using t-test and one way ANOVA at 95% confidence level between means using KyPlot 5.0 software. Descriptive statistics were also applied to identify the number and percentage of species, genera and families of medicinal plants used, their growth forms, proportions of parts harvested, modes of remedy preparation and routes of administration (Alexiades, 1996).

Preference ranking and direct matrix ranking - Values or scores given by key informants on use-preference and/or use diversity of medicinal plants were added and ranked to get the outputs of the preference ranking and direct matrix ranking exercises, respectively, following Martin (1995) and Alexiades (1996).

Informant consensus factor (ICF) - ICF was computed to determine the most important human and livestock ailment categories in the District, and identify potentially effective medicinal plant species in the respective disease categories. Accordingly, reported traditional remedies and corresponding diseases were grouped into 12 categories for humans, and 8 categories for livestock. ICF was then obtained by computing number of use citations in each disease category (n_{ur}) minus the number of times a species used (n_t), divided by the number of use citations in each category minus one (Heinrich, 1998).

ICF= n_{ur-} $n_{t/}$ n_{ur-1}

The relative healing potential of each reported medicinal plant used against human and livestock ailments was evaluated using an index of fidelity level (FL) (Alexiades, 1996), given by FL=Ip/Iu X 100, where Ip is the number of informants who independently cited the importance of a species for treating a particular disease and Iu the total number of informants who reported the plant for any given disease.

3.4.3. Antimicrobial activity study

3.4.3.1. Selection of medicinal plants

Nineteen medicinal plant species with relatively high informant consensus and fidelity level values for treating infectious diseases in the study area were selected for further antimicrobial activity study **(**Trotter and Logan, 1986; Fabricant and Farnsworth, 2001**)**. Local use reports of candidate medicinal plants from the study area were also thoroughly compared for related ethnomedicinal use reports from other parts of the country (Appendix 4). In addition, a second stage of medicinal plant selection was carried out based on available scientific literature.

3.4.3.2. Preparation of extracts

About 15 g of air-dried plant material of each species was finely ground using a Grindomix apparatus (GM100 Retsch, Germany) and extracted at room temperature in 450 ml of 80% ethanol using a laboratory shaker for 24 hrs (Kloucek *et al*., 2005). The ethanol was obtained from laboratory of ethnobotany and ethnopharmacology of Czech University of Life Sciences. According to Sultana *et al*. (2009), selection of solvents for plant extracts has to be based on the efficiency of the extracting solvent. Accordingly, ethanol is used for extraction since it is found the best solvent extensively used for effective plant extractions (Sultana *et al.*, 2009). Extracts from each specimen were subsequently filtered and concentrated to dryness using a rotary evaporator R-200 (Buchi, Switzerland) *in vacuo* at 40 ^{0}C (Cos *et al*., 2006) (Appendix 19). Dry residues were then dissolved in 100% dimethyl sulfoxide (DMSO) to create a concentration of 51.2 mg/ml stock solution of each extract that was stored at -20°C until tested (Cos *et al.*, 2006). Yield (%) of dry residues (samples) was computed by subtracting the weight of empty flask used for evaporation from the weight of flask containing corresponding residues after evaporation, divided by 15 g of initial plant material multiplied by 100 (Cos *et al*., 2006). Or

Yield (%) = weight of flask after evaporation - weight of empty flask/15) x 100.

The range of yields obtained from each plant used as a starting material for the experiment ranges from 7 to 44 %, and the yield (%) of each extract used is shown in Appendix 4.

3.4.3.3. Microorganisms

Antimicrobial activity was evaluated against one yeast and eleven bacterial strains obtained from the American Type Culture Collection (ATCC) (Oxoid, Basingstoke, United Kingdom) and the German Resource Centre for Biological Material (DSM) (Braunschweig, Germany). Bacterial strains were selected as representative of both classes of Gram-positive and Gram-negative bacteria. Microbial strains used were *Bacillus cereus* ATCC 11778, *Bacteroides fragilis* ATCC 25285, *Candida albicans* ATCC 10231, *Clostridium perfringens* DSM 11778, *Escherichia coli* ATCC 25922, *Enterococcus faecalis* ATCC 29212, *Listeria monocytogenes* ATCC 7644, *Pseudomonas aeruginosa* ATCC 27853, *Staphylococcus aureus* ATCC 29213, *Staphylococcus epidermidis* ATCC 12228, *Salmonella enteritidis* ATCC 13076 and *Streptococcus pyogenes* ATCC 19615.

Streptococcus pyogenes was grown in brain-heart infusion broth (Oxoid, Basingstoke, United Kingdom) (Kloucek *et al*., 2005). *Bacteroides fragilis* and *Clostridium perfringens* as representatives of anaerobic bacteria were grown in Wilkins-Chalgren anaerobic broth (Oxoid, Basingstoke, United Kingdom) under anaerobic conditions using anaerobic jar HP11 (Oxoid, Basingstoke, United Kingdom) in the manner described by Kloucek *et al*. (2005). Anaerobiosis was achieved in a Bugbox anaerobic chamber (BioTrace, Bridgend, United Kingdom). The other microorganisms were all grown on Mueller-Hinton broth (Oxoid, Basingstoke, United Kingdom), which was enriched with glucose for *Enterococcus faecalis* cultivation (Landa *et al*., 2009). All cultivation media were obtained from Oxoid (Basingstoke, United Kingdom).

The sensitivity of the tested aerobic bacteria and of *Bacteroides fragilis* to the standard antibiotic Ciprofloxacin (Sigma-Aldrich, Prague, Czech Republic) was checked. For *Candida albicans* and *Clostridium perfringens* Tioconazole and Penicillin G (both obtained from Sigma-Aldrich, Prague, Czech Republic) were checked as positive controls, respectively.

3.4.3.4. Antimicrobial assay

In vitro antimicrobial activity was determined by the broth microdilution method (Jorgensen *et al*., 1999) using 96-well microtiter plates modified according to the recommendations recently proposed for a more effective assessment of anti-infective potential of natural products by Cos *et al*. (2006). Ten two-fold serial dilutions of each extract were prepared in the appropriate broth concentrations ranging from 512 to 4 µg/ml. The dilution was made for 512 µg/ml, 256 µg/ml, 128 µg/ml, 64 µg/ml, 32 µg/ml, 16 µg/ml, 8 µg/ml and 4 µg/ml broth concentration ranges following Cos *et al*. (2006). Each well was then inoculated with 5 µl of bacterial suspension at a density of 10^7 CFU/ml whereas microtiter plates were incubated at 37°C for 24 h (or 48 h for *Candida albicans, Bacteroides fragilis* and *Clostridium perfringens*). All plates were then checked for Minimum Inhibitory Concentrations (MICs).

Growth of microorganisms was observed as turbidity-determined spectrophotometrically using Multiscan Ascent Microplate Reader (Thermo Fisher Scientific, Waltham, USA) at 405 nm. MICs were then calculated based on density of the growth control and expressed as the lowest extract concentrations that resulted in $\geq$ 80% reduction in bacterial growth compared to that of the extract-free growth control (Cos *et al*., 2006). Tests were assayed in triplicate in three independent experiments.

3.4.4. Use diversity study of medicinal plants

3.4.4.1. Data collection

All informants who participated in the ethnomedicinal survey of plants in the District were interviewed at the same time for their knowledge on local use diversity (additional uses) of plants cited for one or more of medicinal uses. Data obtained on local uses of multipurpose medicinal plants, through semi-structured interviews, focus group discussions, participant observation and walks-in-the-woods (Martin, 1995; Cotton, 1996), were all documented so as to evaluate overall use values and use diversity of species following Phillips and Gentry (1993a), Phillips (1996) and Byg and Balslev (2001).

3.4.4.2. Data analysis

Overall use values - To analyse overall use values of species, plants were grouped into eight different use categories adapted from the classification method proposed by Cook (1995). The categories used were:

1. Medicines: human and veterinary medicine.

2. Food: food for humans including beverages, and food additives/flavourings, spices and gums.

3. Fodder: feed for livestock.

4. Materials: handicrafts, construction materials, agricultural tools, roof thatch, dyes, pillow, instrument, tooth brush, comb, rope, drum, mortar and pestle.

5. Fuel: plants used as firewood and/or for making charcoal.

6. Social uses: including ritual and religious uses, stimulant drugs, smoking, cosmetics and baking agent.

7. Environmental uses: live fence, dry fence, hedges, shade, shelter, erosion control, ornamental and soil improvement.

8. Poison: toxic for human, livestock and other animals, insecticide and insect repellent.

Thus, use value (UV) of traditionally useful species was computed so as to make a quantitative assessment of the relative cultural importance of individual species following Phillips and Gentry (1993a) using:

$$UV=\sum Uis/ns$$

where: UVs= Use value of species s;

Uis = number of uses of species s mentioned by informant i;

ns = total number of informants/participants consulted on use of species s

Use Diversity values - Use Diversity (UD) values of species were also computed to estimate for how many use categories a plant species is used and how evenly these categories contribute to its total value following Byg and Balslev (2001). Thus, UDs were computed using Shannon-Wiener diversity index as suggested by Carretero (2005) and Paniagua (2005):

$$UDs= -\sum Pc * \ln (Pc)$$

where: UDs= use diversity value of species s; and

Pc = contribution of use category *c* to total utility of a species *s* (i.e. the number of times species s was mentioned by all participants within each category, divided by the total number of use reports of species s across all use categories). If a species is used in many use categories and its uses are evenly distributed over these categories, then it will have a high UDs value.

Use equitability - Use Equitability (UE) values were computed to measure how evenly different use categories contribute to total use of a species, independently of the number of use categories as described by Thomas (2008) using:

UE = UDs/UDsmax, here by UDsmax= ln(C),

where: UEs = use equitability of species s; UDs = use diversity value of species s; UDsmax = maximum use diversity of species s and C = the number of different use categories species s is used for.

CHAPTER FOUR

4. RESULTS

Results of this study brought forth information on different aspects of botanical and ethnomedicinal resources in Ankober District. The findings are presented under the plant diversity of Dense Forest, ethnomedicinal plants used in the District to treat human and livestock ailments, antimicrobial activities of selected medicinal plant species and the use diversity of traditional medicinal plants used by people in the area described in the following sections.

4.1. Plant diversity in Dense Forest

4.1.1. Floristic composition

A total of 158 plant species representing 143 genera and 75 families was identified in Dense Forest (Appendix 1). Forty-eight percent of the families were represented by more than one species. The highest number of species was recorded for families Asteraceae (20 species, 27%) and Fabaceae (nine species, 12%) followed by Asclepiadaceae, Lamiaceae, Myrsinaceae, Oleaceae, Rosaceae, Rubiaceae and Urticaceae (four species, 5% each). Eight of the families, i.e. Apiaceae, Crassulaceae, Euphorbiaceae, Loganiaceae, Ranunculaceae, Rhamnaceae, Scrophulariaceae and Solanaceae were represented by three species (4%) each. Nineteen (25.33%) of the families were represented by two species, whereas the remaining 39 (52%) families only had single-species representation. About 4.4% (seven species) of the total plant species in Dense Forest are endemic to Ethiopia (Appendix 1). Herbs were found to occur more abundantly (67 species, 42.4%) than trees (43, 27.2%), shrubs (35, 22.2%), climbers (both liana and herbaceous forms) (11, 7%) or epiphytes (two, 1.3%).

4.1.2. Plant community types in Dense Forest

Five plant community types were identified from the hierarchical cluster analysis (Figure 3). Species with the highest synoptic values in the group were used to name the corresponding communities (Table 1). Plot number 51 was found to be insufficiently similar to any other cluster and appeared as an outlier in the dendrogram output of the hierarchical analysis (Figure 3).

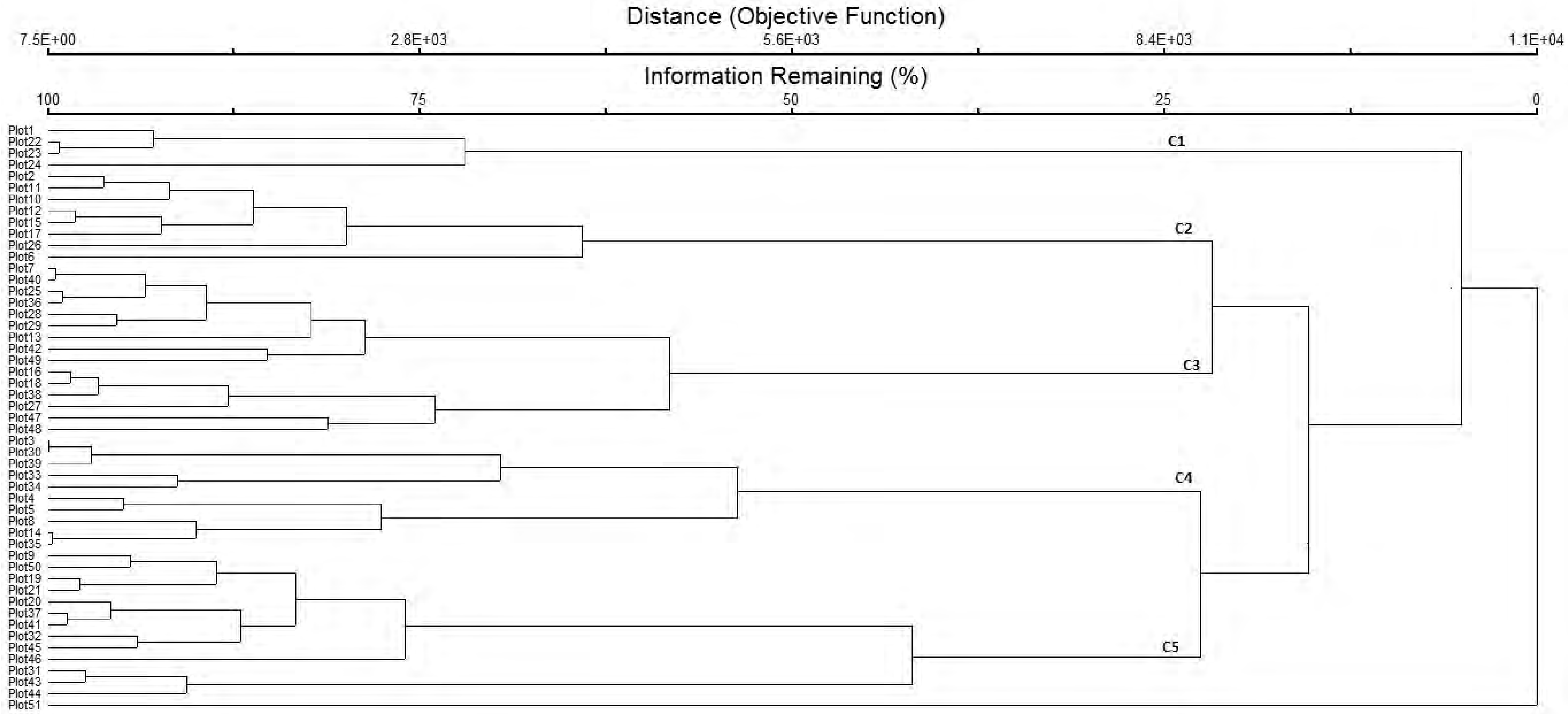


Figure 3. Dendrogram obtained from hierarchical cluster analysis of vegetation data of Dense Forest

The level of grouping was based on about 25% information remaining (C1= community type 1, C2= community type 2, C3= community type 3, C4= community type 4 and C5= community type 5)

Table 1. Synoptic cover abundance values of species reaching a value of > 0.5 in at least one community type in Dense Forest. Values in **bold** refer to species used to name community types.

Community	1	2	3	4	5
Cluster size	4	8	15	10	13
Erica arborea	**4.9**	0.0	0.0	0.0	0.0
Maesa lanceolata	0.0	**6.2**	3.1	3.4	3.2
Discopodium penninervium	0.0	**4.2**	3.3	4.0	1.8
Ilex mitis	0.0	2.9	0.0	2.2	1.2
Podocarpus falcatus	0.0	2.7	**6.8**	4.3	3.4
Allophylus abyssinicus	0.0	3.5	**5.8**	4.2	3.1
Juniperus procera	1.5	2.1	2.7	4.3	1.7
Dovyalis abyssinica	0.8	2.4	1.4	2.4	0.9
Hagenia abyssinica	0.0	1.3	0.0	0.5	0.0
Olea europaea subsp. *cuspidata*	0.0	3.8	3.3	**7.4**	3.1
Galiniera saxifraga	0.0	0.4	3.2	**6.3**	2.6
Nuxia congesta	0.0	2.9	0.9	2.9	0.5
Pavetta abyssinica	0.0	1.1	0.8	1.8	0.7
Ekebergia capensis	0.0	1.1	1.7	1.4	2.0
Dombeya torrida	0.0	0.0	0.0	1.5	0.5
Maytenus arbutifolia	0.0	2.3	4.2	4.8	**6.5**
Bersama abyssinica	0.0	4.1	4.2	3.8	**5.3**
Myrsine africana	0.0	0.0	1.0	1.3	2.4
Croton macrostachyus	0.0	0.8	0.6	0.0	2.2
Halleria lucida	0.0	0.0	0.0	0.0	0.7
Vernonia amygdalina	0.0	0.4	0.7	0.6	0.5

A description of the community types identified in Dense Forest is given below:

Community 1: *Erica arborea* Community Type

The *Erica arborea* community type was found to be distributed between 2821 and 2971 m a.s.l. It consisted of 22 species scattered in four releves. The upper canopy of the community type was dominated by *Erica arborea*. The understory was occupied by *Helichrysum schimperi*, *Helichrysum forsskahlii*, *Kniphofia foliosa*, *Cerastium octandrum* and *Plectocephalus varians.* Species such as *Conyza bonariensis*, *Anthemis tigreensis, Merendera schimperiana, Pelargonium glechomoides* and *Achyranthes aspera* also frequently occur in this community.

Community 2: *Maesa lanceolata-Discopodium penninervium* Community Type

Altitudinal distribution of this community type ranges from 2527 to 2921 m a.s.l. *Maesa lanceolata* and *Discopodium penninervium* were dominant species forming the upper canopy. The community comprised of 61 species distributed in eight plots. Species such as *Ekebergia capensis, Pavetta abyssinica, Dovyalis abyssinica, Juniperus procera* and *Podocarpus falcatus* were also found in a few numbers in this community type. *Impatiens tinctoria, Inula confertiflora, Kalanchoe petitiana, Pennisetum sphacelatum* and *Thalictrum rhynchocarpum* were found to be common in the herbaceous layer of this community.

Community 3: *Podocarpus falcatus-Allophylus abyssinicus* Community Type

This community occurred in 15 quadrats stretching from 2217 to 2819 m a.s.l. and had 88 species. The upper layer was dominated by large-sized *Podocarpus falcatus* and *Allophylus abyssinicus* trees. It also contained some other important species including *Olea europaea* subsp. *cuspidata, Polyscias fulva, Juniperus procera, Croton macrostachyus, Ekebergia capensis, Hagenia abyssinica, Teclea nobilis* and *Prunus africana.* The herb layer of this community included species such as *Thymus schimperi, Tagetes minuta, Rumex nepalensis, Ipomoea obscura* and *Cyperus atroviridis.*

Community 4: *Olea europaea-Galiniera saxifraga* Community Type

This community type was found between 2522 and 2900 m a.s.l. It was composed of 63 species distributed in ten different quadrats. The upper canopy was dominated by

Olea europaea subsp. *cuspidata* and *Galiniera saxifraga*. The community also bears other species such as *Olinia rochetiana, Myrsine africana, Myrsine melanophloeos, Halleria lucida, Ilex mitis* and *Dovyalis abyssinica* distributed over different plots. The understory was dominated by *Urtica simensis, Plantago lanceolata, Laggera tomentosa, Kalanchoe petitiana, Impatiens tinctoria, Hypoestes aristata* and *Cyperus atroviridis*.

Community 5: *Maytenus arbutifolia-Bersama abyssinica* Community Type

This community type was composed of 76 species distributed in 13 plots stretching between 2125 and 2900 m a.s.l. The upper canopy was dominated by *Maytenus arbutifolia* and *Bersama abyssinica*. *Epilobium hirsutum, Buddleja davidii, Buddleja polystachya, Lobelia gibberroa, Osyris quadripartita, Ricinus communis, Carissa spinarum* and *Solanecio gigas* were also common in this community. Climbers including *Embelia schimperi, Dregea schimperi* and *Cissampelos mucronata* were frequent. The herb layer was composed of species such as *Trifolium semipilosum, Tagetes minuta, Cyathula cylindrica* and *Persicaria senegalensis.*

Comparison among the identified plant communities of Dense Forest showed the highest value of overall species richness (88) for community 3, species diversity (Shannon's diversity) (3.55) for community 5, and species evenness (0.82) for community 4 (Table 2).

Table 2. Overall species richness, diversity and evenness values of the five plant communities identified in Dense Forest

Community types	Altitudinal range	Species Richness (S)	Shannon-Wiener Diversity Index (H')	Shannon's evenness index (J)
1: *Erica arborea*	2821- 2971	22	2.40	0.77
2:*Maesa lanceolata - Discopodium penninervium*	2527-2921	61	3.20	0.78
3: *Podocarpus falcatus - Allophylus abyssinicus*	2217-2819	88	3.30	0.74
4: *Olea europaea-Galiniera saxifraga*	2522-2900	63	3.41	0.82
5: *Maytenus arbutifolia- Bersama abyssinica*	2125-2900	76	3.55	0.81
Overall	2125-2971	158	4.07	0.80

In addition, overall species similarity analysis of the five plant communities showed more floristic similarity (0.68) between communities three and five, than between any of the others. The least species similarity with any other community was recorded for community one (Table 3).

Table 3. Sorensen's similarity analysis of floristic composition of plant communities in Dense Forest

Community types	1	2	3	4	5
1: *Erica arborea*					
2: *Maesa lanceolata - Discopodium penninervium*	0.19				
3: *Podocarpus falcatus - Allophylus abyssinicus*	0.23	0.48			
4: *Olea europaea-Galiniera saxifraga*	0.28	0.41	0.66		
5: *Maytenus arbutifolia- Bersama abyssinica*	0.36	0.39	0.68	0.65	

4.1.3. Vegetation structure of the Dense Forest

4.1.3.1. Density of trees and shrubs

The overall tree and shrub species density in Dense Forest was 1,138 individuals ha^{-1}. The density of trees and shrubs with DBH > 2 cm was 478 individuals ha^{-1}. The density of those species with DBH > 10 cm was 395.20 individuals ha^{-1} whereas that of species with DBH > 20 cm was 264.92 individuals ha^{-1} (Appendix 5). Thus, the ratio of density of trees with DBH greater than 10 cm to DBH greater than 20 cm in Dense Forest was 1.5. About 42% of overall tree density came from species with DBH > 2 cm, whereas those with DBH > 10 cm and 20 cm contributed, respectively, 35% and 23% to overall tree density.

Eight common species in Dense Forest contributed 75.25% of the density of trees with DBH > 2 cm, 76.29% of the density with DBH >10 cm, and 75.35% of tree density with DBH > 20 cm. Among these, *Podocarpus falcatus* was found to have the highest density and percentage in both DBH > 2 cm and > 10 cm classes, whereas *Olea europaea* subsp. *cuspidata* was found to have the highest density distribution in DBH > 20 cm class followed by *Allophylus abyssinicus* (Table 4). All the eight common trees with highest density contribution in Dense Forest were reported for one or more traditional medicinal uses in the District.

Table 4. Density and percentage contribution of the eight most-common tree species in Dense Forest

	DBH > 2 cm		DBH > 10 cm		DBH > 20 cm	
Species name	Density	%	Density	%	Density	%
Olea europaea subsp. *cuspidata*	48.15	17.00	48.15	12.18	47.06	17.76
Allophylus abyssinicus	42.48	8.89	40.74	10.31	38.56	14.56
Podocarpus falcatus	81.92	17.14	58.39	14.77	31.81	12.01
Maesa lanceolata	58.61	12.26	51.42	13.01	27.89	10.53
Bersama abyssinica	47.06	9.84	37.04	9.37	19.17	7.24
Galiniera saxifraga	23.31	4.88	22.00	5.57	18.3	6.91
Maytenus arbutifolia	28.54	5.97	24.84	6.28	12.20	4.61
Discopodium penninervium	29.63	6.20	18.95	4.80	4.58	1.73
Total	359.70	75.25	301.53	76.29	199.57	75.35

4.1.3.2. Diameter at Breast Height (DBH)

The percentage distribution of trees and shrubs in Dense Forest across seven DBH classes indicated a relatively high proportion of individuals in DBH class 10-20 cm (27.26%) and DBH class 20-50 cm (25.52%). The lowest proportion of individuals was recorded for DBH class 110-140 cm (Figure 4). *Allophylus abyssinicus*, *Podocarpus falcatus*, *Olea europaea* subsp. *cuspidata*, *Juniperus procera*, *Ficus sur*, *Olinia rochetiana*, *Bersama abyssinica*, *Myrica salicifolia*, *Maesa lanceolata* and *Olea capensis*. subsp. *macrocarpa* were found to be the dominant large-sized trees in Dense Forest, with DBH >110 cm. The percentage distribution of individual tree species in Dense Forest across seven DBH classes is given in Appendix 6.

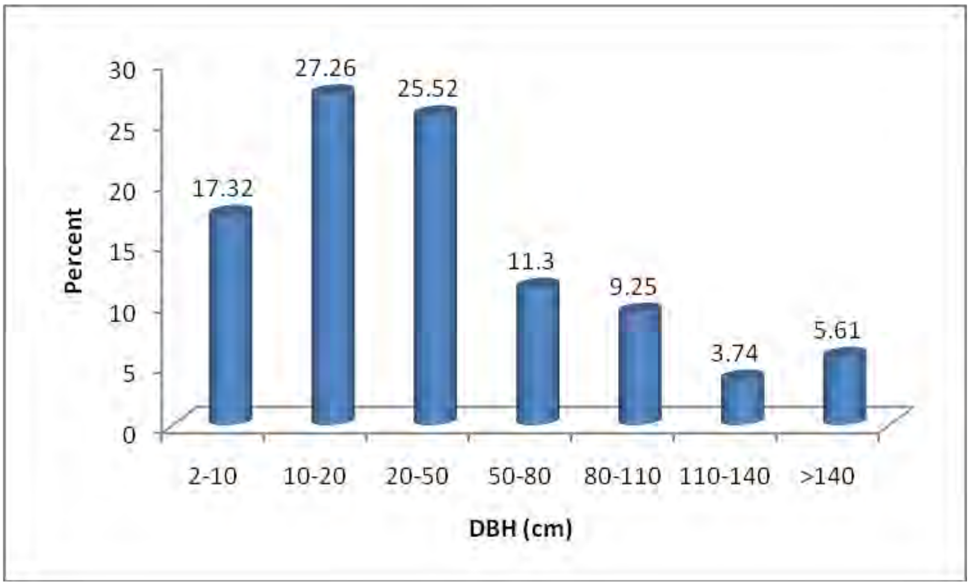


Figure 4. Proportion of DBH class distributions of trees and shrubs in Dense Forest

4.1.3.3. Basal area (BA)

Total basal area of trees in Dense Forest was 66.5 m^2/ha (Appendix 7). About 79% of the total basal area was contributed by six large-sized tree species, i.e. *Olea europaea* subsp. *cuspidata*, *Juniperus procera*, *Podocarpus falcatus*, *Ficus sur*, *Allophylus abyssinicus* and *Bersama abyssinica* (Table 5). These six species were also cited for one or more traditional remedial uses in the study area.

Table 5. Basal area (BA) (m^2 ha^{-1}) and percentage contribution of six most dominant trees in Dense Forest

Species	**BA (m^2/ha)**	**Percent contribution**
Olea europapea subsp. *cuspidata*	22.20	33.42
Podocarpus falcatus	13.80	20.72
Juniperus procera	8.40	12.70
Ficus sur	3.10	4.68
Allophylus abyssinicus	2.90	4.34
Bersama abyssinica	2.20	3.34
Total	**52.60**	**79.2**

4.1.3.4. Frequency

Maesa lanceolata was found to be the most frequent species in Dense Forest occurring in 90% of all quadrats sampled. Species such as *Bersama abyssinica* (86.27%), *Podocarpus falcatus* (84.86%) and *Olea europaea* subsp. *cuspidata* (78.43%) were also common across quadrats. A list of most frequent trees occurring at least in 20% of quadrats sampled is given in Table 6, and frequency of all species documented from Dense Forest with DBH > 2 cm is given in Appendix 8.

Table 6. Most-frequent trees and shrubs in Dense Forest

Scientific name	**Frequency (%)**
Maesa lanceolata	90.20
Bersama abyssinica	86.27
Podocarpus falcatus	84.31
Olea europaea subsp. *cuspidata*	78.43
Maytenus arbutifolia	78.00
Allophylus abyssinicus	74.51
Discopodium penninervium	72.55
Dovyalis abyssinica	56.86
Galiniera saxifraga	52.94
Myrsine africana	39.22
Juniperus procera	35.29
Pavetta abyssinica	31.37
Ekebergia capensis	23.53
Solanecio gigas	23.53
Nuxia congesta	21.57
Osyris quadripartita	21.57

4.1.3.5. Importance Value Index (IVI)

The highest IVI values were recorded for six of the most frequent trees in Dense Forest. The highest IVI value was recorded for *Olea europaea* subsp. *cuspidata* (57.63) followed by *Podocarpus falcatus* (45.61) (Table 7). All six species with the highest IVI values were cited for one or more traditional remedial uses in the District.

Table 7. IVI values of six most-frequent trees in Dense Forest

Scientific name	Relative density	Relative frequency	Relative dominance	IVI
Allophylus abyssinicus	8.89	6.85	4.344	20.08
Bersama abyssinica	9.85	7.93	3.342	21.12
Galiniera saxifraga	4.88	4.87	2.01	11.76
Maesa lanceolata	12.26	8.29	2.34	22.89
Olea europaea subsp. *cuspidata*	17.00	7.21	33.42	57.63
Podocarpus falcatus	17.14	7.75	20.72	45.61

4.1.3.6. Population structure

The population structures of the 20 most-common tree species in Dense Forest were analysed and five representative patterns were identified (Figure 5a-e).

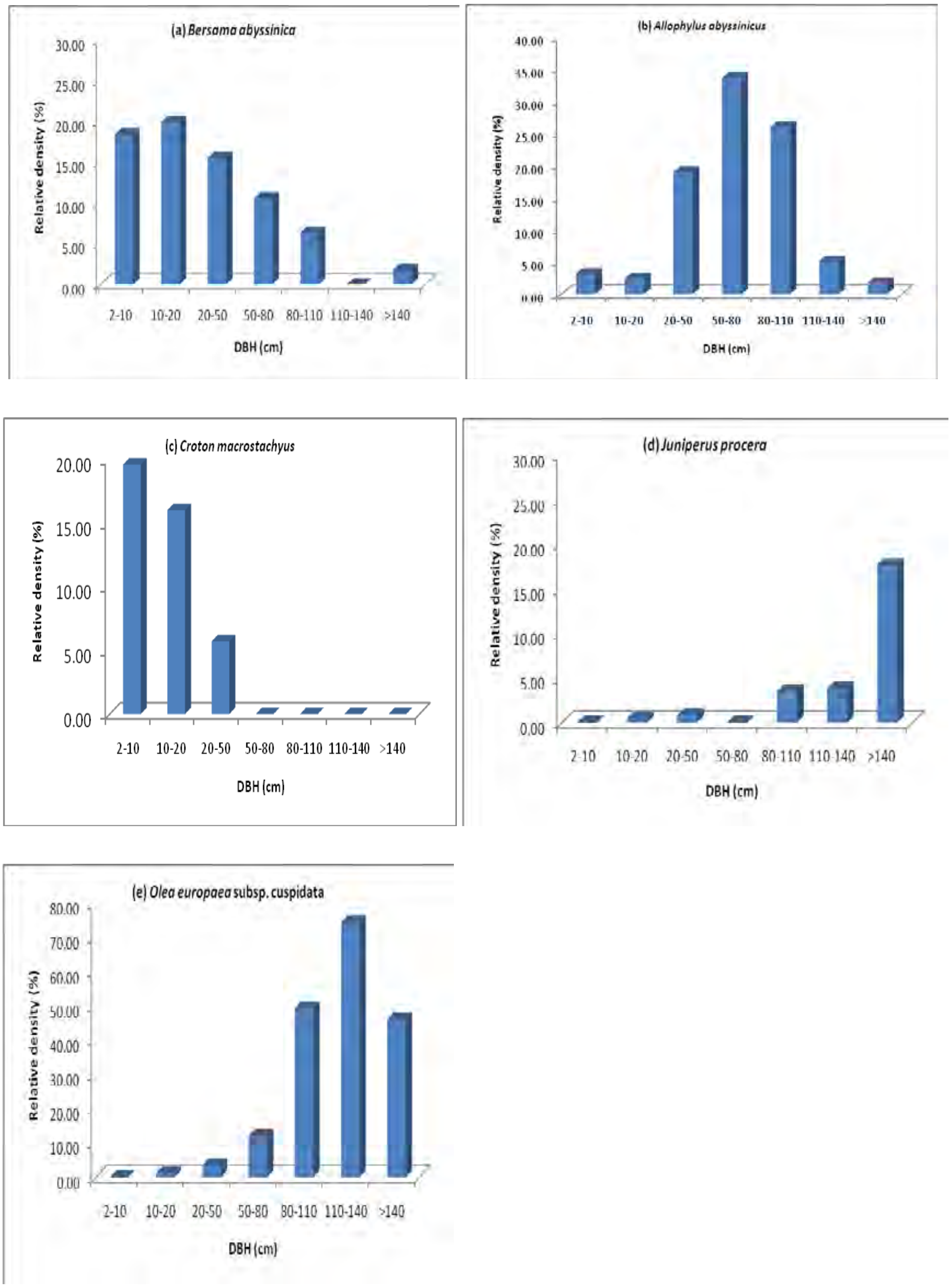


Figure 5 (a-e). Representative patterns of species population structures in Dense Forest

4.2. Ethnobotany of medicinal plants in Ankober District

A total of 151 medicinal plant species that belong to 141 genera and 75 families consisting of one fern, two gymnosperm and 72 angiosperm families was reported in the District. Of the 151 species, 135 species (89%) were cited for their uses to treat human ailments whereas 51 (34%) species were reported for treating livestock ailments and 34 (23%) species for their therapeutic uses against various ailments affecting both humans and livestock (Figure 6).

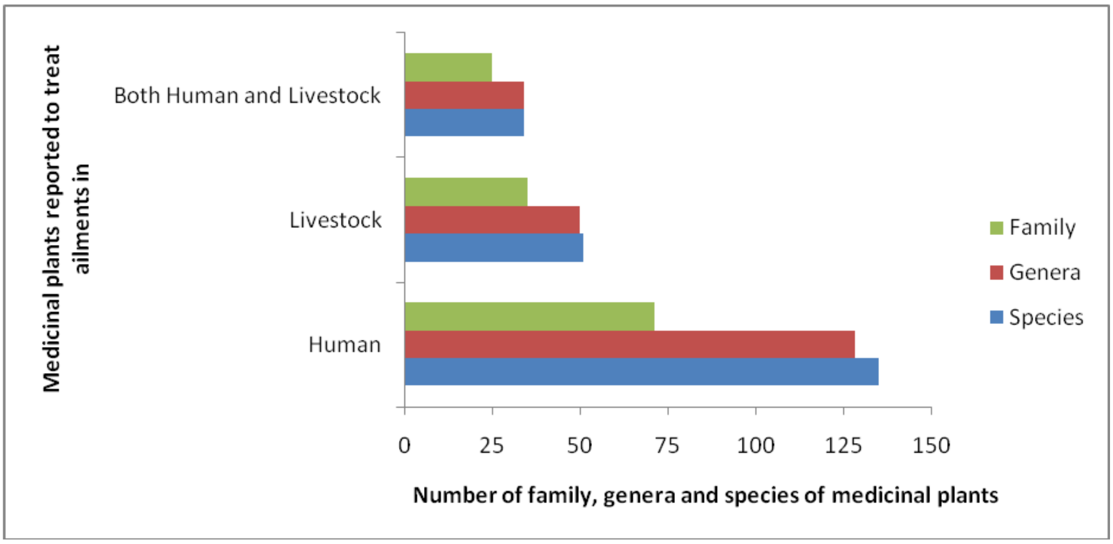


Figure 6. Number of families, genera and species of medicinal plants used to treat human, livestock or both human and livestock ailments in Ankober District

About 6% (nine species) of the medicinal plants of the District were found to be endemic to Ethiopia. The families with the highest number of medicinal plant species representation (contributing more than 10 species) were Asteraceae (13 species, 9%) and Fabaceae (11, 7.3%). About 39% of families were represented by more than one medicinal plant species (Figure 7).

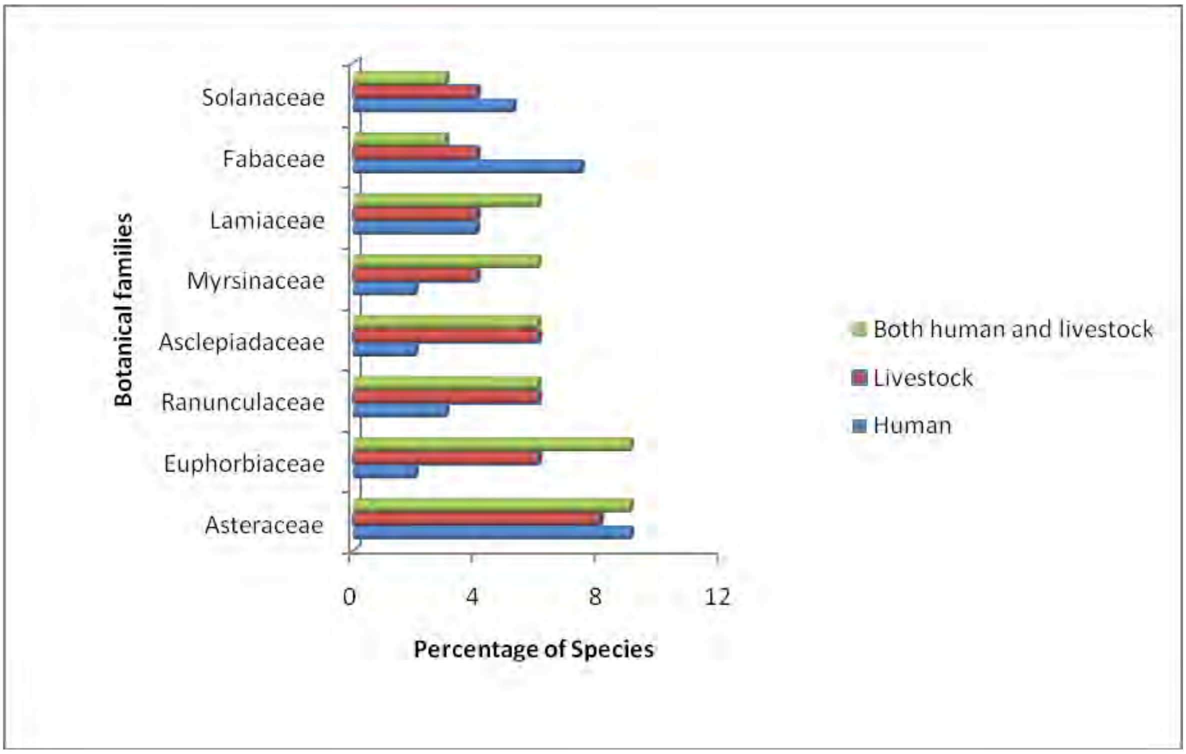


Figure 7. Best-represented families of medicinal plant species (%) used to treat human, livestock or both human and livestock ailments in Ankober District

4.2.1. Ethnomedicinal plants used to treat human ailments

4.2.1.1. Diversity of reported medicinal plants

A total of 135 medicinal plant species belonging to 128 genera and 71 families (68 angiosperms, 2 gymnosperms and 1 fern) were reported to be used for treating human ailments in Ankober District (Appendix 2). Family Asteraceae was represented by the highest number of species (12 species, 9%), followed by Fabaceae (ten, 7.4%), Solanaceae (seven, 5.2%), Lamiaceae (six, 4%), and Cucurbitaceae, Ranunculaceae and Rosaceae (four species each, 3%). Eight of the reported families, i.e. Acanthaceae, Asclepiadaceae, Celastraceae, Myrsinaceae, Oleaceae, Rubiaceae, Rutaceae and Euphorbiaceae were represented by three species each, whereas eight others, i.e. Amaranthaceae, Apiaceae, Apocynaceae, Boraginaceae, Polygonaceae, Sapindaceae, Scrophulariaceae and Urticaceae were represented by two species each. Each of the remaining 48 families had single-species representation. Thus, 32% of the families were represented by more than one medicinal plant species. Identified growth forms of medicinal plants indicated that herbs (51 species; 38%) were more dominant than shrubs (43; 32%) or trees (32; 24%). About 6% (eight species) of medicinal plants used for treating human ailments in Ankober were shown to be endemic to Ethiopia (Appendix 2).

4.2.1.2. Disease types and treatment methods

About 69 disease types, affecting humans, were identified in Ankober District to be treated by traditional medicinal plants (Appendix 2). Constipation, diarrhoea and taeniasis were the most commonly reported human health problems under the gastro-intestinal disease category, whereas atopic eczema was the most frequently reported ailment under the dermatological disease group.

Visual inspection and interviews were the commonly reported diagnosis methods for humans prior to any herbal medicine prescription. Depending on types of ailments reported, traditional healers interview patients for symptoms, followed by visual inspection of eyes, skin colour, tongue, throat, status of sores, bleeding and infections, and sensing body temperature of their patients with their bare hands. Patients with skin infections were reported to be treated by rubbing and pasting herbal preparations, whereas those with sores were treated by chewing the ative part of the medicinal plant and spitting the juice on the sore. For internal ailments, herbal preparations were mainly prescribed to be administered orally, whereas for a general malaise steam bath and vapour inhalation were commonly reported.

4.2.1.3. Plant parts used for remedy preparation

Despite mentioning many plant parts being used for remedy preparation, the majority (44%) of preparations for treating human ailments are solely based on root parts, followed by leaves (17%) alone, and mixtures of roots and leaves (11%) (Figure 8). Plants in which roots (82 species, 61%) and leaves (48 species, 36%) are utilized as medicine either solely or mixed with other plant parts were most frequent in the medicinal flora of the District. Freshly harvested plant parts were the dominant ones (69.9%) used in remedy preparation, whereas dried parts were used least (2.73%); the remaining 27.4% of remedies were reported to be prepared both from dried or fresh parts of medicinal plant species.

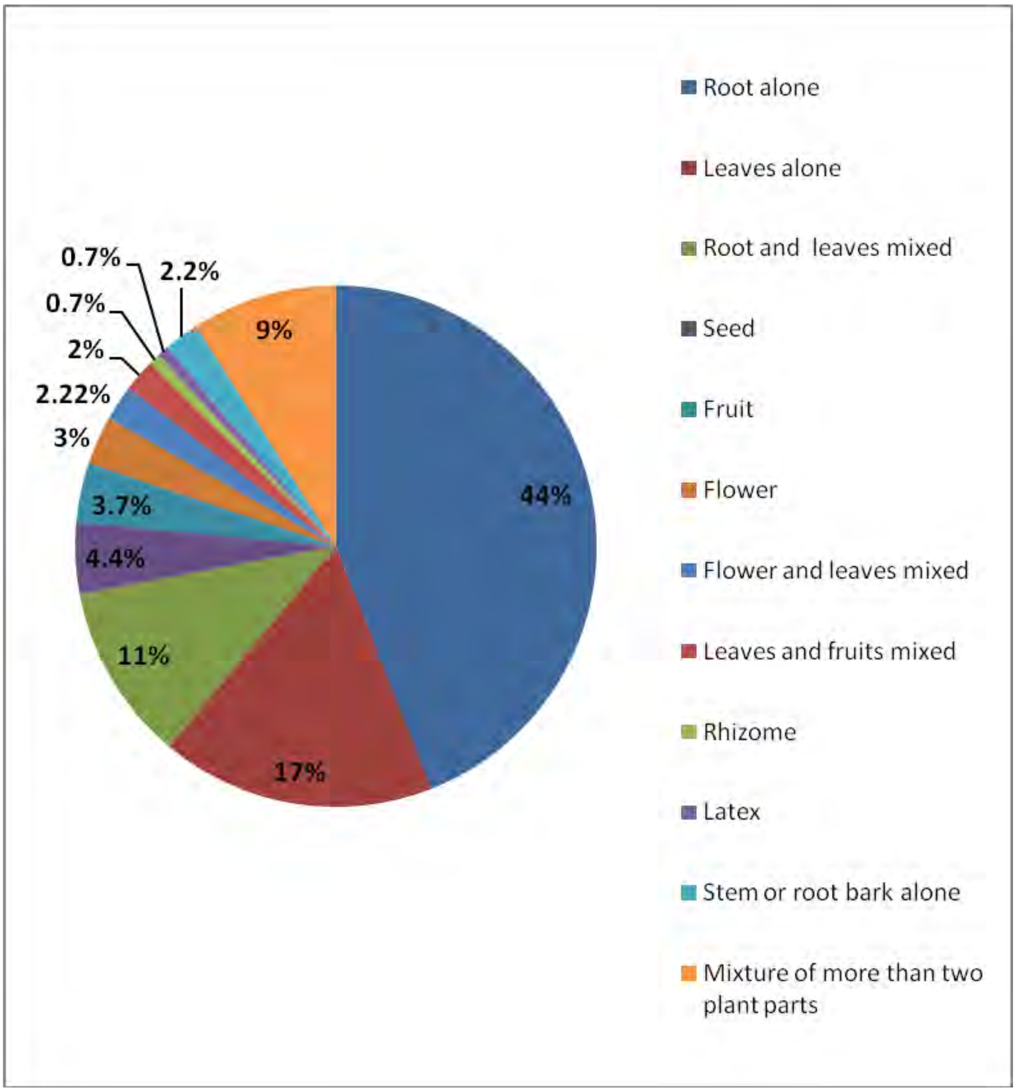


Figure 8. Plant parts used (%) for remedy preparartion to treat human ailments in Ankober District

4.2.1.4. Modes of remedy preparation and application

Traditional healers in the study area reported that they follow various ways of remedy preparation wherby the latter depends, according to their explanations, on the type of ailment which they classify/identify based on symptoms observed on patients. The major modes of remedy preparation for human ailments were decoction (36.47%); extracting juice, oil or latex from the plant (18.54%), and pounding and homogenizing plant parts (14%) (Figure 9).

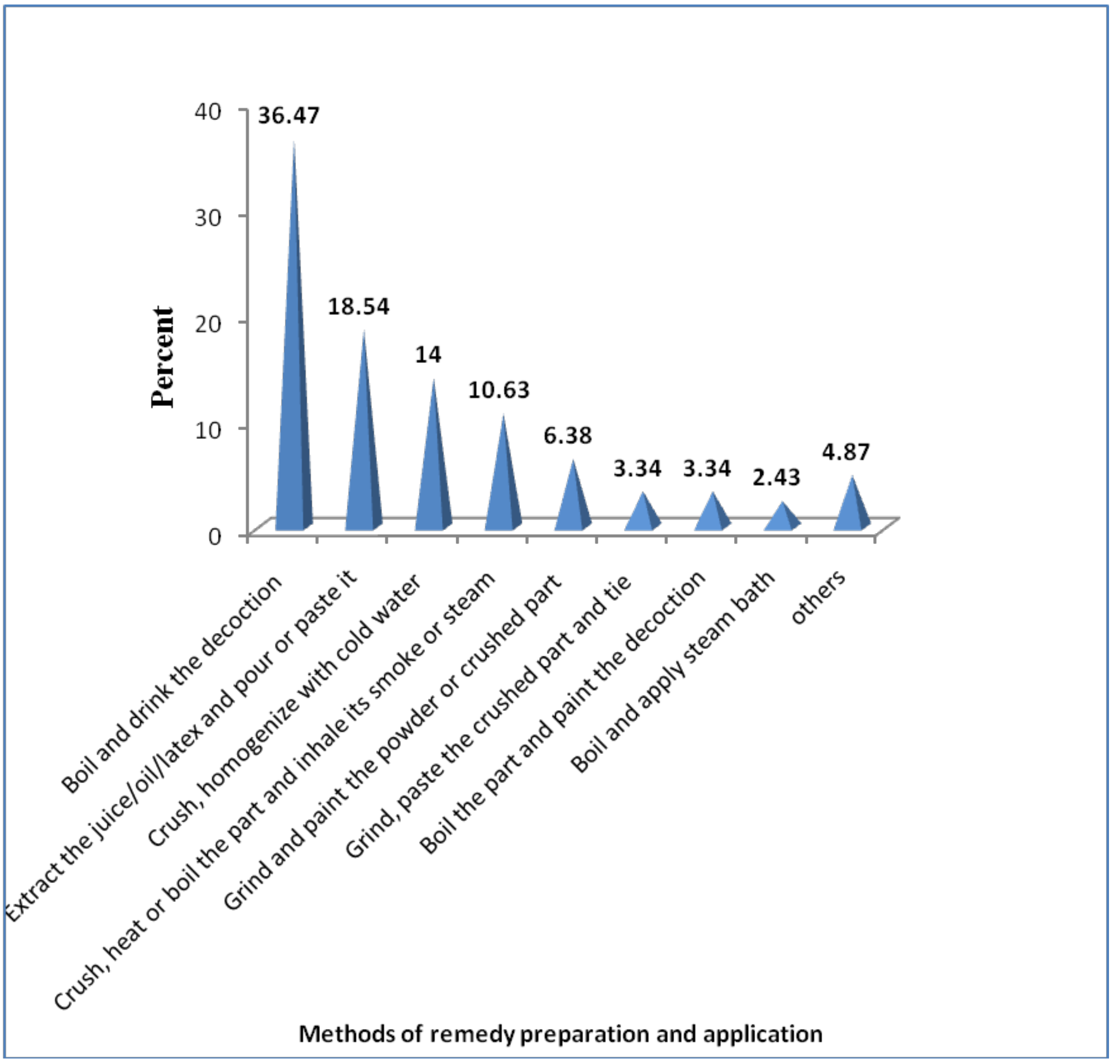


Figure 9. Modes of remedy preparation and application (%) to treat human ailments in Ankober District

4.2.1.5. Routes of administration

Different routes of administration of medicinal plant preparations used in the traditional treatment system against various human ailments were documented. Oral application (181 preparations, 55.01 %) was the best-represented and most commonly used route of administration, followed by topical or dermal application (81 preparations, 25%). The remaining remedies were reported to be administered through nasal (42 preparations, 12.76%); auricular (12 preparations, 3.64%); anal (eight preparations, 2.43%) or optical (five preparations, 1.51%) routes depending on the type of ailment reported by the respective patients.

4.2.1.6. Dosages and antidotes

Traditional medicinal plants prescribed and given to patients are applied mainly without clearly standardised doses. However, approximate dosages (although without any fixed standards) were reported to be determined based on age, gender, pregnancy status and physical appearance of patients visiting local healers. Some medicinal plant preparations were mentioned to be measured in small cups, locally called YEBUNA SINI referring to traditional cups used for drinking coffee or plastic jugs, while others were measured as handful, spoonful or size of a finger. Coffee, milk, honey, yoghurt, butter and dissolved powder of roasted barley, locally known as BESSO were the commonly reported antidotes for herbal preparations with adverse side effects.

4.2.1.7. Marketability of medicinal plants

Out of the 25 (19%) species of medicinal plants claimed to treat human ailments for which information was provided about marketability, only five species, i.e. *Echinops kebericho*, *Embelia schimperi*, *Hagenia abyssinica*, *Withania somnifera* and *Silene macrosolen* were actually found on markets being sold and purchased for the purposes of their medicinal applications. The remaining medicinal plants listed as marketed were mainly sold in bulk for their non-medicinal uses but are occasionally also applied as medicine when the need arises. The average price of a cup (YEBUNA SINI) (≈103 g) of *Embelia schimperi* fruits at Aliuamba, Derefo, Gorabela, Gorgo, Haramba and Zego local markets was 5.50 Ethiopian Birr (0.3 USD), whereas for a bunch (≈250-325 g) of the root material of *Echinops kebericho* or *Silene macrosolen* it was 4 Birr (0.21 USD). A jug of *Hagenia abyssinica* inflorescence was sold for four Birr (0.21 USD).

4.2.1.8. Efficacy of medicinal plants

About twelve disease categories were identified from the total of 69 human ailments reported in the District. Amongst these, the categories with the highest ICF values were gastro-intestinal and parasitic, and dermatological diseases (0.70 each) which were followed by respiratory (0.65), and oral, dental and pharyngeal diseases (0.62) (Table 8). The highest plant use citation (19.75%) was found for gastro-intestinal and parasitic diseases, followed by dermatological diseases (12.46%).

Table 8. ICF values of traditional medicinal plants used for treating human ailments in Ankober District

No	Disease category	No of Species	% all species	Use citations	% all use citations	ICF
1	Gastro-intestinal and parasitic (Intestinal parasites)	20	14.81	65	19.75	0.70
2	Dermatological	13	9.62	41	12.46	0.70
3	Respiratory	7	5.18	18	5.47	0.65
4	Oral, dental and pharyngeal	6	4.44	14	4.25	0.62
5	Sensorial	8	5.92	17	5.16	0.56
6	Urogenital and venereal	15	11.11	30	9.11	0.52
7	Febrile	11	8.14	21	6.38	0.50
8	External injuries, bleeding and snake bite	13	9.62	19	5.77	0.33
9	Musculoskeletal and nervous system	21	15.55	28	8.51	0.26
10	Blood and lymphatic system	18	13.33	24	7.29	0.26
11	Evil spirit	21	15.55	22	6.68	0.05
12	Others	29	21.48	31	9.42	0.06

4.2.1.9. Relative healing potential of medicinal plants used for treating human ailments

The highest fidelity level (95%) was recorded for *Zehneria scabra* followed by *Hagenia abyssinica* (93.75%), *Ocimum lamiifolium* (93.33%) and *Thalyctrum rhynchocarpum* (91.6%) (Table 9). The highest fidelity level values recorded for *Zehneria scabra* and *Ocimum lamiifolium* were both obtained under the febrile therapeutic category. In contrast, the highest fidelity level values of *Hagenia* *abyssinica* and *Thalictrum rhynchocarpum* were both found in the gastro-intestinal and parasitic disease categories.

Table 9. Fidelity level values of medicinal plants commonly reported against a given human ailment category

No	Medicinal plant	Therapeutic category	Ip*	Iu*	FL (%)*
1	*Zehneria scabra*	Febrile	19	20	95.00
2	*Hagenia abyssinica*	Gastro-intestinal and parasitic	15	16	93.75
3	*Ocimum lamiifolium*	Febrile	14	15	93.33
4	*Thalictrum rhynchocarpum*	Gastro-intestinal and parasitic	22	24	91.60
5	*Echinops kebericho*	Evil spirit	17	19	89.47
6	*Croton macrostachyus*	Dermatological	23	26	88.46
7	*Embelia schimperi*	Gastro-intestinal and parasitic	14	16	87.50
8	*Cyathula cylindrica*	External injuries, bleeding and snake bite	11	13	84.60
9	*Jasminum abyssinicum*	Gastro-intestinal and parasitic	10	13	76.92
10	*Olea europaea* subsp. *cuspidata*	Dermatological	15	18	83.33
11	*Asparagus africanus*	Urogenital and venereal	7	10	70.00

*FL= Fidelity Level, Ip = number of informants who independently cited the importance of a species for treating a particular disease, Iu = total number of informants who reported the plant for any given disease

4.2.1.10. Factors threatening multipurpose medicinal plants

The output of the direct matrix ranking (DMR) exercise on ten multipurpose medicinal plants used for treating human ailments enabled to identify which of the multipurpose plants is under greater pressure than other species in the area alongwith the respective factors that threaten the plants. Accordingly, *Podocarpus falcatus* was ranked first (most - threatened) followed by *Olea europaea* subsp. *cuspidata* and *Ekebergia capensis* (Table 10). Results indicated that these multipurpose medicinal plant species are currently exploited more for construction, firewood and lumbering purposes than for their medicinal uses.

4.2.1.11. The most-preferred plants for treating human ailments

The output of preference ranking exercise on medicinal plants that were reported to be used against atopic eczema, the most frequently reported disease in the dermatological disease category, showed that *Olea europaea* subsp. *cuspidata* is the most-preferred species to treat the reported disease. *Allium sativum* and *Datura stramonium* were ranked 2nd and 3rd, respectively, to treat atopic eczema (Table 11).

Table 10. Average DMR score of fifteen key informants for ten medicinal plant species with additional uses

Use diversity	*Bersama abyssinica*	*Cordia africana*	*Croton macrostachyus*	*Dombeya torrida*	*Ekebergia capensis*	*Eucalyptus globulus*	*Juniperus procera*	*Olea europaea* subsp. *cuspidata*	*Podocarpus falcatus*	*Prunus africana*	**Total**	**Rank**
Agricultural tool	3	1	2	4	4	2	1	3	5	3	**28**	**5**
Construction	2	4	2	4	4	5	5	5	5	5	**41**	**1**
Lumbering	2	2	2	4	5	1	4	4	5	5	**34**	**3**
Firewood	4	3	4	5	4	5	4	5	3	3	**40**	**2**
Charcoal	2	3	1	3	3	0	3	3	4	1	**23**	**6**
Medicine	4	2	5	2	3	5	3	4	3	2	**33**	**4**
Total	**17**	**15**	**16**	**22**	**23**	**18**	**20**	**24**	**25**	**19**		
Rank	**8**	**10**	**9**	**4**	**3**	**7**	**5**	**2**	**1**	**6**		

Based on use criteria (5= best; 4= very good; 3=good;2= less used; 1=least used and 0= no value)

Table 11. Results of preference ranking of seven medicinal plants reported for treating atopic eczema

Medicinal plants for atopic eczema	Informants labelled A to O																
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Total score	Rank
Allium sativum L.	6	5	6	7	4	4	5	6	7	6	4	5	4	5	7	81	**2**
Asparagus africanus Lam.	1	2	3	2	1	3	1	2	1	7	3	1	1	7	1	36	**6**
Clematis hirsuta Perr. & Guill.	3	4	2	1	2	1	3	3	2	1	1	2	3	2	2	32	**7**
Croton macrostachyus Del.	4	3	4	5	7	5	4	4	3	4	7	3	5	6	3	67	**4**
Datura stramonium L.	5	7	5	3	6	7	6	5	6	3	5	4	6	3	5	76	**3**
Olea europaea L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	7	6	7	6	5	6	7	7	5	5	6	6	7	4	6	90	**1**
Solanum anguivi Lam.	2	1	1	4	3	2	2	1	4	2	2	7	2	1	4	38	**5**

N:B-Scores in the table indicate ranks given to medicinal plants based on their efficacy. Highest number (7) given for the medicinal plant which informants thought most effective in treating atopic eczema and the lowest number (1) for the least effective plant.

4.2.2. Ethnoveterinary medicinal plants

4.2.2.1. Ethnoveterinary medicinal plant diversity in Ankober District

A total of 51 ethnoveterinary medicinal plant species representing 50 genera and 35 families were identified in the District (Appendices 3 and 16). Thirty-one percent of the families were represented by more than one species. The highest number of species was recorded for family Asteraceae (four species, 8%), followed by Asclepiadaceae, Euphorbiaceae and Ranunculaceae (three, 6% each). Seven of the reported families, i.e. Fabaceae, Lamiaceae, Menispermaceae, Myrsinaceae, Plantaginaceae, Rubiaceae and Solanaceae were represented by two (4%) species each. The remaining 24 (69%) families had single-species representation. About 6% (three species) of the ethnoveterinary medicinal plants of Ankober District are endemic to Ethiopia (Appendix 3).

Regarding the growth forms of plants of ethnoveterinary importance, there were more shrubs (23 species, 45%), followed by herbs (13, 25%), trees (ten, 20%) and climbers (five, 10%). About 80 % (41 species) of the documented ethnoveterinary plant species were harvested from the wild, whereas 6% (three species) were cultivated, and the remaining 14 % (seven species) were collected from both wild and cultivated sources. Deforestation (reported by 89% of informants); agricultural expansion (80%), charcoal making and firewood collection (33%) and overgrazing (29%) were claimed as major factors affecting the ethnoveterinary plant wealth of the area.

4.2.2.2. Types of livestock ailments and traditional diagnosis methods

A total of 33 veterinary ailment types were identified in the study area for which informants reported to use one or more medicinal plant species (Appendix 3). Most of

(18%, six ailment types) the veterinary ailments belong to the gastro-intestinal disease category, followed by dermatological (15%, five), and parasitic and respiratory (12% each, four) disease categories. Diarrhoea and mange were found to be the most commonly reported forms of veterinary ailments in the District.

Traditional medicine practitioners diagnose veterinary ailments based on observation of the animals and/or information obtained by interviewing the livestock owners about major symptoms shown by the diseased animals. Ethnoveterinary medicinal plant remedies are commonly prescribed only after the diseased animal is visually examined by a traditional healer for any symptom on its mouth or foot parts, throat, eyes, nose, ear and/or skin as well as through presence and status of sores/wounds or any form of infection. Rubbing and pasting ethnoveterinary herbal preparations were the commonly reported treatment methods for handling dermatological diseases, whereas oral administration of homogenized herbal preparations was reported as the main treatment method for internal ailments.

4.2.2.3. Applications of ethnoveterinary remedies

Although ethnoveterinary medicinal plants of the District are claimed to be applied for ailments affecting cattle, sheep, goats, equines, camels or chicken, the majority of the reported medicinal plant species (92%, 47 species) was found to be applied to treat one or more of the thirty different cattle ailments (Appendix 3). A relatively low number of species (10%, five species) was mentioned to be used specifically against chicken ailments (Figure 10).

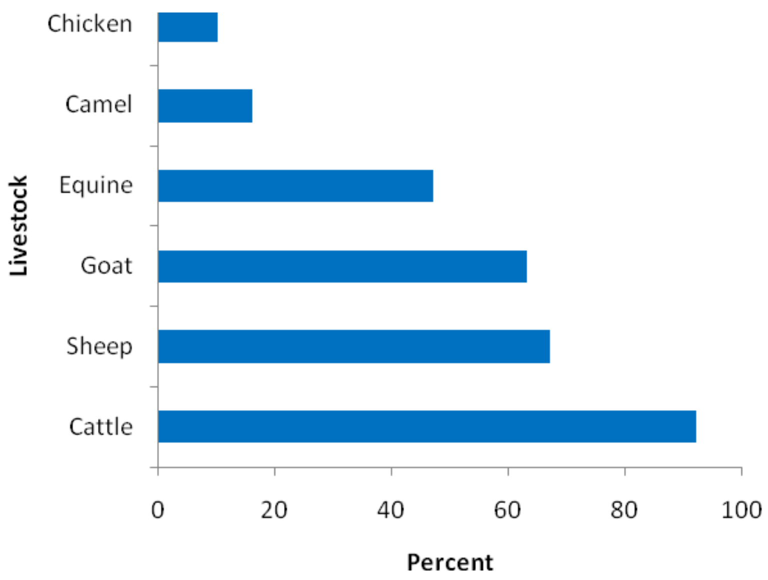


Figure 10. Percentage of ethnoveterinary plants used for different livestock types in Ankober District

Most ethnoveterinary medications (86%) were reported to comprise remedial parts of a single medicinal plant. The remaining, 14% were prepared using formulations from two or more species. Amongst all plants reported, the highest proportion of species was claimed to treat diarrhoea (24%), mange (20%), ringworm and black leg (16% each) and bloat (14%). The highest number of multiple ethnoveterinary uses was recorded for *Allium sativum* (used against eight ailment types) and *Croton macrostachyus* (seven ailment types) (Appendix 3).

4.2.2.4. Plant parts used for ethnoveterinary remedy preparation

Despite different plant parts reported to be used for remedy preparation by the community, the majority (31%) of preparations was found to be from roots alone, followed by mixtures of leaves and roots (21%) and leaves alone (18%) (Figure 11). Plants in which roots (65%, 33 species) and leaves (43%, 22 species) are utilized as ingredient (either alone or mixed with other plant parts) were also frequent in the ethnoveterinary plant lore of the District. Freshly harvested plant parts were the dominant ones used in remedy preparation (83%) whereas the remaining 17% of remedies were reported to be prepared both from dried or fresh parts of documented plant species.

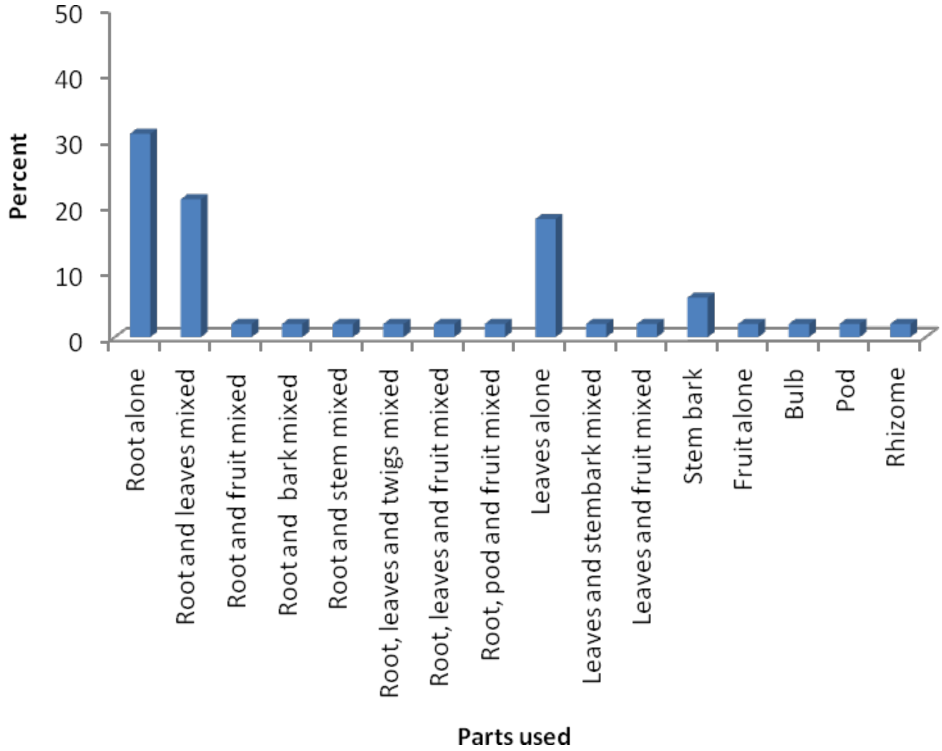


Figure 11. Plant parts used for ethnoveterinary remedy preparation in Ankober District

4.2.2.5. Modes of remedy preparation, routes of administration and dosages

Various modes of ethnoveterinary remedy preparation were reported to be used in the District based on type and degree of complexity of livestock ailment. Pounding the remedial part and homogenizing it with cold water was found to be the major mode of remedy preparation (54%), followed by extracting juice, oil or latex from the plant material (20%) (Figure 12).

Traditional plant remedies were reported to be administered through oral, dermal, nasal or optical routes. Oral application was the most-cited route of administration (69 preparations, 53 %), followed by dermal (53, 40%), nasal (six, 5%) and optical (three, 2%) routes.

Physical appearance of the diseased animal and visually confirmed degree of complexity of illness are used to determine preparation doses to treat livestock ailments. Some traditional practitioners reported use of plastic jugs, glasses, bottles, cups or spoons to determine dosage for some medicinal preparations, while others reported to use a handful or finger-sized preparation to treat ailments. However, no strict standardised doses of herbal preparations as known for modern veterinary medicine were reported by traditional healers for any of the preparations used to treat livestock ailments in Ankober District.

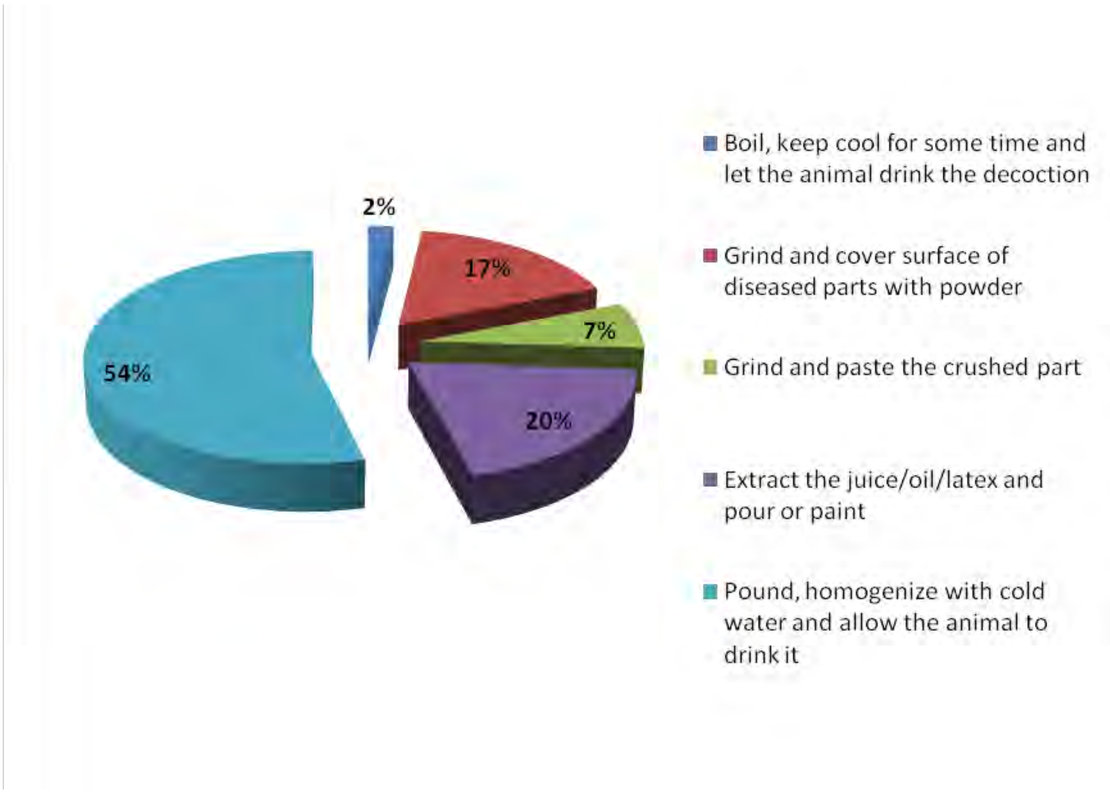


Figure 12. Modes of remedy preparation and administration for treating livestock ailments in Ankober District

4.2.2.6. Marketability of medicinal plants of ethnoveterinary importance

About 20% (ten species) of ethnoveterinary plants were reported to be marketed and can be accessed on Aliuamba, Derefo, Gorabela, Gorgo, Haramba and Zego local markets in the District (Appendix 17). However, out of ten reportedly marketed species, only two, i.e., *Embelia schimperi* and *Withania somnifera* were purchased utterly for the purpose of their traditional medical applications. The remaining eight species mentioned are mainly sold for their non-medicinal uses, but also occasionally applied as medicine when the need arises. This means that these eight species are frequently used for non-veterinary purposes but only seldom used for veterinary purposes. The average price of a bunch (≈250-325 g) of the root material of *Withania somnifera* at five local markets of the District was 3.50 Birr (0.2 USD), whereas the price for a cupful of *Embelia schimperi* fruits was 5.50 Ethiopian Birr (0.3 USD).

4.2.2.7. Efficacy of ethnoveterinary medicinal plants

Nine major livestock ailment categories were identified from the total of 33 veterinary diseases reported in the District. The highest Informants' Consensus Factor (ICF) values were recorded for gastro-intestinal (0.71), ecto- and endo-parasitic (0.69) and dermatological disease (0.66) categories (Table 12). In addition, the highest plant use citation (25.95%) was recorded for dermatological diseases.

4.2.2.8. Relative healing potential of ethnoveterinary medicinal plants

Embelia schimperi showed the highest fidelity level value (90%) for gastro-intestinal disease category, followed by *Rubus steudneri* (84%). Under the dermatological therapeutic category, the highest fidelity level value was recorded for *Croton macrostachyus* (83%). *Achyranthes aspera* (81%) also showed relatively high healing potential under the external injuries, bleeding and poisoning disease category (Table 13).

Table 12. ICF values of traditional medicinal plants used for treating livestock ailments in Ankober District

No	Disease category	Number of species	% all species	Use citations	% all use citations	ICF
1	Gastro-intestinal	7	13.72	22	16.79	0.71
2	Ecto- and endo-parasitic	5	9.80	14	10.68	0.69
3	Dermatological	12	23.50	34	25.95	0.66
4	Sensorial	3	5.88	5	3.81	0.50
5	Respiratory	7	13.72	11	8.39	0.40
6	External injuries, bleeding and poisoning	11	21.56	18	13.74	0.40
7	Reproductive	3	5.88	4	3.05	0.30
8	Musculo-skeletal	8	15.68	9	6.87	0.13
9	Others	12	23.50	14	10.68	0.20

Table 13. Fidelity level values of medicinal plants commonly reported against a given veterinary ailment category

No	Medicinal plant	Therapeutic Category	IP*	IU*	FL Value (%)*
1	*Embelia schimperi*	Gastro-intestinal	36	40	90.00
2	*Rubus steudneri*	Gastro-intestinal	26	31	84.00
3	*Croton macrostachyus*	Dermatological	25	30	83.00
4	*Achyranthes aspera*	External injuries, bleeding and poisoning	39	48	81.00
5	*Phytolacca dodecandra*	Ecto- and endo-parasites	23	29	79.00
6	*Cissampelos mucronata*	Respiratory	24	32	75.00
7	*Trichocladus ellipticus*	Sensorial	19	27	70.00
8	*Withania somnifera*	Musculo-skeletal	28	39	71.00
9	*Aeonium leucoblepharum*	Reproductive	17	23	74.00
10	*Ocimum lamiifoium*	Gastro-intestinal	30	38	66.00

*FL= Fidelity Level, Ip = number of informants who independently cited the importance of a species for treating a particular disease, Iu = total number of informants who reported the plant for any given disease

4.2.2.9. Preference ranking of ethnoveterinary plants

Based on a preference ranking exercise with 15 key informants (selected randomly) for medicinal plants that were reported to be used against diarrhoea, the most frequently reported livestock disease under the gastro-intestinal disease category, showed that *Embelia schimperi* and *Rubus steudneri* were the most-preferred species to treat the reported disease (Table 14).

4.3. Distribution of indigenous knowledge on medicinal plants in the community

Although more medicinal plants were reported by men than by women, the difference was not significant (P >0.05) when the average number of medicinal plants reported by each group was compared. However, there was a significant difference (P< 0.05) in the number of medicinal plants reported by senior members of the community (40-80 years old) and young- to middle-aged members (20-39 years old); key informants and general informants, illiterate and literate informants (Table 15). More number of medicinal plants were reported by elderly (≥ 40 years old) and key informants than by young and general informants. There was no significant difference observed in the number of medicinal plants listed by informants living around (≤ 5 km) health centres and those living relatively far away (>5 km) from these health centres.

Table 14. Results of preference ranking exercise of medicinal plants reported for treating livestock diarrhoea

Medicinal plants for diarrhoea	**Informants labelled A to O**																
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**Total score**	**Rank**
Dodonaea angustifolia L. f.	1	3	3	2	2	3	1	2	3	4	2	3	4	7	7	47	**5**
Gomphocarpus fruticosus (L.) Ait. F.	2	1	2	3	1	1	5	3	1	3	1	4	2	3	2	34	**6**
Zingiber officinale Roscoe	6	7	6	5	5	6	4	4	5	7	5	7	6	4	4	81	**3**
Clutia abyssinica Jaub. & Spach	3	2	1	1	3	4	2	1	2	2	3	2	3	1	1	31	**7**
Ocimum lamiifolium Hochst.	4	4	4	6	4	2	3	6	7	1	4	1	1	2	3	52	**4**
Rubus steudneri Schweinf.	5	6	5	7	6	5	7	5	4	5	6	5	5	5	6	82	**2**
Embelia schimperi Vatke	7	5	7	4	7	7	6	7	6	6	7	6	7	6	5	93	**1**

N:B-Scores in the table indicate ranks given to medicinal plants based on their efficacy (highest number (7) was given for the medicinal plant which informants thought most-effective in treating diarrhoea, and the lowest number (1) was given for the least-effective plant).

Table 15. Statistical test of significance on average number of medicinal plants among different informant groups in Ankober District

Parameters	**Informant groups**	**N**	**Average± SD**	**t -value****	**p –value**
Gender	Male	235	4.23± 0.13	1.61	0.1075
	Female	117	3.85±0.19		
Age	Young members	122	2.59 ±0.08	-11.65	0.0001*
	Senior members	230	4.90±0.13		
Literacy level	Illiterate	85	4.73±0.11	-11.90	0.0001*
	Literate	267	2.12 ± 0.10		
Distance from health centres	Proximity to health centre	80	4.22±0.22	0.57	0.5681
	Far away from health centre	272	4.07 ±0.12		
Experience (Informant category)	Key/knowledgeable	88	6.94±0.16	23.88	0.0001*
	General informant	264	3.16±0.07		

*Significant difference ($p<0.05$); ** t(0.05) (two tailed), df = 350, N= number of respondents

4.4. Indigenous knowledge transfer

The major way of transfer of indigenous knowledge on types of medicinal plants, traditional concepts of illnesses, methods of diagnosis and treatment among traditional healers of Ankober District was by word of mouth to a family member, especially to an elder son. Such knowledge is kept secretly as it is passed only within the family circle. None of the participants had any written documents on traditional medicine, whereas all healers reported that they had received the knowledge from their parents, grandparents or someone in the family circle orally and through observation based practice, in turn sharing it to their children in a similar manner.

4.5. Medicinal plants and their distribution in Dense Forest

4.5.1 Medicinal plants in Dense Forest

About 119 plant species of Dense Forest (belonging to 112 genera and 66 families) were cited for one or more traditional medicinal uses in the District (Appendix 1). The medicinal flora of Dense Forest is composed of 40 (34%) herbaceous species, 38 (32%) shrubs, 31 (26%) tree species and 10 (8%) climbers. Dominant medicinal families of Dense Forest were Asteraceae (ten species, 8.4%) and Fabaceae (nine species, 8%). About 39% (26) of the families in Dense Forest were represented with more than one medicinal species.

4.5.2. Distribution of medicinal plants across plant communities in Dense Forest

Traditional medicinal plants cited for one or more remedial uses by people in Ankober District were found distributed in each of the identified plant community types in Dense Forest. Community 1 (*Erica arborea* community type) contained 13 different traditional medicinal plant species, of which *Achyranthes aspera*, *Cynoglossum coeruleum*, *Kniphofia foliosa* and *Erica arborea* were among the most cited species available in this community type. A total of 49 medicinal plant species was found in community 2 (*Maesa lanceolata-Discopodium penninervium* community type). Some of the major medicinal plants in this community type were *Croton macrostachyus*, *Embelia schimperi*, *Hagenia abyssinica*, *Kalanchoe petitiana*, *Olea europaea* subsp. *cuspidata*, *Phytolacca dodecandra*, *Rubus steudneri*, *Stephania abyssinica*, *Urtica simensis* and *Zehneria scabra*.

Community type 3 (*Podocarpus falcatus-Allophylus abyssinicus* community type) was found to be the richest in medicinal plant composition in that it contained 62 species of traditionally used remedial plants. The medicinal flora of this community includes *Asplenium aethiopicum*, *Carissa spinarum*, *Chenopodium ambrosioides*, *Cissampelos mucronata*, *Croton macrostachyus*, *Dracaena afromontana*, *Embelia schimperi*, *Hypericum revolutum*, *Juniperus procera*, *Olinia rochetiana*, *Pavetta abyssinica*, *Plantago lanceolata*, *Podocarpus falcatus*, *Ranunculus multifidus* and *Rumex nepalensis*. Community 4 (*Olea europaea-Galiniera saxifraga* community type) was found to contain a total of 50 medicinal plant species. Some of the most-cited medicinal plant species available in this community type include *Acokanthera schimperi*, *Berberis holstii*, *Embelia schimperi*, *Halleria lucida*, *Impatiens tinctoria*, *Maytenus arbutifolia*, *Nuxia congesta*, *Osyris quadripartita*, *Rubus steudneri*, *Solanum anguivi*, *Solanum marginatum*, *Stephania abyssinica* and *Woodfordia uniflora*. Community type 5 (*Maytenus arbutifolia-Bersama abyssinica* community type) was found the second richest in its medicinal plant species composition. *Aeonium leucoblepharum*, *Arisaema schimperianum*, *Buddleja polystachya*, *Calpurnia aurea, Clutia abyssinica, Cyathula cylindrica, Galiniera saxifraga, Hypoestes forskaolii, Lobelia gibberroa, Myrsine africana, Rhus vulgaris, Ricinus communis* and *Urera hypselodendron* were the major medicinal plant species available in this community type.

The medicinal plant species richness, diversity and evenness values of each plant community type in Dense Forest is summarized in Table 16. The highest value of medicinal species richness (62) was recorded for community three; medicinal species diversity (Shannon's diversity) (3.28) and medicinal species evenness (0.82) were both highest for community four. Overall medicinal species diversity of Dense Forest was 4.09 (Table 16).

Table 16. Medicinal plant species richness, diversity and evenness values of plant communities in Dense Forest

Community types	**Medicinal *Species Richness* (S)**	**Medicinal species diversity *Shannon-Wiener Diversity Index* (H')**	**Medicinal species evenness *Shannon's evenness index* (J)**
1: *Erica arborea*	13	1.81	0.70
2: *Maesa lanceolata - Discopodium penninervium*	49	2.97	0.76
3: *Podocarpus falcatus - Allophylus abyssinicus*	62	2.86	0.69
4: *Olea europaea-Galiniera saxifraga*	50	3.28	0.84
5: *Maytenus arbutifolia-Bersama abyssinica*	59	3.22	0.79
Overall	**119**	**4.09**	**0.85**

4.6. Conservation practices

Traditional practitioners and local communities in Ankober District mainly depend on the natural environment for collecting medicinal plants, however the effort to conserve and sustainably utilize resources was frail. Despite harvesting the majority of their medicinal plants (99 species for human ailments, 73%; and 41 species for livestock ailments, 80%) from the wild environment alone, no attempt of any *in situ* conservation initiative was observed to save the fast-eroding medicinal plant resources bases in the District. About 15% (20 species) of medicinal plants used to treat human ailments, and 6% (three species), for livestock ailments were cultivated in homegardens (Appendices 2 and 3), whereas the remaining 12% (16 species for humans) and 14 % (seven species for livestock diseases) were reported to be harvested both from homegardens and wild sources. In addition to the observed rudimentary nature of cultivating medicinal plants in homegardens, it was reported that most medicinal plants are under threat due to an ever-increasing anthropogenic influence on medicinal plants natural habitats of the area. Deforestation (reported by 89% of informants); agricultural expansion (80%); charcoal production and firewood collection (33%), and overgrazing (29%) were claimed to be the major factors affecting medicinal plant wealth of the area (Appendix 18).

4.7. Antimicrobial activity

From literature review no antimicrobial activity reports were found for *Thalictrum rhynchocarpum* and *Dodonea angustifolia,* but for the remaining elite plants few antimicrobial activity reports were found against one or four (maximum) microbial strains. However, we found no report of a wide range of antimicrobial activity tests for none of the target medicinal plant species.

In our experiment, among the 23 plant extracts tested for antimicrobial activity, 74% (17 extracts) showed antimicrobial activity, at a concentration of 512 µg/ml or below, against one or more of the twelve microbes tested (Table 17). Extracts of *Embelia schimperi*, *Ocimum lamiifolium* and *Rubus steudneri* showed the broadest spectrum of action as they inhibited growth of *Bacillus cereus*, *Candida albicans*, *Enterococcus faecalis*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Streptococcus pyogenes* strains with MICs ranging from 64 to 512 µg/ml. In addition, extracts of *Embelia schimperi* and *Ocimum lamiifolium* showed inhibitory activity against *Clostridium perfringens* at a MIC value of 512 µg/ml, whereas those of *Rubus steudneri* were found to be effective against *Pseudomonas aeruginosa* and *Salmonella enteritidis* in a MIC range of 256 to 512 µg/ml. Moreover, extracts from *Jasminum abyssinicum*, *Bersama abyssinica*, *Rumex nepalensis* and *Vernonia amygdalina* inhibited growth of three or more of the twelve microbes. No antimicrobial activity was observed with extracts of *Calpurnia aurea*, *Carissa spinarum*, *Clematis hirsuta*, *Cyathula cylindrica*, *Thalictrum rhynchocarpum* and *Verbascum sinaiticum* against either one of the microbes tested.

The strongest antibacterial activity (MIC = 64 µg/ml) was shown by leaf and twig extracts of *Embelia schimperi* against *Bacillus cereus*, *Listeria monocytogenes* and *Streptococcus pyogenes.* Moreover, seed and fruit extracts of this species also showed strong activity (MIC = 128 µg/ml) against *Bacillus cereus* and *Streptococcus pyogenes.* Similarly, strong growth inhibition (MIC = 128 µg/ml) was observed for extracts of *Ocimum lamiifolium* against *Streptococcus pyogenes*, and those of *Rubus steudneri* against *Staphylococcus epidermidis.*

Extracts of *Rubus steudneri* were the only extracts to show antimicrobial activity against Gram-negative bacteria *Pseudomonas aeruginosa* and *Salmonella enteritidis.* Two of the Gram-negative bacteria, i.e. *Bacteroides fragilis* and *Escherichia coli,* were resistant to all extracts tested in this study. Among the Gram-positive bacteria, *Clostridium perfringens* was found to be less sensitive as it was inhibited by extracts of only two species, i.e. *Embelia schimperi* and *Ocimum lamiifolium*, whereas *Streptococcus pyogenes* was shown to be the most-sensitive bacterium which was inhibited by 76% of extracts (13 extracts) with MIC values ranging from 64 to 512 µg/ml. Gram-positive bacteria were generally found to be more susceptible to extracts than the Gram-negative ones. The growth of yeast strain *Candida albicans* was inhibited by extracts from *Bersama abyssinica, Embelia schimperi, Ocimum lamiifolium, Rubus steudneri, Rumex nepalensis* and *Zehneria scabra.* No growth inhibition was observed in the negative controls.

Table 17. MIC values of ethanol extracts of medicinal plant species with antimicrobial activities, Ankober District

Plant species/ reference compound name	**Part**	**Microorganisms/Minimum inhibitory concentration (µg/ml)**											
		Gram Positive							**Gram negative**				**Yeast**
		B.c.	C.p.	L.m.	S.ep.	E.f.	S.a.	S.p.	B.f.	E.c.	P.a.	S.en..	C.a.
Bersama abyssinica	R	-	-	512	512	-	-	-	-	-	-	-	512
Clutia abyssinica	R	-	-	-	-	-	-	256	-	-	-	-	-
Croton macrostachyus	LT	-	-	-	-	-	-	256	-	-	-	-	-
Dodonaea angustifolia	L	-	-	-	-	-	-	512	-	-	-	-	-
Embelia schimperi	S/F	128	512	256	512	512	512	128	-	-	-	-	512
	LT	64	512	64	256	512	512	64	-	-	-	-	512
Jasminum abyssinicum	L	512	-	512	512	-	-	256	-	-	-	-	-
Maesa lanceolata	LT	-	-	-	-	-	-	256	-	-	-	-	-
Ocimum lamiifolium	L	256	512	256	512	512	512	128	-	-	-	-	512
Olinia rochetiana	L	-	-	-	-	-	-	512	-	-	-	-	-
Rubus steudneri	R	256	-	512	128	512	256	512	-	-	256	512	-
	LT	512	-	512	256	512	512	512	-	-	512	-	512

Table 17. contd.

Plant species/ reference compound name	Part	Microorganisms/Minimum inhibitory concentration (µg/ml)											
		Gram Positive							**Gram negative**				**Yeast**
		B.c.	C.p.	L.m.	S.ep.	E.f.	S.a.	S.p.	B.f.	E.c.	P.a.	S.en..	C.a.
Rumex nepalensis	R	512	-	-	256	512	-	-	-	-	-	-	-
	LT	-	-	-	-	-	512	512	-	-	-	-	512
Vernonia amygdalina	F	-	-	-	512	512	512	-	-	-	-	-	-
	LT	512	-	-	-	512	-	256	-	-	-	-	-
Zehneria scabra	LT	-	-	-	-	-	-	-	-	-	-	-	512
Ciprofloxacin, Tioconazole, Penicillin (µg/ml)[a]		0.125	0.125	1	0.125	0.5	0.25	0.5	8	0.015	0.625	0.031	0.125

N:B R, root; LT, Leaves and twigs; S, Seed; F, Fruit; L, Leaves; B.c., *Bacillus cereus;* C.p., *Clostridium perfringens;* L.m. *Listeria monocytogenes;* S.ep., *Staphylococcus epidermidis;* E.f., *Enterococcus faecalis;* S.a., *Staphylococcus aureus;* S.p., *Streptococcus pyogenes;* B.f., *Bacteroides fragilis;* E.c., *Escherichia coli;* P.a., *Pseudomonas aeruginosa;* S.en., *Salmonella enteritidis;* C.a., *Candida albicans;* **-**, *Not active (>512* µg/ml*)*, [a] C, ciprofloxacin, T, Tioconazole, P, Penicillin

4.8. Use diversity of medicinal plants

Out of a total of 151 medicinal plant species recorded in the District, 123 (81%) were cited for one or more uses other than their medicinal role. The proportion of medicinal plant species over different use categories is summarised in figure 13.

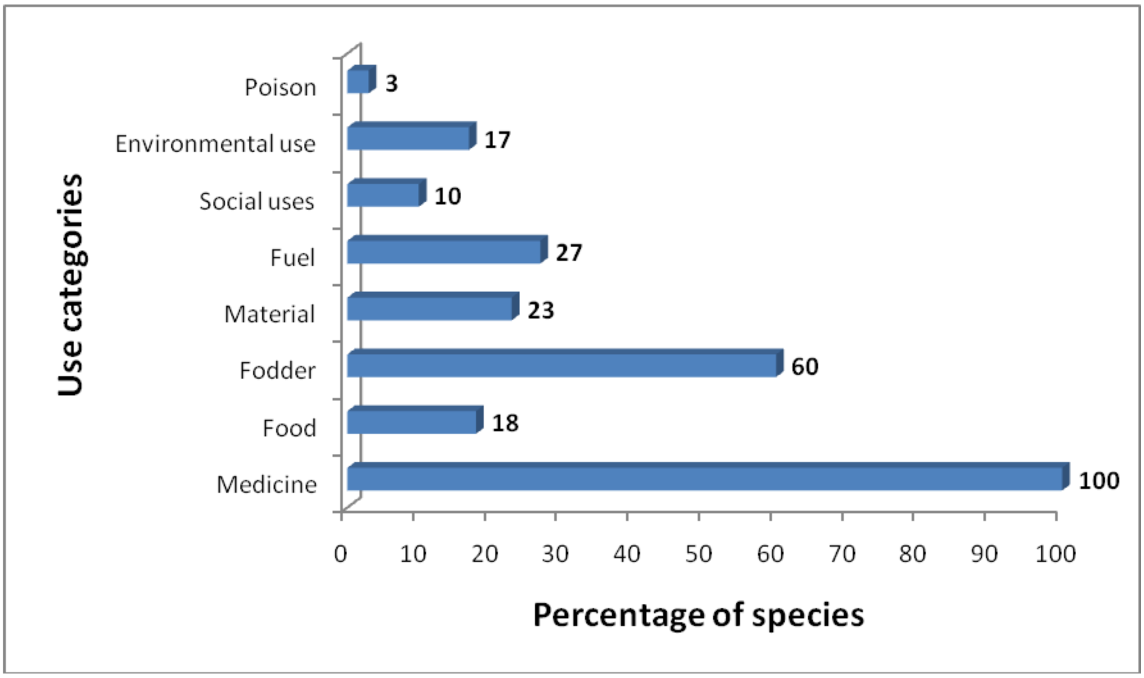


Figure 13. Percentage distribution of medicinal plants of Ankober District over different use categories

4.8.1. Traditional medicinal values

The traditional medicinal uses of 151 different medicinal plant species against a number of human and livestock ailments were compiled. Of these species, the highest medicinal use values (UVmed) were recorded for *Allium sativum* (8.20), *Clematis hirsuta* (7.51) and *Croton macrostachyus* (7.27) (Table 18).

Table 18. Medicinal use values (UVmed) of most-cited remedial plants in Ankober District

Species	**Family**	**No. of Informants citing the species**	**Number of medicinal uses for ailments in**		**Total No. of remedial uses**	**UVmed***
			human	**livestock**		
Allium sativum	Alliaceae	150	9	8	17	**8.20**
Clematis hirsuta	Ranunculaceae	80	11	2	13	**7.51**
Croton macrostachyus	Euphorbiaceae	102	4	7	11	**7.27**
Zingiber officinale	Zingiberaceae	127	5	4	9	6.18
Carissa spinarum	Apocynaceae	135	7	2	9	5.67
Clutia abyssinica	Euphorbiaceae	110	6	5	11	5.41
Dodonaea angustifolia	Sapindaceae	94	6	4	10	4.87
Asparagus africanus	Asparagaceae	80	8	1	9	3.88

*UVmed= Medicinal use value

4.8.2. Plants used as food for humans

4.8.2.1. Food plants diversity

Edible plants constituted 18% (27 species, in 27 genera and 23 families) of the medicinal flora of Ankober District. Families Cucurbitaceae (three species, 12%), Myrsinaceae and Rutaceae (two species, 8% each) were best-represented among families cited for edibility. Shrubs (41%) followed by herbs (37%) and trees (23%) were the dominant growth forms of the edible plants of the area.

4.8.2.2. Parts used and modes of consumption

Although different plant parts were reported for consumption, fruits (18 species, 67%) shared the highest edibility report (Figure 14). About 78% (14 species) of these fruits were reported to be eaten raw, whereas 17% (three species) were consumed cooked or processed, and one species was reported to be eaten either raw or cooked as an ingredient for hot sauce. Seeds of five species were claimed for edibility, four of which were reported to be eaten after grinding and processing. About 15% of edible species were mentioned for their uses as spices and condiments, whereas 12% were reported for use in the preparation of distilled and undistilled alcoholic beverages/local drinks known as KATIKALA, TEJ and TELLA.

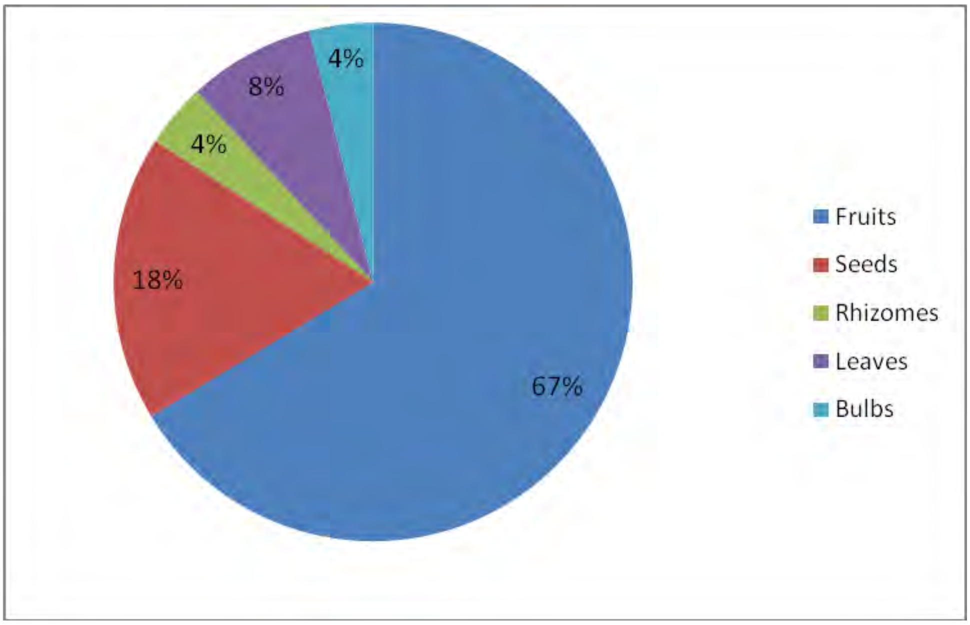


Figure 14. Plant parts used as source of food for humans in Ankober District

4.8.2.3. Food from the wild

Edible species were harvested both from wild and cultivated sources each accounting for 44% (12 species each) of food plants used as traditional medicine (Table 19). Cultivated edible plants were available from homegardens and agricultural fields. Three species were harvested from both wild and cultivated sources.

Table 19. Medicinal plants reported as sources of food in Ankober District

No	Scientific name	Family	Edible part	Remark
1	*Allophylus abyssinicus*	Sapindaceae	Fruit	
2	*Carissa spinarum*	Apocynaceae	Fruit	
3	*Cucumis ficifolius*	Cucurbitaceae	Fruit	Beverage used for brewing local mead (TEJ)
4	*Dovyalis abyssinica*	Flacourtiaceae	Fruit	
5	*Embelia schimperi*	Myrsinaceae	Fruit	
6	*Ficus sur*	Moraceae	Fruit	
7	*Momordica foetida*	Cucurbitaceae	Seed	
8	*Myrsine africana*	Myrsinaceae	Fruit	
9	*Rhus vulgaris*	Anacardiaceae	Fruit	
10	*Rubus steudneri*	Rosaceae	Fruit	
11	*Thymus schimperi*	Lamiaceae	Leaf	Spicing food and tea
12	*Woodfordia uniflora*	Lythraceae	Fruit	

4.8.3. Forage plants

4.8.3.1. Source and diversity of forage plants

Medicinal plants reported for having additional uses as feed for livestock and bee forage account for 91 species (60%) belonging to 84 genera and 52 families (Appendix 9). Asteraceae (nine species, 17%), Fabaceae (six species, 12%) and Lamiaceae (five species, 10%) were the families having the highest number of species among those used as fodder plants. Herbs (37%) were found to be the dominant sources of forage.

4.8.4. Material plant use

4.8.4.1. Material plant diversity

Medicinal plants of Ankober were also reported for their additional uses as resources for construction, lumbering, household furniture, beehives and other locally used materials. Thirty-four (23%) species distributed in 33 genera and 28 families were cited for material uses (Appendix 10). Asclepiadaceae, Celastraceae, Fabaceae, Myrsinaceae, Rosaceae and Sapindaceae were among the most frequently mentioned (7% each) families for this use category. Twenty-one percent of families mentioned for material uses were represented by more than one species, with trees (24 species, 70%) and shrubs (six species, 18%) being dominant in this category.

4.8.4.2. Sources, parts used and material types

Almost all plants (97%) cited for one or more material uses were harvested from the wild. Stem parts of these plants were mentioned for their role in local construction or making other materials. Most of the material plants (17 species) were reported for their uses in local construction (Figure 15).

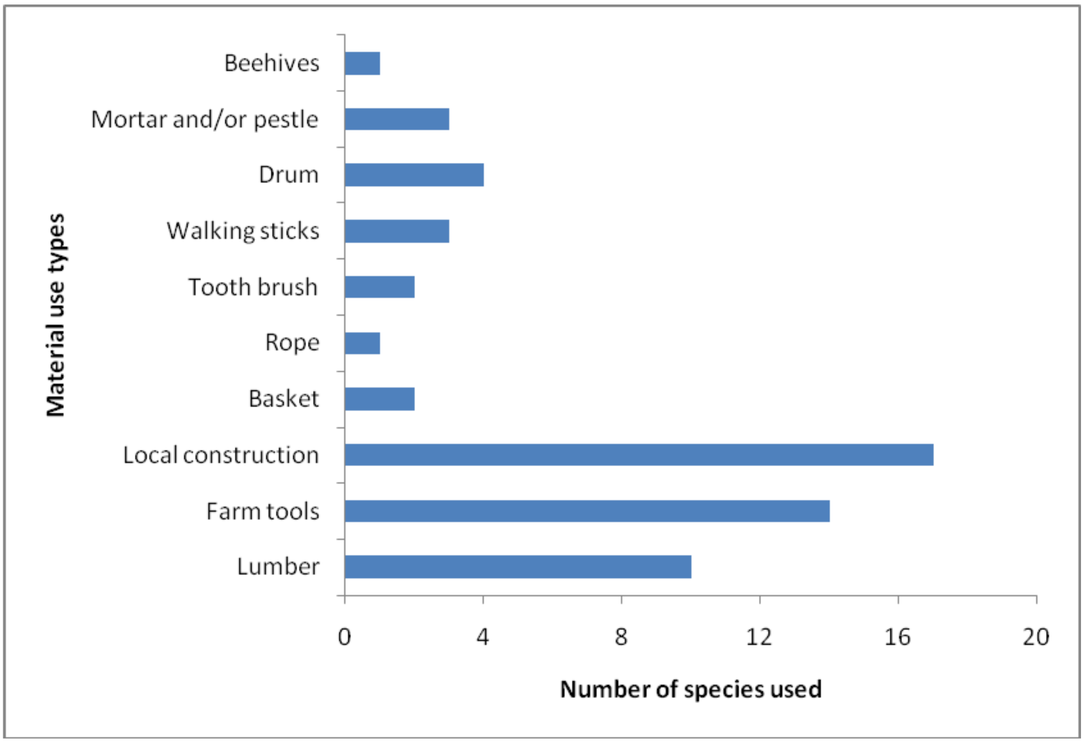


Figure 15. Material use types and number of species used for each use type in Ankober District

4.8.4.3. Use value of most-cited material plants

Seven medicinal plant species were found with relatively high material use values (Table 20). The top most material use values (UVmat) were recorded for *Podocarpus falcatus*, *Juniperus procera* and *Olea europaea* subsp. *cuspidata.*

Table 20. Most-cited plants for material uses among medicinal plants of Ankober District

Species	**Family**	**No. of informants citing the species**	**Total number of material uses**	**UVmat***
Dombeya torrida	Sterculiaceae	51	4	3.2
Ekebergia capensis	Meliaceae	58	5	3.6
Eucalyptus globulus	Myrtaceae	98	7	5.9
Juniperus procera	Cupressaceae	58	10	8.5
Olea europaea subsp. *cuspidata*	Oleaceae	80	9	7.7
Podocarpus falcatus	Podocarpaceae	54	10	9.2
Prunus africana	Rosaceae	53	5	3.8

* UVmat= Material use value

4.8.5. Fuelwood plants

4.8.5.1. Fuelwood plant diversity

All informants cited plants as the basis to fulfil fuelwood requirement in Ankober District. About 40 species distributed in 39 genera and 32 families (accounting for 27% of all medicinal plants) were mentioned for their local fuel uses. The best-represented families as fuel sources in the study area include Celastraceae, Rosaceae and Fabaceae (9% each), followed by Loganiaceae, Myrsinaceae and Sapindaceae (6% each). Fifteen percent of fuel source families were represented by more than one species. About 65% (26 species) of the best fuel plants were trees with the remaining 35% being shrubs.

4.8.5.2. Sources, parts used and fuel types

The major fuel types used in the study area were firewood and charcoal. Amongst the 40 different species cited as sources of firewood, 30% (12 species) were frequently reported for making charcoal (Appendix 11). Almost all (98%) of fuel source plants were harvested from the wild. Stem and dried leaf parts were reported as major fuel sources.

4.8.6. Social use plants

4.8.6.1. Social use plants diversity

Medicinal plants in Ankober were also reported for different social uses including ritual, religious or spiritual ceremonies (Figure 16). About 10% (15 species) of the medicinal plants of the study area were cited for one or more social purposes. The species in this category belong to 15 genera and 14 families. Euphorbiaceae was the only family represented with two species, whereas all the rest had only one species. Shrub (67%) was the dominant growth form in social use plants (Appendix 12).

4.8.6.2. Sources, parts used and social plant use types

The majority (ten species, 67%) of social use plants were reported to be harvested entirely from the wild. Purposive cultivation of 20% of social use plants in homegardens was also reported from the area. Two more species were claimed for presence in the wild and as being cultivated. Stem and leaves were the dominant plant parts (33% each) most cited in the social use plant category.

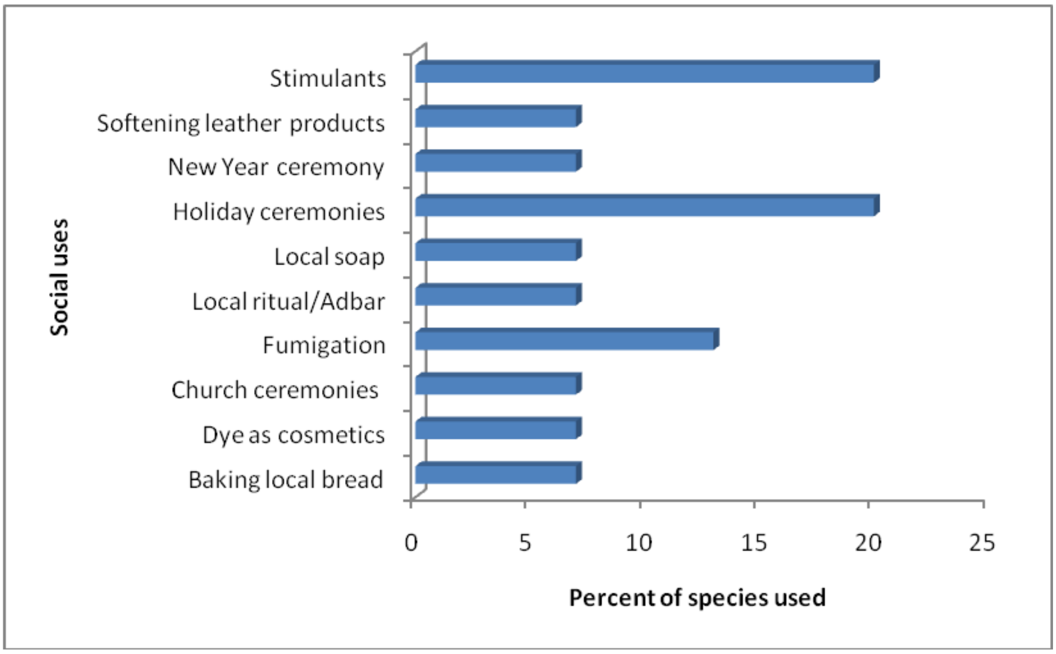


Figure 16. Social use types and corresponding proportion of species used in Ankober District

4.8.7. Environmental uses of plants

4.8.7.1. Environmental plant use diversity

About 17% (26 species) of medicinal plants of Ankober District was also reported for one or more environmental uses including erosion control, soil improvement and ornamental purposes (Appendix 13). These species were distributed in 25 genera and 22 families. Most plants cited for environmental purposes belong to the families Rosaceae (three species, 14%) and Fabaceae (two species, 9%). Fourteen percent of families in this category were represented by more than one species. Trees represented 69% (18 species) of the growth form of plants under these families.

4.8.7.2. Sources, parts used, and environmental service types

The majority (24 species, 92%) of medicinal plants with environmental uses were reported to occur in the wild environments. Whole plants accounted for 73% of use forms reported within this category. Live fence was the most commonly reported type of environmental use of plants within this category (Figure 17).

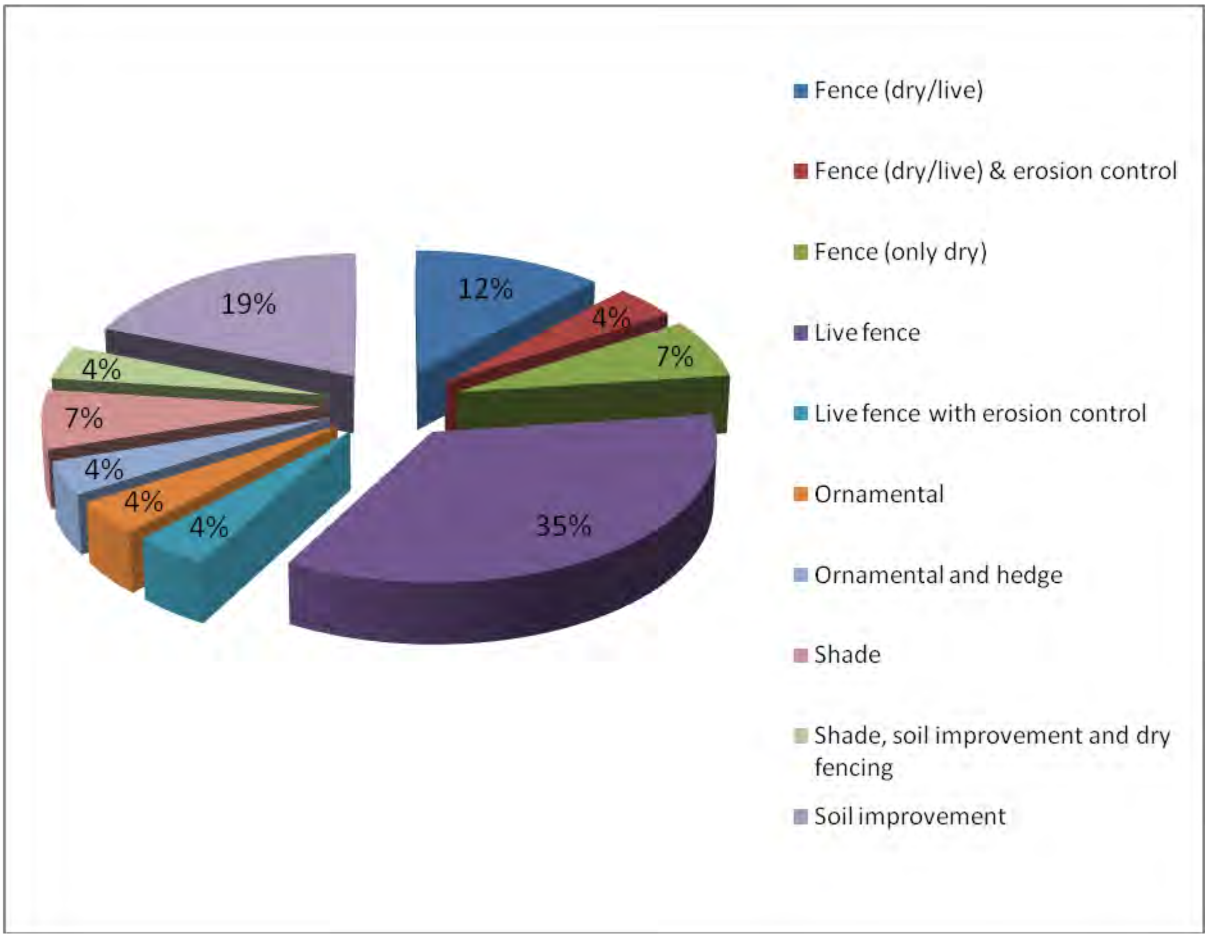


Figure 17. Medicinal plants of Ankober District categorized in the environmental use types with the corresponding proportion of species

4.8.8. Poison plants

Acokanthera schimperi (Apocynaceae), *Calotropis procera* (Asclepiadaceae), *Chenopodium ambrosioides* (Chenopodiaceae) and *Datura stramonium* (Solanceae) were reported for their poison contents. The latex of *Acokanthera schimperi* and *Calotropis procera* was cited for arrow poison (poisoning the tip of the arrow), whereas leaf extracts of *Chenopodium ambrosioides* were mentioned for their uses as insect repellent.

4.8.9. Use value, diversity and equitability of twenty high ranking species based on overall usefulness

Twenty species scored relatively high overall use value (UVall), use diversity value (UD) and use-equitability values (UE). On the basis of overall usefulness (use across different use categories) of medicinal plant species, *Podocarpus falcatus* and *Olea europaea* subsp. *cuspidata* had the highest UVall, while *Eucalyptus globulus* showed highest UD and UE values (Table 21).

Table 21. Overall use value (UVall), use diversity (UD) and use-equitability (UE) values of the top 20 medicinal plant species in Ankober District

No	Scientific name	Family	*Number of respondents reported same uses	Total Number of uses reported in different categories	No. of Use categories	UDs	UEs	UVall
1	*Podocarpus falcatus*	Podocarpaceae	79	15	5	**5**	**3.1**	**9.7**
2	*Olea europaea* subsp. *cuspidata*	Oleaceae	65	15	4	4.4	3.0	**9.0**
3	*Ekebergia capensis*	Meliaceae	55	15	4	4.6	2.9	**7.0**
4	*Dombeya torrida*	Sterculiaceae	59	9	5	4.8	3.0	**7.3**
5	*Juniperus procera*	Cupressaceae	60	10	4	3.8	2.4	**7.7**
6	*Prunus africana*	Rosaceae	54	9	4	4.5	2.8	**6.8**
7	*Eucalyptus globulus*	Myrtaceae	65	15	6	**6**	**3.3**	6.1
8	*Bersama abyssinica*	Melianthaceae	61	6	4	4.5	2.8	5.1
9	*Croton macrostachyus*	Euphorbiaceae	52	15	4	4.8	3.0	4.8
10	*Celtis africana*	Ulmaceae	54	8	4	4.3	2.7	4.2
11	*Hagenia abyssinica*	Rosaceae	51	9	5	**5**	**3.1**	3.8
12	*Nuxia congesta*	Loganiaceae	57	6	4	4.8	3.0	3.1
13	*Ficus sur*	Moraceae	60	4	4	3.8	2.1	2.7
14	*Maytenus arbutifolia*	Celastraceae	54	5	4	4.2	2.6	2.6
15	*Ehretia cymosa*	Boraginaceae	51	5	4	2.8	1.8	2.4
16	*Acacia abyssinica*	Fabaceae	51	4	5	**5**	**3.1**	2.3
17	*Allophylus abyssinicus*	Sapindaceae	51	4	5	4.7	2.7	2.3
18	*Erythrina brucei*	Fabaceae	51	3	4	4	2.9	2.1
19	*Myrsine africana*	Myrsinaceae	50	3	4	4.2	2.6	2.1
20	*Polyscias fulva*	Araliaceae	50	3	4	4	2.9	2.1

*N:B: Only species cited at least by 15% of participants (n=352) for similar uses in $\geq$ 50% of different categories (n=4) are included

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Discussion

5.1.1. Vegetation of the Dense Forest

5.1.1.1. Plant species composition

Results show that Dense Forest is rich in species composition as shown by the presence of 158 species (distributed in 143 genera and 75 families). The observed diverse flora of Dense Forest is in line with the general pattern of rich species-presence in East African montane forests. According to Coetzee (1978), among the Afromontane forest regions, the East African Mountains (found in Ethiopia, Kenya, Tanzania and Uganda) have the richest and most diverse flora. It was also shown that Dense Forest is a reservoir of 119 traditional medicinal plant species. The finding shows the pattern that most tropical forests are sources of vital traditional medicinal plants, and even serve as the basis for at least 25% of modern drugs (Jin-Ming *et al*., 2003).

Results also show that the Dense Forest has higher species richness than some other forests in Ethiopia such as Masha (130 species) (Abreham Assefa *et al*., 2013), Tara Gedam (111 species) and Abebaye (88 species) (Haileab Zegeye *et al*., 2011), Zegie (113 species) (Alemnew Alelign *et al*., 2007) or Jibat Forest (131 species) (Tamrat Bekele, 1993). However, its species richness was found to be by far less than that of Yayu Forest (220 species) (Tadesse Woldemariam Gole *et al*., 2008), Mana Angetu (212 species) (Ermias Lulekal *et al*., 2008b) and Komto (180 species) (Fekadu Gurmessa *et al*., 2013). Variation in species composition over different forests could be attributed to topographic differences among the forests compared, as well as the degree of availability of suitable environmental gradients in the respective forests (Chen *et al.*, 2003). The latter is shown by higher species richness recorded for the more moist montane forests (Mana Angetu and Komto) and transitional rainforest (Yayu) of Ethiopia compared to Dense Forest which belongs to the dry montane type. Moreover, forests with a high degree of human interference and disturbances for prolonged periods show relatively lower species richness than others (Urban *et al*., 2000). According to Chen *et al*. (2003), environmental heterogeneity, regeneration success and competition are also important factors that shape species composition of forests.

The highest representation of species from the family Asteraceae (20 species, 27%) in Dense Forest could be related to the fact that it is one of the species rich families in the flora area, Ethiopia and Eritrea (Mesfin Tadesse, 2004). Asteraceae was also shown to be well-represented in other montane forests in Ethiopia including Komto (17 species, 9.44%) (Fekadu Gurmessa *et al*., 2013), Adelle and Boditi (39 species, 17%) (Haile Yineger *et al*., 2008c) and Mana Angetu (13 species, 6%) (Ermias Lulekal *et al*., 2008b) forests. Results also showed that herbaceous species outnumber in Dense Forest when compared to the other growth forms. This could be related partly to interference and opening up of the forest due to resource extraction. This observation agrees with similar patterns of dominance of herbaceous species in other Ethiopian montane forests (Ermias Lulekal *et al*., 2008b; Haile Yineger *et al*., 2008c; Fekadu Gurmessa *et al*., 2013) and elsewhere in other tropical forests (Dhillion *et al*., 2003).

We observed that 4.4% of the plant species in Dense Forest are endemic to Ethiopia. This is in line with the typical feature of Afromontane forests that house numerous endemic species (White, 1978). According to this author, the Afromontane region is an important centre of endemism housing over 3,000 endemic plant species. The highest presence of endemic species in Eastern African montane forests was also mentioned as one of the major reasons (in addition to loss of natural habitats) to recognize the whole region as a biodiversity hotspot. It is an area that will fast loose the endemic and other taxa along with the natural habitat beyond the 70% it has already sacricified (Mittermeier *et al*., 2005). Thus, conservation measures which might be designed for forest resources of Ankober District by policy makers, natural resource managers or stakeholders would need to take into account special protection and monitoring of the endemic taxa as well as the useful species found in the Dense Forest.

5.1.1.2. Plant communities and vegetation categories in Dense Forest

Differences in species composition observed among the five plant communities identified in Dense Forest could be attributed to variations in environmental gradients. According to Whittaker *et al*. (2003), vegetation patterns among communities can best be explained by differences in environmental gradients. Urban *et al*. (2000) also explained that plant community distribution is an expression of physical gradients (elevation, soil heterogeneity and microclimate), biotic responses to these gradients and human-induced and/or environmental disturbances in a region.

In Dense Forest, the observed community structure can best be explained by differences in altitudinal ranges that are proper to the identified communities, and habitat disturbances. Hedberg (1964) stated that altitude affects atmospheric pressure, moisture and temperature in an area whereby the latter directly influence growth and development of plants, and the corresponding patterns of vegetation distribution. Since Dense Forest stretches on a mountain range with clear altitudinal variation, altitudinal drops/rises will always be accompanied by varying degrees of differences in microclimatic conditions which influence temperature and soil moisture, resulting in variations in community structure. Bolstad *et al.* (1998) have also explained that plants in mountainous regions respond to small-scale variations related to elevation changes that affect microclimatic conditions. The role of altitudinal gradients in shaping distribution of vegetation in East African Mountains has also been mentioned by Hamilton (1982). In addition, since Dense Forest is also subjected to human interference mainly to fulfil fuelwood requirements, disturbances are evident. Such human-induced disturbances are also mentioned to affect local (community) level species diversity (Whittaker *et al*., 2003). Deforestation has been mentioned as a factor hampering natural regeneration and seedling establishment in tropical forests, and hence influences diversity and structure of plant communities (Bussmann, 2001).

Community 1 (the *Erica arborea* Community) was composed of 22 species distributed in plots of higher altitudinal ranges (2821-2971m a.s.l.) in Dense Forest. This is in agreement with the general pattern of presence of *Erica arborea* dominated communities at higher altitudinal ranges of Afromontane forests (Demel Teketay and Tamrat Bekele, 1995). Tamrat Bekele (1993) also showed that *Erica arborea* dominated communities prevail at altitudinal ranges above 2700 m a.s.l. in Jibat, Chilimo, Menagesha, and Wof-Washa montane forests. Haile Yineger *et al.* (2008c) also showed that an *Erica arborea* community extends to 3410 m a.s.l. in the dry montane forests of the Bale Mountains National Park, southeastern Ethiopia.

Dominance of the upper tree layer of communities 3 and 4 by *Podocarpus falcatus* and *Olea europaea* subsp. *cuspidata*, respectively, indicated ample presence of characteristic species of dry Afromontane forests in the study area. These taxa were also mentioned to form the upper canopies of different dry montane forests in Ethiopia (Tamrat Bekele, 1993; Demel Teketay and Tamrat Bekele, 1995; Haile Yineger *et al.*, 2008c). The other characteristic species of dry montane forests, i.e. *Juniperus procera,* was also found to occur in different plant communities in Dense Forest. However, this species has been subjected to anthropogenic pressure (due to its multipurpose role) as proved by a number of stumps of the species observed in the Forest.

Plot number 51 was not grouped within any of the communities identified in Dense Forest as observed from the output of the hierarchical cluster analysis. This might be related to the fact that the whole plot is taken by one species, i.e. *Trichocladus ellipticus* (Hamamelidaceae). According to Verdcourt (1989b), *Trichocladus ellipticus* is known to form dominant and nearly pure stands in *Juniperus* and *Podocarpus* forests, which is in agreement with the current finding.

Although different species dominated the upper canopies of the identified plant communities in Dense Forest, we observed various degrees of intermingling of similar species across communities. This can be attributed to an overlap in altitudinal ranges of different communities, and the resulting relatively small differences in environmental gradients across adjacent plots forming different communities. According to Condit *et al.* (2002), small differences in species composition across plant communities may reflect adaptations of species to similar environmental conditions coupled with efficient dispersal of the respective species forming the communities.

Identified species composition, plant communities, altitudinal ranges, types of dominant species in the upper canopies of the forest and climate readings of the area indicated that the Dense Forest belongs to the category of dry evergreen montane forest. According to Friis *et al*. (2011), dry evergreen forests lie between altitudinal ranges of 1800-3000 m a.s.l., and consist of canopies dominated by *Podocarpus falcatus, Juniperus procera* and *Olea europaea* subsp. *cuspidata,* which were all found to be true for Dense Forest.

5.1.1.3. Species diversity in Dense Forest

The observed overall Shannon-Wiener diversity index (H'=4.07) of Dense Forest showed high species diversity. This value was found to be higher than that of other Ethiopian montane forests such as Chilimo (H'=2.72) (Tadesse Woldemariam *et al*., 2000), Zegie (H'=3.72) (Alemnew Alelign *et al*., 2007), Abebaye (H'=1.31) or Tara Gedam (H'=2.98) (Haileab Zegeye *et al.*, 2011) forests. Results also revealed a higher medicinal species diversity (H'=4.09) in Dense Forest in line with the overall observed species diversity in the area. Kent and Coker (1992) explained that the Shannon-Wiener diversity index normally varies between 1.5 and 3.5, and rarely exceeds 4.5. Accordingly, the high H' value of Dense Forest indicates affluent plant diversity of the study site, which might relate to the relatively high degree of habitat, microhabitat and land form differences in the area. Results also show better overall species evenness (J= 0.80) in Dense Forest, which is higher than in Chilimo (J=0.68) (Tadesse Woldemariam *et al*., 2000), Tara Gedam (J=0.65) and Abebaye forests

(J=0.31) (Haileab Zegeye *et al.*, 2011), indicating a relatively much more equitable distribution of individuals among various species in the study area.

Comparison of overall species diversity among the five plant communities of Dense Forest indicates the highest H' value to occur in community five. This might be explained by the wide altitudinal range of this community extending from 2125 to 2900 m a.s.l. which may induce different microclimatic conditions, and the concomitant occurrence of species adapted to these different microclimates. According to Austin *et al*. (1996), altitudinal gradients involve different interacting ecological factors which influence growth, development, diversity and distribution pattern of plants among plant communities in an area.

The observed relatively high overall and medicinal species evenness for community four shows that there is no single dominant species, but rather a coexistence of species over all plots in this community. According to Feyera Senbeta and Demel Teketay (2003), local climatic variations and forest disturbances are mentioned among the factors most responsible for variations in species diversity and evenness in a given forest. Engelbrecht *et al*. (2007) also stated that forest disturbances affect species diversity, amongst others, due to their effect on removal of some preferred species, and the resulting change in light environment of the understory species. Similarly, Bongers *et al*. (2009) explained that intermediate levels of forest disturbance may promote species diversity by facilitating regeneration of some species. The maximum value of Sorensen's coefficient of similarity observed between communities three and five showed occurrence of relatively similar species in both communities. This probably relates to the relative overlap in altitudinal ranges of the plots forming the two communities.

5.1.1.4. Vegetation structure of Dense Forest

Most plant species in Dense Forest were represented by only a few individuals scattered in different plots, a pattern which is common for most tropical forests (Valencia *et al*., 1994). However, Dense Forest showed relatively high woody species density (1,138 individuals ha^{-1}) when compared to some other Afromontane forests such as Adelle (898 individuals ha^{-1}) and Boditi (498 individuals ha^{-1}) (Haile Yineger *et al*., 2008c), whereas its density was found to be lower than that of some other forests such as Dindin (1,750 individuals ha^{-1}) (Simon Shibru and Girma Balcha, 2004) and Masha-Anderacha (1,709 individuals ha^{-1}) forests (Kumlachew Yeshitela and Tamrat Bekele, 2002). According to Whittaker *et al*. (2003), variations in density distributions can be attributed to variations in topographic gradients and habitat preferences of species forming the forest, and the degree of anthropogenic influences.

The value obtained from a comparison of the ratio of density distribution of trees or shrubs in DBH > 10 cm and DBH > 20 cm classes of the Dense Forest (1.5) was found to be lower than that of some other montane forests such as Chilimo (2.6) and Menagesha (2.3) (Tamrat Bekele, 1993), Mana Angetu (2.09) (Ermias Lulekal *et al*., 2008b), Masha Anderacha (2.4) (Kumlachew Yeshitela and Tamrat Bekele, 2002), Dindin (1.99) (Simon Shibru and Girma Balcha, 2004) and Denkoro (1.90) (Abate Ayalew, 2006), indicating a higher predominance of small-sized individuals in these forests compared to that of Dense Forest. According to Grubb *et al*. (1963), lower values for the ratio of small-sized individuals to large-sized individuals are mentioned as indicators of forests which developed under natural conditions and with minimum disturbances, while higher values indicate a predominance of small-sized individuals that start to grow following excessive cuttings or other anthropogenic disturbances.

The results on the overall proportion of trees and shrubs in Dense Forest across the seven DBH classes indicates an inverted J-shape distribution except for a slight decrease in the first DBH class (2-10 cm). Such inverted J-shape distributions across DBH classes are indicative of an overall healthy regenerating forest (Silvertown and Doust, 1993). In addition, more specific information about regeneration status of individual species can be obtained through the analysis of the population structure of individual tree and shrub species (Popma *et al*., 1988). Feyera Senbeta and Demel Teketay (2003) also reported an inverted J-shape distribution for a population pattern assessment of Kimphee Forest in southern Ethiopia and reached similar conclusions.

The percentage distribution of trees in Dense Forest in DBH class 50-80 cm was found to be higher (11.3) than that of some other montane forests in Ethiopia such as Menagesha (6.5) and Chilimo (2.6) (Tamrat Bekele, 1993), Denkoro (6.3) (Abate Ayalew, 2006) and Mena Angetu (8.91) (Ermias Lulekal, 2008b), indicating a better distribution of trees in the middle DBH class (50-80 cm) of Dense Forest than the forests it was compared with. In the relatively higher DBH class (80 -110 cm), better species distribution was observed for Dense Forest (9.25) than Menagesha (2.5) (Tamrat Bekele, 1993), Denkoro (1.1) (Abate Ayalew, 2006) and Mena Angetu forests (2.38) (Ermias Lulekal, 2008b). However, in DBH class (10-20 cm) density distribution of trees in Dense Forest was found to be lower (27.26) than for some other montane forests such as Wof-Washa (32.6), Menagesha (56.9) and Chilimo (60.8) (Tamrat Bekele, 1993), Denkoro (46) (Abate Ayalew, 2006), and Mena Angetu (32.78) forests (Ermias Lulekal, 2008b). Hence, the result still confirms that there is dominance of small-sized individuals in the forests used for comparison than in Dense Forest.

The results of a basal area analysis are used to measure the relative dominance of woody species in a forest (Cain and Castro, 1959). Accordingly, six woody species were identified to be more dominant than others. Among those, *Olea europaea* subsp. *cuspidata*, *Podocarpus falcatus* and *Juniperus procera* ranked the three most dominant species accounting for 67% of the total basal area in Dense Forest. These three species were also mentioned to be characteristic species of dry Afromontane forests (Tamrat Bekele, 1993); hence this result confirms the dry montane nature of the study area. However, among the six dominant species two species, i.e. *Juniperus procera* and *Ficus sur* were not found in the list of eight species which were identified to display the highest densities in Dense Forest. High basal area but low density of these two species can be taken as a good evidence for the presence of a low number of large-sized individuals representing the species. Moreover, the low density of *Juniperus procera* might be related to the very poor regeneration capacity under its own canopy (Tamrat Bekele, 1993), whereas that of *Ficus sur* might be related to the lack of specific environmental conditions, mainly river courses, which the species needs to regenerate (Chapman and White, 1970). White (1983) also stated that *Juniperus procera* is a light-demanding species which does not commonly regenerate under its own shade, and therefore shows low density in closed forests.

The highest density value for *Olea europaea* subsp. *cuspidata* could be attributed to its relatively good regeneration capacity under shaded conditions in dry environments (Rey *et al*., 2000; Masresha Fetene and Yonas Feleke, 2001; Tamrat Bekele, 2005). The same is true for high density of *Podocarpus falcatus* which has good regeneration capacity under its own canopy (Tamrat Bekele, 1993). Human-induced removal of canopy species in Dense Forest may ultimately end in losing these native species by hampering their regeneration. Thus, the finding calls for a caution in designing any conservation measure in the area, i.e. a conservation strategy for Dense Forest should take into account maintaining canopy species, in addition to reforestation.

Maesa lanceolata was found to be the most frequent woody species in Dense Forest, occurring in 90% of the sampled quadrats. This might be attributed to its usual occurence along wide altitudinal range that extends from 1,350 to 3,000 m a.s.l. (Sebsebe Demissew, 1995). *Bersama abyssinica* was the second most frequent species present in 86% of the quadrats sampled. According to Verdcourt (1989a), *Bersama abyssinica* is common in *Juniperus-Podocarpus* forests and their degraded remnants, growing in a wide altitudinal range extending from 1,700 to 2,715 m a.s.l. High frequency of a species always depends on factors which relate to habitat preferences, adaptation, degree of exploitation and availability of suitable conditions for regeneration (Rey *et al*., 2000).

Importance Value Index (IVI) analysis showed higher values for *Olea europaea* subsp. *cuspidata* and *Podocarpus falcatus* than for any other species in Dense Forest. High basal area values of these species were the major factors explaining these high IVI values. According to Mueller-Dombois and Ellenberg (1974) and Curtis and McIntosh (1950), the relative ecological significance and/or dominance of a tree species in a forest ecosystem could best be identified from IVI analysis. Thus, in this investigation, the IVI results also confirmed that these two species (*Olea europaea* subsp. *cuspidata* and *Podocarpus falcatus*) are the most important/dominant species in the study area.

5.1.1.5. Population structure

Results from population structure analysis of woody species in Dense Forest showed five major representative patterns of density distribution of trees across different DBH classes. According to Popma *et al*. (1988), plant population structures help to understand population dynamics and regeneration status of species in a forest. The first population structure represented by *Bersama abyssinica* (Figure 5a), indicates the presence of the highest density in the lower DBH classes with a gradual decrease in density towards the higher classes. It represents a reverse J-shaped distribution except for a slight decrease in the first DBH class. Such population pattern is an indication of a stable population structure and good regeneration status (Silvertown and Doust, 1993; Getachew Tesfaye *et al.*, 2010). *Maesa lanceolata* and *Ekebergia capensis* also show such an inverted J-shaped distribution, similarily indicating good reproduction and recruitment.

The second population structure type was represented by *Allophylus abyssinicus* (Figure 5b). It represents Gauss-type distribution pattern. It shows low frequency in the first and second DBH classes, a gradual increase in the middle class followed by a decrease in density towards the higher classes. Such population structure indicates poor reproduction (Tamrat Bekele, 1993), and also a decline in number of big trees. Selective cutting of large-sized individuals for various purposes, mainly timber for construction, could be the reason for decline in number of large-sized trees. *Galiniera saxifraga* also shows this type of pattern. In this study too, we found that species exhibiting such population structure type including *Allophylus abyssincus* and *Galiniera saxifraga* are most-preferred for local construction and making farm tools, hence subjected for selective removal.

The third pattern was represented by *Croton macrostachyus* (Figure 5c). It shows high frequency in lower DBH classes followed by a gradual decrease and absence of representative individuals after the middle-size DBH classes. It suggests good reproduction and bad recruitment (Ermias Lulekal *et al*., 2008b; Haile Yineger *et al*., 2008c). *Prunus africana* also shows this type of population structure. Use-based exploitation of species in these category (for instance, *Prunus africana* is most-preferred for making pestles in the study area) can also be mentioned as a factor for absence of individuals after the middle-size DBH classes.

The fourth pattern was represented by *Juniperus procera* (Figure 5d). It is characterized by the highest representation of big (DBH > 80cm) and old individuals, with a hampered regeneration. This pattern typically indicates bad reproduction and poor recruitment (Tamrat Bekele, 1993). Missing representative individuals in the middle-size DBH classes clearly indicate that there is a selective removal of individuals of specific size classes by local people. This population pattern was also evident for *Nuxia congesta* in Dense Forest.

The fifth pattern was represented by *Olea europaea* subsp. *cuspidata* (Figure 5e). The pattern shows a J-shaped distribution of individuals except for a decline in the upper DBH class (>140 cm). This pattern suggests good recruitment and relatively weak reproduction. It also indicates the presence of selective cutting of preferred size classes by local people. *Ilex mitis* and *Olea capensis* subsp. *macrocarpa* have the same distribution pattern. Generally, the observed representative population structures of species in Dense Forest are indicators to the ultimate need of overall conservation activities, giving priorities to those species with poor reproduction and recruitment.

5.1.1.6. Floristic similarity of Dense Forest with other montane forests

The output of a floristic similarity analysis between Dense Forest and some other Ethiopian montane forests is summarised in Table 22.

Table 22. Comparison of floristic similarities between Dense and some montane forests in Ethiopia (N= Number of species included in comparison; a= species composition to both forests compared; b= species available only in Dense Forest; c= species available only in the other forest compared; Ss= Sorensen's coefficient of similarity)

Forest	Data Source	Elevation (m a.s.l)	N	a	b	C	Ss
Mana Angetu	Ermias Lulekal *et al.* (2008b)	1533-2431	116	30	58	86	0.34
Harenna	Lissanework Nigatu and Mesfin Tadesse (1989)	2200-3300	85	27	51	58	0.33
Jibat	Tamrat Bekele (1993)	2200-2900	51	21	57	30	0.33
Chilimo	Tamrat Bekele (1993)	2400-2800	33	19	59	14	0.34
Wof-washa	Tamrat Bekele (1993)	2400-3000	30	19	58	11	0.36
Menagesha	Tamrat Bekele (1993)	2400-3000	31	19	59	12	0.34
Masha	Abreham Assefa *et al.* (2013)	1700-3000	58	15	63	43	0.20
Tara Gedam	Haileab Zegeye *et al.* (2011)	2142-2484	96	34	44	62	0.39
Dense	Present study	2125-2971	158	158	0	0	1

The observed high Sorensen's similarity values obtained from the floristic comparison of Dense and Tara Gedam forests (0.39), and Dense and Wof-Washa forests (0.36) indicate that Dense Forest is floristically more related to Tara Gedam and Wof-Washa Forests than to the other six forests compared. Tara Gedam Forest is found in South Gondar Zone of Amhara National Regional State, northwestern Ethiopia (Haileab

Zegeye *et al*., 2011). The observed similarity between Dense and Tara Gedam forests may be attributed to the relative similarities in elevation and climatic factors. Although the highest elevation in Dense Forest extends up to 2971 m a.s.l., both forests show similar readings for the lowest elevation points (2142 m a.s.l. in Tara Gedam and 2125 m a.s.l. in Dense). In addition, the mean annual rainfall in Tara Gedam reaches to 1200 mm (Haileab Zegeye *et al*., 2011), whereas that of Dense is at 1250 mm. Thus, the overlap in elevation ranges coupled with exposure to relatively similar climatic conditions may have resulted in a similarity in the species composition (Urban *et al*., 2000) between the two forests. *Olea europaea* subsp. *cuspidata* was found to be the most dominant species in Tara Gedam Forest (Haileab Zegeye *et al*., 2011), which was also evident for Dense Forest as observed in this investigation.

The high floristic similarity observed between Dense and Wof-Washa forests could also be attributed to geographical proximity and the relatively similar altitudinal ranges and climatic conditions. The Wof-Washa Forest is located in North Shewa Zone of Amhara National Regional State. Its elevation ranges from 2400 to 3000 m a.s.l. (Tamrat Bekele, 1993). Both Dense and Wof-Washa forest areas share relatively similar bimodal rainy seasons. Thus, proximity and overlaps in elevation and climatic conditions may have resulted in good floristic similarity observed between the two forests. Generally, our results indicate that Dense Forest shows relatively better floristic similarity with dry montane forests (Tara Gedam, Wof-Washa, Chilimo and Menagesha) than with moist montane forests (Mana Angetu, Harenna, Jibat and Masha) of Ethiopia.

5.1.2. Medicinal plants for humans

5.1.2.1. Diversity

Results showed that Ankober District is rich in medicinal plant diversity as shown by the presence of 135 species for treating human ailments with the latter exhibiting wide taxonomic diversity (125 angiosperm, two gymnosperm and one fern genera in 68 angiosperm, two gymnosperm and one fern families). The diversity is also obvious from the elaborate system of traditional naming of plants (based on morphology of a plant part or its remedial uses) and the indigenous knowledge engraved in each medicinal plant species' name and knowledge about the uses of each medicinal plant species. Results also showed the role played by traditional medicinal plants and the local community holding considerable traditional health knowledge in assisting the primary healthcare needs of the District. The number of medicinal plants harvested in the District is found to be far higher than that of other areas in the country investigated for their ethnomedicinal wealth (Haile Yineger *et al*., 2008a; Tesfaye Hailemariam Bekalo *et al*., 2009; Mirutse Giday *et al*., 2009; Mirutse Giday *et al*., 2010). Although cultural, economic, ease of accessibility and efficacy related factors might have played major roles for the people of Ankober to rely on traditional medicine, the cultural factor might have been the most important one resulting in a sentimental adherence to ancestral medical traditions/practices by upholding the latter as a highly valued heritage of the society or of the great fathers and mothers.

Dominance of medicinal plant species of the families Asteraceae, Fabaceae, Solanaceae, Lamiaceae, Cucurbitaceae, Ranunculaceae and Rosaceae could be attributed to their wider distribution and abundance in the flora area (Thulin *et al.*, 1989; Hedberg, 1989; Jeffrey, 1995; Demel Teketay, 2000; Mesfin Tadesse, 2004;

Friis, 2006; Ryding *et al*., 2006). This is also confirmed by consistent recording of ethnomedicinal uses of species from the aforementioned families in other Ethiopian ethnobotanical inventories (Haile Yineger *et al*., 2007; Ermias Lulekal *et al*., 2008a; Tesfaye Hailemariam Bekalo *et al*., 2009; Tilahun Teklehaymanot, 2009; Mirutse Giday *et al*., 2010). Moreover, the wide utilization of species from these families might also relate, as earlier described in other areas (Gazzaneo *et al*., 2005), to the presence of effective bioactive ingredients against ailments.

5.1.2.2. Growth form and habitat

A good number (38%) of medicinal plants used for human ailments in the area were shown to be herbs. This could relate to the fact that they are more easily accessible from the nearby areas than trees and shrubs that are often harvested from patches of forests distantly located from resident areas, in addition to the fact that the number of species of herbs is far morethan that of the species of woody plants in the Flora area. This finding agrees with the general pattern of dominance of herbaceous species seen in most medicinal plant inventories in Ethiopia and elsewhere (Mirutse Giday *et al*., 2003; Tabuti *et al*., 2003; Muthu *et al*., 2006; Haile Yineger *et al*., 2007; Mirutse Giday *et al*., 2010). Wild habitats of Ankober were found to be major pools of traditional medicinal plants harbouring about 74% of all reported medicinal plants. However, the investigation showed that these habitats are subjected to negative anthropogenic influences and consequently shrinking in size due to an ever-increasing population pressure with possible result in the loss of many medicinal species growing in the wild. Our observation is also in agreement with previous reports of overdependence on wild habitats for harvesting of medicinal plants (Ermias Lulekal *et* *al*., 2008a; Haile Yineger *et al*., 2008a; Girmay Zenebe *et al*., 2012) than an effort to cultivate and use them sustainably.

5.1.2.3. Part and form used

Overexploitation of roots for a great proportion of human medicinal plant preparations (61%) shows the threat posed to long-term survival of the corresponding medicinal plants. Mining of roots of medicinal plants was also commonly reported by other ethnomedicinal inventories elsewhere (Dawit Abebe and Ahadu Ayehu, 1993; Getachew Addis *et al*., 2001; Haile Yineger *et al*., 2007; Ermias Lulekal *et al*., 2008b, Tilahun Tekehaymanot, 2009). Harvesting of roots (especially rooting off herbaceous medicinal plant species) kills the parent plant and could be a severe threat for survival of the often rare and slowly reproducing medicinal plants of the area. As leaves of medicinal plant species were also reported to be harvested for most remedy preparations together with roots, gathering leaves should be promoted as a more sustainable method of accessing plant materials since in most cases, at least a certain number of leaves is left over on the parent plant which then allows it to carry on its life functions.

Results also showed prominent use (69.9%) of freshly harvested plant parts for traditional remedy preparation used against various human ailments. The recurrent use of freshly harvested medicinal plant could be attributed to the wide-spread traditional belief of attaining high efficacy from fresh remedies due to the higher presence of active ingredients in the form of secondary metabolites in the cases of fresh plant parts which community members thought could be lost on drying. Other ethnomedicinal inventories (Haile Yineger *et al*., 2007; Ermias Lulekal *et al*., 2008a) have also indicated the wide use of fresh plant materials for various remedy preparations due to the reportedly better efficacy than when using dried plant materials.

5.1.2.4. Traditional methods of diagnosis, remedy preparation and dosage determination

The high number and different types of human diseases (69 disease types) for which traditional healers were most-visited by patients indicated heavy reliance of local people in the study area on traditional healers and nature's pharmacy for various ailments. Economic, cultural, efficacy and availability factors were reported as the key factors which lead the community to knock at the door of traditional healthcare practitioners rather than to go and consult the few distantly located healthcare centres with unaffordable high prices. Similar findings were reported by Tesfaye Hailemariam Bekalo *et al*., (2009) and Fisseha Mesfin *et al*. (2009).

Visual inspection of patients is the more frequent diagnostic method practiced by all local healers in the area. Although changes in body temperature, skin and eye colour, low appetite and physical appearance help traditional healers to detect which patients face which disorders, it was mainly through visual experience that identification of diseases and prescriptions were made. Other researchers (Mirutse Giday *et al*., 2003; Haile Yineger *et al*., 2007; Ermias Lulekal *et al*., 2008b; Fisseha Mesfin *et al*., 2009) have also reported similar diagnostic methods in different cultural groups. Misidentification of diseases commonly leads to wrong diagnosis and inappropriate prescription which may result in adverse effects to patients.

Even though dosages of remedies for various ailments were reported to be determined based on age, occurrence of pregnancy, physical fitness/appearance and gender of the patient, there were no standardised measurements or guidelines set nor shared by traditional healers. Overdose of remedies was also reported to bring adverse effects like vomiting, diarrhoea, burning sensations and sometimes fainting of the patient. Lack of precision and standardization has been mentioned as a global drawback of the traditional healthcare system (Dawit Abebe, 2001). Traditional healers in our study area reported the use of different antidotes including BESSO (dissolved powder of roasted barley), milk, coffee, honey, yoghurt, and butter for reversing adverse effects and stabilising disorders. The same pattern of using antidotes was also reported for other cultural groups elsewhere in the country (Ermias Lulekal *et al*., 2008b; Haile Yineger *et al*., 2008a; Mirutse Giday *et al*., 2010).

The dominant use of medicinal plant decoctions for various ailments might be related to their proven effectiveness over many years of trial and indigenous knowledge accumulated on efficacy of such preparations. Decoction was reported as one of the major ways of remedy preparation in ethnomedicinal inventories of a number of other socio-cultural groups in the country (Haile Yineger *et al*., 2007; Fisseha Mesfin *et al*., 2009).

5.1.2.5. Marketability

The results from the market survey of medicinal plants indicated that most human medicinal plants (81%) have no marketability report and were not available on major market places of the District during the time of this research. This would show that the majority of medicinal plants are collected for remedy preparations only when the need arises. Although 19% of medicinal plants were available on the market at the time of survey, *Echinops kebericho, Embelia schimperi*, *Hagenia abyssinica*, *Withania somnifera* and *Silene macrosolen* were the only ones that were sold and/or purchased for their traditional medicinal uses. The market value of these species (with a price range from 0.21 USD per bunch of root or jug of inflorescences to 0.3 USD for a cup of fruits) showed the income generation potential of a number of medicinal plants and gives an indication of potential demand of those plants by the community. However, such marketability could also indicate that the plants are under pressure since they are purposefully hunted for economic reasons. Other reportedly marketable medicinal plants of Ankober were mainly gathered and sold for their uses related to edibility, lumbering, firewood and construction purposes. Although the investigation indicated the current market potential of medicinal plants in Ankober, a relatively wider domestic trade in a number of Ethiopian medicinal plants was reported for other cultural groups in the country (Kloos, 1976; Dessalegn Dessissa, 2001; Mander *et al*., 2006). Thus, our finding can also be used as a base for more in-depth future study of the money-making potential of medicinal plants in the area through successive longitudinal market surveys over a number of years together with value chain analyses of potential plants.

5.1.2.6. Efficacy and relative healing potential of medicinal plants

The highest calculated ICF values (0.7 and 0.65) indicated the best agreement among informants on the use of human medicinal plant species for treating gastro-intestinal and parasitic, and dermatological diseases, respectively. The observed high informant agreement coupled with high plant use citations for these disease categories could also indicate the relatively high incidence of the latter diseases in the area. According to Heinrich *et al*. (1998), high ICF values are important to identify plants of particular interest in the search for bioactive compounds. Accordingly, about 19 medicinal plants of Ankober (with high ICF values) for treating diseases under gastro-intestinal and parasitic disease category were thoroughly investigated for their antimicrobial properties by our research team and findings discussed.

The reported highest fidelity level values for *Zehneria scabra* (95%) and *Ocimum lamiifolium* (93.33%) against febrile diseases; and for *Hagenia abyssinica* (93.75%) against gastro-intestinal and parasitic diseases could be considered a clue for the high healing potential of these plants against the corresponding diseases. Plants with high fidelity level values could also be targeted for further phytochemical testing to verify the bioactive role inducing high healing results (Trotter and Logan, 1986; Heinrich *et al*., 1998). Accordingly, activity-testing experiments were carried out on extracts of medicinal species with high fidelity levels, the finding of which are discussed.

5.1.2.7. Top ranking medicinal plants

The output of a direct matrix ranking exercise showed that a number of multipurpose medicinal plants of the study area including *Podocarpus falcatus*, *Olea europaea* and *Ekebergia capensis* ranked in the first circle. Further scrutiny showed that these plants are being more exploited for their non-medicinal uses than for the reported human medicinal values. Overharvesting of multipurpose medicinal plant species for making agricultural tools, construction materials, lumbering and firewood purposes were the factors responsible for aggravating depletion of the species in the area. Thus, the results call for an urgent complementary conservation action to save the fast-eroding multipurpose medicinal plant species of the area. Haile Yineger *et al*. (2007) have also reported on the same pattern of high exploitation of multipurpose medicinal plants for uses other than their traditional medicinal importance in south eastern Ethiopia.

Ranking of medicinal plant species by key informants helped to identify *Olea europaea* subsp. *cuspidata*, *Allium sativum* and *Datura stramonium* as the most-preferred medicinal plant species for treating atopic eczema. Ethnobotanical investigations undertaken elsewhere in Ethiopia (Haile Yineger *et al.,* 2008a) also reported on the use of *Olea europaea* subsp. *cuspidata* for treating eczema. Further investigation of these species for their bioactive components acting against atopic eczema may produce promising results.

5.1.3. Ethnoveterinary plants

5.1.3.1. Diversity and indigenous use of ethnoveterinary plants

The identified ethnoveterinary medicinal plants of Ankober (51 species belonging to 50 genera and 35 families) showed that the District is rich in ethnoveterinary herbal diversity and indigenous knowledge associated with each traditionally used species. Comparison of the number and diversity of ethnoveterinary medicinal plant species used in Ankober with other ethnoveterinary research results of cultural communities in Ethiopia (Teshale Sori *et al*., 2004; Haile Yineger *et al*., 2008b, Damtew Bekele *et al*., 2012, Mirutse Giday and Tilahun Teklehaymanot, 2013; Gebremedhin Gebrezgabiher, 2013) and elsewhere in Uganda (Tabuti *et al*., 2003), Kenya (Njoroge and Bussmann, 2006), South Africa (Botha *et al*., 2001), Pakistan (Khan and Hussain, 2012) and India (Selvaraju *et al*., 2011; Devendrakumar and Anbazhagan, 2012) confirms its richness in diversity of ethnoveterinary plants. The millennia-old interaction of indigenous people in the area with locally available medicinal plants might have enabled them to develop an indigenous knowledge system best fit to select and use diverse curative medicinal plants to treat frequently occurring livestock diseases. According to Rindos (1984), knowledge on plant use is the result of many years of human interaction and selection on the most desirable and successful plants present in the immediate environment at a given time.

One of the driving factors which made the people of Ankober District to rely on wild plants of ethnoveterinary importance to treat veterinary ailments is inadequate number of formal veterinary clinics (only five) and veterinarians (only eight) available in the area that would never be enough to provide healthcare services for more than 200,000 livestock heads (AWFPEDO, 2012). Moreover, almost all of the rural community lives in marginal areas which are not easily accessible to the limited modern veterinary services, which are also known for their scorching prices that are totally unaffordable to the less economically endowed people living there.

Some ethnoveterinary species of Ankober are also found with use reports in other ethnic groups in the country. Examples are *Calotropis procera* and *Withania somnifera* that also occur in the ethnoveterinary medicinal flora of the Afar people (Mirutse Giday and Tilahun Tekelehaymanot, 2013); *Croton macrostachyus* and *Ricinus communis* recorded for the Gilgel Ghibe area and Borana pastoralists (Teshale Sori *et al*., 2004; Haile Yineger *et al*., 2008b) and *Calpurnia aurea* and *Achyranthes aspera* reported for Tanqua-Abergele and Kolla-Tembien Districts in Tigray Region (Gebremedhin Gebrezgabiher *et al.*, 2013). Similarity of medicinal plant species used in different communities can be attributed to cross-fertilization of cultural knowledge among different ethntic groups besides distribution/availability of the species in use in areas investigated for their ethnomedicinal knowledge.

Best-representation of ethnoveterinary species from families Asteraceae, Asclepiadaceae, Euphorbiaceae and Ranunculaceae could be related to their wider distribution and use in Ethiopia (Gilbert, 1995; Demel Teketay, 2000; Goyder *et al*., 2003; Mesfin Tadesse, 2004). These families were also reported to have the largest share of ethnomedicinal species in other ethnobotanical inventories (Haile Yineger *et al*., 2007; Damtew Bekele *et al*., 2012; Mirutse Giday and Tilahun Tekelehaymanot, 2013; Gebremedhin Gebrezgabiher *et al.*, 2013).

5.1.3.2. Growth habit, source and remedial parts of ethnoveterinary plants

Results showed higher utilization of shrubs followed by herbs in ethnoveterinary remedy preparation. Dominance of shrubs was also reported by earlier ethnobotanical inventories (Debela Hunde *et al*., 2006; Ermias Lulekal *et al*., 2008a; Fisseha Mesfin *et al.*, 2009). In contrast, other investigators (Mirutse Giday *et al*., 2003; Tabuti *et al*., 2003; Muthu *et al*., 2006; Haile Yineger *et al*., 2007) reported dominance of herbaceous species for ethnomedicinal preparations in Ethiopia and elsewhere. However, the variation in dominance of growth forms of medicinal plants used over different ethnic groups in the country could be attributed to the wide agro-ecological diversity and specific indigenous knowledge of different communities. Results also showed the dominant practice of harvesting the majority (80%) of ethnoveterinary plants in Ankober from non-cultivated sources. This would indicate the extent of anthropogenic pressure exerted on wild plant resources of the area. Overdependence on wild resources coupled with shrinking of the wild habitat due to ever-increasing population pressure pose a threat to the medicinal plant wealth of the area. Comparable trends in overharvesting medicinal plants from the wild were also reported elsewhere (Getachew Addis *et al*., 2001; Kebu Balemie *et al*., 2004; Girmay Zenebe *et al.,* 2012).

The finding of roots to be the most-harvested plant parts used for ethnoveterinary remedy preparation in the District might be associated with shared traditional beliefs in different communities about a more powerful therapeutic effect of root over other plant parts for treating various ailments (Voeks, 2009; Van Andel *et al*., 2012; Ketema Tolossa *et al*., 2013). Overharvesting of roots for remedy preparation was also reported for different cultural groups in the country and elsewhere (Dawit Abebe and Ahadu Ayehu, 1993; Getachew Addis *et al.*, 2001; Tabuti *et al*., 2003; Haile Yineger *et al*., 2007; Ermias Lulekal *et al*., 2008a; Tilahun Teklehaymanot, 2009) calling for coordinated conservation measures built on local sustainable harvesting methods like not removing the major roots and covering the expose parts to save the fast-eroding therapeutic plants ruthlessly hunted for their roots. According to Sheldon *et al*. (1997), the main factor to be considered for conservation and sustainable use of medicinal plants is the particular plant part harvested for its curative value and the way it is harvested. Results also indicate pronounced preference of traditional healers in Ankober to make use of freshly harvested plant parts (83%) over dried forms for ethnoveterinary remedy preparations too, which could also be attributed to the wide-spread traditional belief of attaining high efficacy from fresh ingredients better than dried ones. Similar observations were reported (Haile Yineger *et al.,* 2007; Ermias Lulekal *et al*., 2008a) for other cultural groups living in Ethiopia.

5.1.3.3. Livestock ailments, remedy preparation and traditional diagnosis

The observed frequent utilization of finely pounded remedial parts which are then homogenized with cold water (54%) and used against various ailments could relate to age-old traditional experiences on proven efficacy of such preparations. Homogenizing remedial parts with water and applying the latter against various ailments has also been reported from other cultural groups (Haile Yineger *et al*., 2007; Ketema Tolossa *et al*., 2013). The observed trend of using two or more medicinal plants (accounting for about 14% of preparations) for treating livestock ailments may be attributed to the expected synergistic effect of these combinations of parts and their bioactive ingredients to treat ailments. Mirutse Giday *et al*. (2007) also reported on the therapeutic efficacy of combinations of medicinal plant parts used by Shinasha, Agew-awi and Amhara peoples living in northwest Ethiopia for treating various ailments.

Identification of specific livestock ailment types in the area was found to be based on age-old cultural knowledge on symptoms and corresponding livestock illnesses held in the memories of indigenous people. The same was found true in selecting those curative plants which were thought to be most appropriate to heal various veterinary diseases. However, no standardised volume or weight measurements were set by traditional healers on the amount of herbal prescriptions for different livestock ailments. Ethnoveterinary studies conducted in Pakistan (Hussain *et al*., 2008) and Brazil (Monteiro *et al*., 2011) also reported on the lack of standardised doses in traditional prescriptions of livestock remedies. In addition, similar patterns of diagnosis and herbal prescriptions were reported by other researchers (Haile Yineger *et al*., 2007; Martínez and Luján, 2011).

The observed diverse medicinal uses of plants against various livestock ailments in the area would be indicative of the presence of a number of inherent curative properties within each medicinal plant. The relatively high number of medicinal plants cited for treating cattle ailments may also be related to a higher incidence of a number of diseases affecting cattle populations in the area as well as the importance of cattle to the community and the likelihood that people are more concerned about their cattle's health than other animals. Similarly, the highest proportion of medicinal plants used to treat dermatological diseases in the study area could also be related to high incidence of such diseases in Ankober and ease of application. This is justified by the high number of dermatological diseases (accounting for 15% of all livestock ailments in Ankober District) reported by community members. In addition, the finding indicates that traditional veterinary practices in the area are well-focused on the most-prevalent animal health problems. Presence of a large share of ethnoveterinary plants for treating cattle ailments, which in a way shows the importance of cattle to the life of the people, was also reported for other cultural groups in the country (Mirutse Giday and Gobena Ameni, 2003).

5.1.3.4. Marketability of ethnoveterinary plants

Local communities in Ankober mainly collect and use ethnoveterinary plants for a private use for their own livestock. However, a limited scale of buying and selling traditional medicine was observed at Aliuamba, Derefo, Gorabela, Gorgo, Haramba and Zego local markets in the District. Although 20 % (ten species) of the local ethnoveterinary medicinal plants were shown to be available on the market, only two species, i.e. *Embelia schimperi* (0.3 USD per cup of fruits) and *Withania somnifera* (0.2 USD per bunch of root material) were said to be purchased solely for use in traditional veterinary applications. The specific market price of these medicinal plants mainly depends on the availability of species in the area and the distance travelled to collect the respective plants. *Embelia schimperi* and *Withania somnifera* were reported for scarcity in the area by all informants and local retailers whereby the latter was explained to be due to overharvesting of species. This made collectors travel long distances to gather these species. The remaining eight species were on the market mainly sold for uses other than medicine, i.e. for food, lumbering and firewood purposes although they were mentioned to be occasionally used as remedies when there is a need. Local retailers of medicinal plants, even though they are not herbalists, have also shown some knowledge on use, local distribution and local market demand of economically useful medicinal plants which in turn indicated that knowledge on curative plants is not limited only to local healers or traditional herbalists. Market status and availability of marketable medicinal plants were also reported in various sources (Kloos, 1976; Dessalegn Dessisa, 2001) for other cultural groups in Ethiopia.

5.1.3.5. Efficacy, healing potential and ranking of ethnoveterinary plants

The observed high informant consensus (ICF=0.71) on ethnoveterinary medicinal plants used to treat gastro-intestinal diseases in the area indicated the popularity of those curative plants in their uses against diseases in the latter category. Sharma *et al*. (2012) have explained that high ICF values indicate big share of similar plant use information within a community. Those medicinal plants with a low informants consensus indicate that there is few share of similar plant use information, may be due to secrecy on their healing power or due to their ineffectiveness upon trial against a given ailment. The recorded high plant use citation (25.95%) for treating ailments in the dermatological disease category may also indicate the relatively high incidence of such diseases together with an ease of identifying symptoms and the corresponding curative plants occurring in the District.

The highest fidelity level values were obtained for *Embelia schimperi* (90%) and *Rubus steudneri* (84%) in the gastro-intestinal disease category, and *Croton macrostachyus* (83%) for the dermatological therapeutic category. This would indicate the relatively high healing potential of the species for treating ailments under the respective ailment categories (Trotter and Logan, 1986; Heinrich *et al*., 1998). Thus, results call for pharmacological investigations on these plants since high percentage of informants agreed on their curative values. Plants with high fidelity level values obtained in this investigation were tested for antimicrobial activities and the findings discussed.

Output of the preference ranking exercise also indicated that *Embelia schimperi* and *Rubus steudneri* are the most-preferred ethnoveterinary medicinal plants used to treat diarrhoea, the most commonly reported disease in the area. This may be attributed to the presence of bioactive compounds against the causative agents of diarrhoea in these species. Hence, both species were investigated in the laboratory for further antimicrobial activities against different microbial strains and the corresponding findings discussed.

5.1.4. Ethnomedicinal knowledge of the community

The significant difference ($P<0.05$) on average number of medicinal plants reported by different age groups compared in this investigation showed that indigenous knowledge on use of medicinal plants is still stronger with elderly people (4.90 $\pm$ 13) than in the younger generation (2.59 $\pm$ 0.08). Moreover, the observed extremely significant difference ($p=0.0001$) showed the gap between generations and the decline of indigenous knowledge on medicinal plants down generations. This could be attributed to the impact of modernization (including urbanization and advent of formal education) and the very poor system of sharing indigenous knowledge (through word of mouth, with maximum secrecy and only along family lines) on medicinal plants with the younger generation. In addition, the lack of interest in traditional medicine among younger members of the community could also be taken as a factor for the observed knowledge gap. The scenario is the same for other cultural groups in Ethiopia (Ermias Lulekal *et al*., 2008a; Haile Yineger *et al*., 2008a; Mirutse Giday *et al*., 2009; Tilahun Teklehaymanot, 2009) and elsewhere (Begossi *et al.*, 2002; Uniyal *et al*., 2006; Silva *et al*., 2011). This result calls for an effort to close the observed generation gap through continuous professional support and training of local communities with the objective of preserving their traditional health knowledge and practices through systematic documentation. According to de Boer *et al*. (2012), measuring traditional knowledge on medicinal plant use among community members provides information on the degree of consensus of the community on use of traditional remedies. Our results likewise indicate more consensus and knowledge on medicinal plant use among elderly members of the community than that of the younger groups in the District. Silva *et al.* (2011) explained that greater knowledge of older people on medicinal plants is the result of a high degree of opportunity for more cultural contact and experience with plants and associated therapeutic uses. Absence of continuous cultural interaction with plants was also reported as one factor for the loss of traditional knowledge down generations (Reyes-García *et al*., 2007; Winter and McClatchey, 2008).

The other significant difference (p=0.0001) observed between key and general, and literate and illiterate informants could relate to the impact of age-old experience and maximum degree of secrecy in using medicinal plants in the former, and modernization in the latter case. Similar results were reported by Teferi Gedif and Hahn (2003), Mirutse Giday *et al*. (2009) and Tilahun Teklehaymanot (2009). According to Voeks (2007), community members who have greater contact with medicinal plants are more knowledgeable about therapeutic uses of these plants than those with only intermittent contact.

Male informants of the District reported more medicinal plants on average (4.23 $\pm$ 0.13) than women (3.85 $\pm$ 0.19) even though the difference was not statistically significant (p=0.1075). Thus, the results indicated that both men and women are knowledgeable on use of traditional plant remedies despite the relative dominance of medicinal plant tradition with men which could relate to the traditional flow of information along the male line in the country (Tilahun Teklehaymanot, 2009) and elsewhere (Begossi *et al.,* 2002; Collins *et al*., 2006). In addition, this may also be attributed to gender of the interviewer which might made women informants not to discuss freely and exhaustively about women's ailments. Moreover, it could also be attributed to the less number of women informants ecountered during the research, amd/or it might be due to the dominantly wild sourcing of medicinal plants in the area which are less accessible to women. The occurrence of the relatively comparable knowledge on medicinal plants among male and female traditional medicine practitioners was reported by Almeida *et al*. (2010) for three communities in north eastern Brazil and by Ayantunde *et al*. (2009) for a community in southwest Niger. In contrast Voeks and Leony (2004) have reported on the presence of more specialized knowledge on medicinal plants with women informants than with men since they are often called upon to diagnose and treat certain types of diseases. Generally, gender-based differences in medicinal plant knowledge can be derived from experience and degree of cultural contact with curative plants (Voeks, 2007).

5.1.5. Indigenous medicinal plant knowledge transfer

Lack of interest in traditional medicines was observed among the youngest generation of Ankober due to factors related to 'modernization'. Similar findings were reported for other cultural groups in Ethiopia (Kebu Balemie *et al*., 2004; Ermias Lulekal *et al*., 2008a; Mirutse Giday *et al*., 2009). It was also found that traditional healers show maximum secrecy in handling medicinal plant knowledge, a trend which is also reported for other ethnic groups in the country (Haile Yineger *et al*., 2007; Mirutse Giday *et al*., 2009; Tilahun Teklehaymanot, 2009). Moreover, the observed secrecy by knowledgeable healers not to leak medicinal plant knowledge beyond the specific family circle might be taken as a guarantee for social respect and means of securing charges from patients. These facts, coupled with the absence of any written document on medicinal plants of the area, show the threat on continuity in indigenous medicinal plant knowledge down the generation ladder in the District.

5.1.6. Medicinal plant conservation practices

Even though medicinal plants play a crucial role in Ankober District to address various human and livestock ailments for generations, results indicate that there is almost no deliberate *in situ* or *ex situ* conservation practice to protect the fast-eroding remedial plant resource base. Similar concern was reported for curative plants used by other cultural groups in the country (Mirutse Giday *et al*., 2003; Haile Yineger *et al*., 2007; Fisseha Mesfin *et al*., 2009). Moreover, few medicinal plants which were reported to be harvested from homegardens in Ankober District were all, mainly, cultivated for purposes other than their medicinal role. The observed overdependence of the community on the wild medicinal plants coupled with the reported very high deforestation, overgrazing, agricultural land expansion and population pressure are threatening the remedial plants of the District. The findings call for the need to look for sound conservation practices so as to guarantee continual use of curative species for the present and coming generations as well.

Many conservationists recommend promotion of homegardening and cultivation of medicinal plants as a means to ensure continual survival of remedial plants down the generation ladder (Cunningham, 1997). According to Hareya Fassil (2003), promoting medicinal plant cultivation in homegardens can only be feasible if linked to the cultivation of, preferably, a variety of other income-generating species along with the medicinal ones. However, the practice needs adequate supply of land and water resources for adequate implementation (Cunningham, 1997). Any conservation strategy for medicinal plants of Ankober District has to promote both homegardening and cultivation, in addition to *in situ* conservation of remedial plants in their natural habitats. It would also be better to give prior conservation attention to the identified multipurpose and root-medicinal plants of the District. One of the endemic medicinal plants of Ethiopia reported in Ankober District, i.e. *Inula confertiflora* is listed as a near-threatened species in the Red list of Ethiopian endemic plants (Vivero *et al*., 2005), and hence calls for attention while designing and implementing conservation strategies for the District's medicinal plants.

5.1.7. Antimicrobial activity

The results of the present investigation substantiate the potential therapeutic role of traditionally used medicinal plants against some microbial diseases. About 17 (74%) of the 23 ethanol extracts obtained from 19 medicinal plant species have been shown through this work to have antimicrobial activities against one or more of 12 microbial strains tested. Results also confirm the importance of considering the ethnomedicinal background of medicinal plants to run antimicrobial activity tests for a high hit rate (74% in this case). Similar investigations on antimicrobial activity tests based on ethnomedicinal background (Belachew Desta, 1993; Kloucek *et al*., 2005; de Boer *et al*., 2005; Buwa & van Staden, 2006; Tsige Gebre-Mariam *et al*., 2006; Hussain *et al*., 2010; Tekwu *et al*., 2012) have also been reported for a high hit rates.

The broad-spectrum antimicrobial activity of extracts from *Embelia schimperi*, *Ocimum lamiifolium* and *Rubus steudneri,* each inhibiting growth of 67% (eight) of the 12 microbes (Table 9) with a MIC range between 64 to 512 μg/ml supports the assertions from a number of traditional use reports on these species in Ethiopia and neighbouring countries (Kokwaro, 1976; Teferi Gedif and Hahn, 2003; Tilahun Teklehaymanot and Mirutse Giday, 2007; Tigist Wondimu *et al*., 2007; Fisseha Mesfin *et al*., 2009; Pascaline *et al*., 2011). In addition, Awino *et al*. (2008) have reported antimicrobial activity of extracts from *Embelia schimperi* against *Staphylococcus aureus* using a disc diffusion method, which complements the results of the present work. Reports from the same authors on the antimicrobial activity of a pure compound, 2,5-dihydroxy-3-methyl-1,4-benzoquinone, from *Embelia schimperi* against two of the Gram-negative bacteria i.e. *Pseudomonas aeruginosa* and *Escherichia coli* using a disc diffusion method, which were shown not to be susceptible in the present work, suggests presence of other antibacterial constituents in the extract tested in this study. Moreover, Bøgh *et al*. (1996) described anthelminthic usage of extracts from *Embelia schimperi* berries against *Taenia saginata* using an experimental parasite/rodent models, which confirms the diverse medicinal role of the species in the treatment of infective agents.

The observed strong antibacterial activity of *Embelia schimperi* against *Bacillus cereus, Listeria monocytogenes* and *Streptococcus pyogenes* correlates with its reported traditional use of treating diarrhoea which is one of the major bacterial diseases in the study area. Reports on chemical constituents of this broad-spectrum species show that *Embelia schimperi* leaves possess embelin and rapanone (Midiwo & Manguro, 1993), schimperinone (Machocho *et al*., 2003), oleanane-type triterpenes (Manguro *et al*., 2006), and flavonol glycosides (Manguro *et al*., 2004). Embelin has been reported for its antibacterial properties when tested by a disc diffusion method against *Staphylococcus aureus*, *Streptococcus pyogenes* and *Pseudomonas aeruginosa* (Chitra *et al*., 2003). A wide spectrum of biological and pharmacological properties of embelin has also been described by Machocho *et al*. (2003). Hence, the broadest spectrum action (against 67% of the microbes in the present study) and the strong antimicrobial activity (MIC 64 μg/ml) shown by both leaf and twig extracts of *Embelia schimperi* against *Bacillus cereus*, *Listeria monocytogenes* and *Streptococcus pyogenes* could be attributed to the presence of such active chemicals with pharmacological properties.

Runyoro *et al*. (2010) applied an agar-dilution technique and reported on the antimicrobial activity of extracts from *Ocimum lamiifolium,* obtained by a hydro-distillation method, against *Staphylococcus aureus* and *Staphylococcus epidermidis,* which confirms our own results. In addition, the investigated strong growth inhibitory activity of extracts from *Ocimum lamiifolium* and *Rubus steudneri* were also found to be support of the recorded ethnobotanical uses of the species to treat common bacterial diseases, such as diarrhoea, in the District. Previous studies have described anti-inflammatory, anti-pyretic and analgesic properties of aqueous and ethanol extracts of leaves from *Ocimum lamiifolium* (Eyasu Makonnen *et al*., 2003a; 2003b; Weldesellassie Mequanint *et al*., 2011). Growth inhibition of *Staphylococcus aureus* and *Pseudomonas aeruginosa* by methanolic extracts of *Rubus steudneri* has also been reported by Kamoga (2010), which also matches the current findings.

Presence of chemical compounds including bornyl acetate, *p*-cymene, camphene, α-pinene and sabinene was also reported from essential oil analysis of *Ocimum lamiifolium* using a hydro-distillation method (Tchoumbougnang *et al.,* 2006; Runyoro *et al*., 2010). Literature search for relevant information on antimicrobial activities of chemicals from this plant indicates the antimicrobial role of sabinene (Tchoumbougnang *et al*., 2006; Oji and Shafaghat, 2012) and bornyl acetate (Runyoro *et al*., 2010). Therefore, the observed broad-spectrum activity from extracts of *Ocimum lamiifolium* could relate to these active components.

Although our results demonstrate significant antimicrobial effects of extracts from *Rubus steudneri,* inhibiting growth of 67% of microbes tested in our study, no report was found on its chemical constituents. Hence, this new observation calls for more in-depth investigation on *Rubus steudneri* to isolate and characterize its antimicrobial active components.

Antimicrobial action of extracts from *Jasminum abyssinicum, Bersama abyssinica, Rumex nepalensis* and *Vernonia amygdalina* against three or more strains also relates to their traditional use reports (Amare Getahun, 1976; Ermias Lulekal *et al*. 2008a; Fisseha Mesfin *et al*., 2009). A report by Mesfin Goji *et al*. (2006) described the antibacterial role of leaf extracts of *Jasminum abyssinicum* against *Staphylococcus aureus, Pseudomonas aeruginosa* and *Streptococcus pyogenes* through agar-well diffusion method. The results of the present work are in agreement with the reported antimicrobial activity against *Streptococcus pyogenes,* but not with that of *Staphylococcus aureus* and *Pseudomonas aeruginosa.* The discrepancy may be attributed to differences in methods followed for activity testing. A difference in geographical location, season and developmental stage of samples collected could also be mentioned as factors for differences in outputs of activity tests (Runyoro *et al*., 2010). A report by Gallo *et al.* (2006) on chemical constituents of the root bark of *Jasminum abyssinicum,* determined by spectroscopic and chemical correlations methods, ascertained the presence of esters of a cyclopentanoid monoterpene but no information on their antimicrobial effect was provided.

Abera Geyid *et al*. (2005) used the agar-dilution method and reported on the antimicrobial role of root and stem bark extracts of *Bersama abyssinica* against *Staphylococcus aureus* at concentrations between 500 and 2000 μg/ml. In the present work, we found no activity for this species for the range we tested for. Antimicrobial effect of methanolic extracts of *Rumex nepalensis* on *Staphylococcus aureus* reported by Hussain *et al.* (2010) was also found to be in agreement with the results of this work but their report on antimicrobial effect of methanolic extracts of this species against *Escherichia coli* differs from our results. The observed discrepancy may be attributed to differences in solvents used for extraction and methods followed for activity testing besides aforementioned factors that could explain differences in output of activity tests.

Stem and leaf extracts of *Vernonia amygdalina,* obtained by aqueous and ethanolic extraction methods, have also been reported to possess an antimicrobial role against

Klebisella spp. (Uzoigwe & Agwa, 2011). The same authors have also shown that *Escherichia coli* is not susceptible to aqueous and ethanolic extracts of *Vernonia amygdalina*, which matches our finding. Ijeh and Ejike (2011) reviewed current perspectives on medicinal potentials of *Vernonia amygdalina*. Chemical constituents of *Vernonia amygdalina* include flavonoids and steroidal alcohols, whereas sesquiterpene lactones have also been reported as chemically active by Luo *et al*. (2010). The latter may be responsible for the relatively broad spectrum of actions of this species observed in the present work.

Since most microbes are reported for little or no susceptibility to DMSO up to 2% concentration (Wadhwani *et al*., 2008), the effect of DMSO on our results was negligible. Microbes exhibit a high growth decrement when exposed to DMSO at a higher concentration i.e., 4% and beyond (Wadhwani *et al*., 2008). Howard *et al*. (2006) have also reported a full-growth inhibitory action of DMSO on three microbial strains i.e., *Escherichia coli, Pseudomonas aeruginosa*, and *Bacillus megaterium* at a concentration of 15%. In our negative controls DMSO was not added so as to make sure that the microbes were growing in a pure broth medium, and hence all the microbes were fully grown. However, absence of DMSO in the negative controls hinders us to compare its effect on growth of test strains (though negligible since we used a concentration of DMSO < 3%) in which it was used as a dispersing solvent for plant extracts.

Our investigation has shown that Gram-positive bacteria are more susceptible to the tested medicinal plant extracts than Gram-negative ones. This might relate to differences in cell wall morphology of the two groups of bacteria. Hodges (2002) explained that Gram-negative bacteria have an outer phospholipid membrane composed of lipo-polysaccharide constituents that make their cell wall impermeable to antimicrobial chemicals, whereas Gram-positive groups possess cell walls composed of a peptidoglycogen layer that is an inefficient permeability barrier. Although there are such barriers in Gram-negative bacteria, extracts of *Rubus steudneri* were found to be the only ones to be active and effective against two of the Gram-negative bacteria, i.e. *Pseudomonas aeruginosa* and *Salmonella enteritidis*. Moreover, among the Gram-negative groups, *Bacteroides fragilis* and *Escherichia coli* were found to be susceptible to none of the extracts and this could also partly be attributed to cell wall impermeability. Multi-drug resistance of Gram-negative bacteria has also been reported by Sader *et al*. (2002). Earlier reports also confirmed that Gram-negative bacteria are less susceptible to diverse medicinal plant extracts than Gram-positive groups (Hailu Tadeg *et al.*, 2005; Kloucek *et al*., 2005) hence supporting the present result.

5.1.8. Overall usefulness of medicinal plants in Ankober District

Results show that most plants (81%) in Ankober District known for one or more medicinal uses are playing multipurpose roles and were cited for various uses across eight different major use categories. The highest proportion of medicinal plant species (60%) was cited for additional uses as fodder indicating their supplementary role in supporting the livestock wealth of the District, on which most people depend for their livelihoods. Dominance of forage plants was also reported from various ethnobotanical inventories addressing plant use knowledge of indigenous people in Odo-Bulu and Demaro areas of Bale Zone, Ethiopia (Bussmann *et al*., 2011), Massai people, Kenya (Bussmann *et al*., 2006) and Gorom Gorom people, Burkina Faso (Sop *et al*., 2012). Almost all informants knew and identified one or more forage species since they encounter them in their everyday life activities.

Most woody plant species of the District were also identified for their uses as sources of fuel (27%) and for material use (23%) which could relate to high reliance of the community on the nearby fast-eroding plants for collecting firewood (on a daily basis), making charcoal (for household and market), collection of plants for local construction and manufacturing of household furniture. Most rural people in the District have no access to electricity and hence entirely depend on plants (firewood and charcoal) for cooking and lighting. According to Thomas (2008), the highest proportion of plant species used across different use categories reflects the relative importance of different types of plant uses in a people's daily life. Thus, the high species number (for fodder, fuel and material uses) indicates the categories which are highly important for peoples' subsistence in the District. Moreover, it also shows the categories which have major impact on medicinal plant survival in the area.

5.1.9. Categorical uses of medicinal plants in Ankober District

5.1.9.1. Remedial use

Results on overall traditional medicinal plants of Ankober (consisting of 151 medicinal plant species representing 141 genera and 75 families) indicated that the District is rich in medicinal plant diversity and indigenous knowledge linked with these traditionally used species. In addition, the results have also proven the role played by traditional medicinal plants and indigenous people of the area in supporting the primary healthcare needs of people in the District. The highest proportion of medicinal plants (89%) cited for treating human ailments could relate to higher incidence and ease of identification of perceived symptoms of human ailments (69 ailments reported) in the area than that of livestock diseases (33 ailments reported). However, the observed intersection of medicinal plant use knowledge for treating both human and livestock ailments indicates the tremendous worth of remedial plants and associated knowledge in safeguarding people's and livestock's health in the District. It also indicates the possibility of designing and implementing a medicinal plant conservation plan in the area with a dual purpose of conserving remedial species (treating both human and livestock diseases commonly collected from similar wild environment) with multiple other uses, and the environment as well.

5.1.9.2. Food plant use for human consumption

The results of this investigation demonstrate that a relatively high number (27 species, 18%) of medicinal plant species also serve as food source for humans. It was practically observed during walk-in-the-woods that the local people and research participants picked up and ate ripe fruits of species like *Carissa spinarum*, *Ficus sur*, *Myrsine africana* and *Rubus steudneri*. This indicates that there is to date living indigenous knowledge of the community on identification and tasting of useful wild edible plants despite their primary reliance on staple crop plants. About 3% of the 413 wild edible species of Ethiopia catalogued to date (Ermias Lulekal *et al*., 2011) were observed in Ankober District during the course of this study. However, this figure would increase if an overall inventory targeting wild edible plants of the District (which has never been done before) would be conducted.

The results indicate that fruits, seeds, leaves, rhizomes and bulbs are the most commonly harvested plant parts for direct consumption, preparation of local alcoholic beverages and/or as spices. However, fruits (67%) were the most commonly utilized plant parts for direct consumption. Our findings are in agreement with those of Ermias Lulekal and co-workers (2011) who reported that fruits are the dominant plant parts (210 wild edible species, 51%) reported for direct consumption in the wild edible plants group in Ethiopia. In Ankober District, most fruits including those of *Allophylus abyssinicus*, *Carissa spinarum*, *Dovyalis abyssinica*, *Ficus sur*, *Myrsine africana*, *Rhus vulgaris*, *Rubus steudneri* and *Opuntia ficus-indica* are consumed unprocessed/raw. Similar observations were reported by Getachew Addis *et al*. (2005); Kebu Balemie and Fassil Kibebew (2006) and Demel Teketay *et al*. (2010).

The use of leaves and twigs of plant parts for making traditional teas, flavouring of milk/yoghurt and/or coffee also depict additional use diversity of medicinal plants in the area. Examples include leaves of *Thymus schimperi*, and leaves and twigs of *Ruta chalepensis* that are soaked in boiling water to make aromatic teas, whereas the twigs of the latter are also soaked in boiling coffee to add flavour. Moreover, leaves and twigs of *Ruta chalepensis* are also commonly used for flavouring milk and yoghurt. These practices are common in many cultural groups in Ethiopia (Demel Teketay *et al*., 2010).

Some wild medicinal plant species of Ankober District were shown to be mixed/processed with cultivated crops such as maize, wheat and barley for preparation of local alcoholic beverages. Leaves and fruits of *Foeniculum vulgare* Miller are used to prepare a local alcoholic beverage/liquor known as KATIKALA/AREKE, whereas leaves and twigs of *Rhamnus prinoides* are processed for making well-known alcoholic drinks in the District and beyond known as TELLA, TEJ and KATIKALA. Fruits of *Cucumis ficifolius* are commonly added to TEJ so as to increase its intoxicating power (making the drink stronger). Similar patterns of plant use were reported by other sources (Demel Teketay *et al*., 2010; Ermias Lulekal *et al*., 2011).

Despite the wide availability of wild edible plants in Ankober District, there is no documented ethnobotanical information on cultural, socio-economic and nutritional values of these plants. The scenario is a reflection of the overall poor documentation of wild edible plants (so far only 5% of the 494 Ethiopian Districts have been addressed) across the country (Ermias Lulekal *et al*., 2011). Areas in Ethiopia for which at least some wild edible plant information has been documented are southwestern Ethiopia (Guinand and Dechassa Lemessa, 2000; Abbink, 2002), Alamata, Cheha, Goma, Yilmana Densa Districts (Getachew Addis *et al.*, 2005), Derashe and Kucha Districts (Kebu Balemie and Fassil Kibebew, 2006), Dera town in Dodotana Sire District (Tigist Wondimu *et al*., 2006), Hamar and Konso Districts (Getachew Addis *et al*., 2013a,b), Addi Arkay, Debark and Dejen Districts (Mengistu Fentahun and Hager, 2010), Kara and Kewego people of South Omo Zone in Kuraz and Hamar Districts (Tilahun Teklehaymanot and Mirutse Giday, 2010) and Fantalle and Boosat Districts (Debela Hunde Feyssa *et al.*, 2012). Although our findings add value in documenting some wild edible plants (which also have prime traditional medicinal value) in one of the unexplored Districts in the country, the results still call for an overall or more in-depth documentation of wild edible plants of Ankober District in the years ahead. Such documents would assist in the nation-wide effort to combat food insecurity and ensure dietetic diversity over and beyond serving as key elements for targeting plant conservation programmes around their nutritional and medicinal values.

5.1.9.3. Forage use

The results of this investigation show that a high number (90 species, 60%) of medicinal plants of Ankober District including *Cyperus bulbosus, Thymus schimperi, Thalictrum rhynchocarpum, Plantago lanceolata* and others are also known for their uses as fodder. It was also shown that herbaceous species (37%) of the area constitute the major component of forage plants. About 87% of forage plants were reported to be gathered from the wild. Thus, it can be deduced that a conservation plan that would target herbaceous species (which are commonly neglected in conservation programmes) would play a role in conserving not only medicinal plants but also a considerable number of forage plants supporting the lives of thousands of livestock in the area. Despite pronounced grazing of aerial parts of most herbaceous species, it is obvious that leaves of shrubs and trees, and young shoots of most plant species are all palatable for livestock. Bussman and co-investigators (2006) reported high representation of forage plants (30 species, 19%) in a plant use inventory of the Massai people in Kenya. Largest share of forage plants (172 species, 59%) was also recorded in use-based ethnobotanical inventory of plants used in the cultural groups of both Odo-Bulu and Demaro areas of Ethiopia (Bussmann *et al*., 2011). Similarly, Ayantunde *et al*. (2009) reported a high proportion of forage plants (52 species, 60%) in the use diversity study of plants used by the Banizoumbou, Tigo Tegui and Kodey agro-pastoralist communities in Niger. Rich indigenous knowledge on fodder plants in different cultural communities including those in our study area may be attributed to an age-old reliance of the majority of rural people on livestock as source of livelihood. Best-representation of families Asteraceae (17%) and Fabaceae (12%) among fodder plants of the District could also relate to the wide distribution of species belonging to these families in thelocal flora area. Generally, the results infer that most (60%) of the medicinal plant species of Ankober District are also under constant pressure offering a choice of grazing for most livestock heads in the area and hence call for conservation attention.

5.1.9.4. Material use

The results of this part of investigation show that about 23% (34 species) of the medicinal plants of Ankober District are also utilized for one or more material uses. Species preference was observed among community members based mainly on good/quality material need and availability of species. Examples include preference of the community to use *Podocarpus falcatus* for lumbering (making beds, boxes, benches, tables, doors, windows, etc), and for light and heavy construction; *Acacia abyssinica* for making drums (locally known as KEBERO which is commonly used in the Ethiopian Orthodox Church) and mortars (locally known as MUKECHA and used for peeling, grinding and pounding of grains); *Prunus africana* for making pestles (known as ZENEZENA which are also used along with the mortar for dehulling, splitting and pounding of grains). In addition, other species include *Allophylus abyssinicus* which is specially preferred for making farm tools such as yokes (locally known as KENBER), *Dodonaea angustifolia*, for making baskets (along with *Gomphocarpus fruticosus* which is especially used for weaving baskets) used for collecting hay and dung, making handles for farm tools, making a local broom for sweeping and cleaning the grain threshing ground /WUDIMA METREGIA/ and walking sticks; *Erythrina brucei* for making traditional beehives and drums; and *Eucalyptus globulus* for house construction.

Although community members rely on different plant species for many of their material requirements, high utilization of species was observed for construction (17%), carving farm tools (14%) and lumbering (10%) purposes. Dominance of trees and shrubs for material use (accounting for 70% and 18% of species, respectively) indicates the preference of the community for woody species to fulfil their material needs. Community members seemed to prefer durable plant species (which they thought are strong enough to resist termite attacks) for all forms of construction purposes. In contrast species with light and flexible (which do not splinter easily) woods are preferred for making handles for axes, shovels and other farm tools.

The observed highest material use values (UVmat) for *Podocarpus falcatus* (9.2), *Juniperus procera* (8.5) and *Olea europaea* subsp. *cuspidata* (7.7) indicate the high use preference for these species. According to Ayantunde *et al*. (2009), high material use values are evidences for high use preferences of species in a community. High use preferences of species can also be attributed to an age-old indigenous knowledge on the quality and strength of materials produced from the most preferred species.

5.1.9.5. Fuelwood use

The results indicate that a high number of medicinal plants of Ankober (40 species, 27%) is also exploited for its uses as fuel sources. Almost all households in the District use firewood and/or charcoal for cooking. Every household has a match and uses it to light firewood, charcoal or dried leaves of one or more of the fuel species on daily basis. The observed highest percentage of harvesting fuel species from the wild (98%) indicates high degree of exploitation of useful medicinal plants of the study area for their uses other than their medicinal values. Although people collect every piece of wood or dried leaf for use as fuelwood due to the high demand for fuel use, there were preferences of species based on quality of fuel sources. Plant species which can be sliced into small sticks and lit swiftly were most preferred for firewood. In contrast, species with very hard wood and those that donot produce good flame or those which produce more smoke when lit are less preferred for firewood.

Although the highest proportion of fuelwood species are mentioned to be directly harvested for firewood use, 30% (12 species) of fuel species were also cited to be processed into charcoal. *Acacia abyssinica*, *Nuxia congesta*, *Olea europaea* subsp. *cuspidata* and *Prunus africana* were among the most-cited plants for production of high quality charcoal for household and market consumption. Generally, harvesting of plant material for fuel use is found to be one of the most-pressing threats to woody vegetation of the area, and hence the finding calls for conservation measures to protect or save species of dual (medicinal and fuel) importance from depletion.

5.1.9.6. Social use

It was observed that some medicinal plants of Ankober (15 species, 10%) were harvested for one or more of their social uses. Species such as *Erica arborea* and *Clutia abyssinica* are used to make traditional torches (locally known as CHIBO) which are lighting/burning up so as to celebrate religious holidays and the eve of Ethiopian New Year. This may be related to the knowledge on the ease of burning and producing good flames when lit. Oil from seeds of *Ricinus communis* is used for softening/tanning local leather products either for household or market purposes, whereas dyes from *Impatiens tinctoria* are reported for local cosmetic uses to decorate hands/palms and feet of women. Decorating hands and feet is commonly practiced during festivities such as religious holidays, New Year and wedding ceremonies. *Catha edulis* and *Nicotiana tabacum* were most-cited stimulants used in the area. *Laggera tomentosa* was reported as being used for fumigating milk containers so as to improve the milk's flavour. *Cymbopogon citratus* is reported for its use in church ceremonies for its sweet aromatic aroma. The observed utilization of those species for uses other than their medicinal role indicates wide exploitation of the corresponding species, and has a conservation implication beside a threat for losing long-established cultural/symbolic value of those species. According to Balick (1996), conserving biodiversity helps to strengthen cultural integrity and values of indigenous communities by running targeted conservation activities to safeguard those plants with high cultural/symbolic significance. In addition, designing a focused sustainable management and conservation strategy for symbolic species will have a social benefit over and above their main traditional medicinal importance.

5.1.9.7. Environmental use

The finding that 17% of the medicinal species of Ankober District provide one or more environmental services in the area indicates that the community members are aware about major local environmental services provided by wild plants of the area. Most species were mentioned for their uses as living fences and for improving soil fertility. Erosion control, providing shade/shelter and ornamental uses in and around homegardens and at village sites were also among environmental services of plants identified by participants.

Species such as *Carissa spinarum*, *Dovyalis abyssinica*, *Erythrina brucei* and *Rosa abyssinica* were most-preferred as living fences around homes or agricultural fields. This may relate to the spiny nature of these plants which prevents animals and people from trespassing into homes or farmlands. Many woody species are used for making dry fences around homes. The local practice of soil improvement using compost heaps made from cut leaves and twigs of species such as *Hagenia abyssinica*, *Pavetta abyssinica* and *Polyscias fulva* buried along/alternating with layers of dung from livestock shows that the local people have an indigenous knowledge in maintaining soil fertility using local resources.

5.1.9.8. Poisonous plants

Millennia-old cultural interaction of the local people with plants enabled them to identify poisonous plants of the area. The use of *Acokanthera schimperi* and *Calotropis procera* latex for poisoning arrows was mentioned as a weapon for self-defence or attack. This might be a practice gained from earlier experience with using such poisoned arrows for hunting wild animals which are now rare in the area. The practice of using leaf extracts/chopped leaf pieces of *Chenopodium ambrosioides* as an insect repellent may also be attributed to its contents and pungent smell which respondents thought that it is effective to keep away insects (especially ants) from resident places. *Datura stramonium* was also cited for its deadly seeds. Generally, the observed knowledge on identification of some poisonous plants of the area reflects wide indigenous knowledge of the local people in traditional plant utilization. According to Amare Getahun (1976), the art of preparing poisons is as rich in its lore as that of conventional medicine in Ethiopia.

5.1.10. Use value, use diversity and use equitability of high ranking species based on overall usefulness

The twenty top species that came up with high UVall are all woody plants, indicating relatively higher local uses of these species compared to the herbaceous forms. This may relate to the principle of the *apparency hypothesis* which states that plants that are quite visible and dominant in an ecosystem are more likely to be used than those that are non-apparent, most commonly herbaceous species with short life cycles (Phillips and Gentry 1993a; 1993b). Other ethnobotanical inventories on local use values of plant species in different cultural groups (Lykke *et al.,* 2004; Ayantunde *et* *al*., 2008) also reported higher overall use values for woody species than for herbaceous ones.

Since use value indices reveal more information about the relative importance of a species than a simple count of uses (Phillips and Gentry 1993a; 1993b), our results which are shown in table 13 reveal that a species with a high number of uses does not necessarily have the highest use value. The observed highest UVall for *Podocarpus falcatus*, *Olea europaea* subsp. *cuspidata* and *Juniperus procera* indicates the relatively higher importance of these species across different use categories. Moreover, the highest UD values recorded for *Eucalyptus globulus*, *Podocarpus falcatus*, *Hagenia abyssinica* and *Acacia abyssinica* reflect the occurrence of these species in a relatively higher number of (diverse) use categories, together with an even distribution of uses over these diverse use categories. However, the variation in UVall of these species can be explained by differences in degree of contribution of each use category to the overall use value of a species (Byg and Balslev, 2001). In addition, high UE values for the latter species also indicate a relatively better contribution of the different use categories to the total use of a species, independently of the number of use categories.

5.2 Conclusion

As seen from the results and discussion, our findings give a broad support to the five central hypotheses set for this research. Investigation on Dense Forest of Ankober District indicates that the Forest is a major reservoir of a number of medicinal plants used by the people of the area. The Dense Forest is serving as a major source of medicinal plants for people in Ankober District. The PC-ORD output shows presence of five plant community types in Dense Forest, all of which consist of traditionally used medicinal plants beside other economically important species. The two plant community types, namely the *Podocarpus falcatus-Allophylus abyssinicus* (62 medicinal plant species) and the *Maytenus arbutifolia-Bersama abyssinica* (59 medicinal species) are the major potential sites for first-line medicinal plant conservation in Dense Forest. Since this Forest is currently being severely exploited by local people and illegal saw mills, it calls for serious attention to conserve and sustainably manage it together with the medicinal plants sheltered in it.

The results reveal that Ankober District is very rich in medicinal plant diversity and traditional medicinal knowledge as a corollary of the rich plant diversity and its historical richness. It was also shown that there is a paramount importance of traditional medicinal plants whereas the local community holds wide indigenous medicinal knowledge in assisting the primary healthcare needs (of both humans and livestock) in the District. It was observed that there has been a deep-rooted culture of plant use for successive generations in Ankober District which led the community to sentimental adherence to ancestral medical traditions which are to date widely implemented to address a number of ailments. In addition, it was identified that economic, efficacy and ease of accessibility factors related to use of medicinal plants play important roles on the reliance of people in the area on traditional medicine.

Most remedial plants of Ankober (81%) were found to play a multipurpose role across different use categories. Hence, it is deduced that they are under serious pressure challenging their survival. Wild habitats of Ankober which are major pools of traditional medicinal plants are shown to be alarmingly shrinking in size due to an ever-increasing population pressure. Moreover, the remaining few wild patches and natural forests in the area face extensive use-based exploitation (as sources of firewood, charcoal, construction and other materials) resulting in the loss of many medicinal species sheltering in the wild. Recorded high use value indices of multipurpose medicinal plant species in the area are signals of high use pressure and hence can be used as keys to design and implement a focused and well-coordinated complementary *in situ* and *ex situ* conservation strategy to save these widely sought-after plants.

Results from this investigation also reveal that there is overharvesting of root parts of most medicinal plants to prepare various traditional remedies. Although seeking after roots for medicine is associated to the traditional attitude/belief of community members about the prevailing curative effect of underground plant parts to treat ailments, the practice always demands complete removal of respective herbaceous medicinal plants from the natural environment. Hence, the latter is identified as the most serious threat on long-term survival of the corresponding medicinal plant species. Thus, conservation work in the area needs to give prior attention to protect plants targeted for their remedial roots.

The traditional pattern of identification of specific ailment types and local prescription of corresponding remedies shown in the study area is based on cultural knowledge on symptoms, corresponding illnesses and therapeutic medicinal species held in the memories of indigenous people. This warrants special attention of the District's health office to run community health education about the root causes of major diseases and their modes of transmission so as to assist traditional practitioners on basic ailment identification and at the same to protect the community from communicable diseases.

Community members in Ankober District showed varying degrees of traditional medicinal plant use knowledge based on differences in age, gender, experience and literacy level. More ethnomedicinal knowledge was observed in elderly/senior members of the community than in younger groups; experienced/key practitioners than the general public; and more with the illiterate than the literate. It was also found that both men and women members of the community in the District are knowledgeable on medicinal plant use despite the relative dominance of medicinal plant tradition at male level which could be associated with the traditional flow of information along the male line in the country.

It was found that community members in the study area acquire knowledge about medicinal plants mainly from family members and close relatives. The principal mode of traditional knowledge transmission in the area is by oral imparting, and the pattern dominantly patrilineal (father to son). Modernization and a high degree of secrecy in passing knowledge on medicinal plants within the family circle only to elder sons, and lack of interest in traditional remedies by younger groups might also explain the decline of indigenous knowledge going down the generation ladder in the District.

The output of the market survey analysis in this investigation indicates the potential demand of marketable medicinal plants for addressing human and livestock ailments, beside their uses for non-medicinal purposes. It also showed the income-generation potential of many medicinal plants in the District. However, marketability reports also indicate that many useful medicinal plants are under pressure since they are purposefully hunted for economic reasons over and above family home medicines.

High ICF and fidelity level values based bioactivity testing of selected medicinal plants of Ankober District shows promising results. We were able to show that 74% of medicinal plant extracts tested exhibited antimicrobial effect against one or more of twelve different types of microbial strains. *Embelia schimperi*, *Ocimum lamiifolium* and *Rubus steudneri* are the most-promising plants for possible discovery of lead compounds against microbes. The antimicrobial activities of extracts from *Jasminum abyssinicum, Bersama abyssinica, Rumex nepalensis* and *Vernonia amygdalina* are also promising and call for further investigation. Among the most-promising plants for antimicrobial properties, *Embelia schimperi* and *Ocimum lamiifolium* were found with few reports on chemical constituents whereas no report was found for *Rubus steudneri.*

Although the District is rich in medicinal plant diversity, the effort to conserve remedial plants and their associated indigenous knowledge has not been done as desired. Only little effort by some traditional practitioners is made to cultivate medicinal plants in homegardens. The situation calls for a wide range of sustained governmental support to promote an overall complementary *in situ* and *ex situ* conservation strategy for medicinal plants of the District. Recorded high use value indices for plant species of Ankober are signals of high use pressure and hence can be used as keys to design and implement a focused and well-coordinated *in situ* and *ex situ* conservation strategy in the study area.

5.3. Recommendations

Based on the results of the study the following recommendations are forwarded:

1. Establish a medicinal plant reserve in certain part of the Dense Forest that encompasses the *Podocarpus falcatus-Allophylus abyssinicus* and the *Maytenus arbutifolia-Bersama abyssinica* community types;

2. Conservation action need to be followed by taking measures for protection of the forest from grazing, human interference and other anthropogenic influences;

3. Taking legal measures on illegal sawmills and raising public awareness to initiate reforestation is a must to maintain Dense Forest and valuable medicinal plant wealth in it ;

4. Conservation strategy for Dense Forest should take in to account maintaining canopy species to favour regeneration of medicinal plant species that have good regeneration capacity under shaded conditions (e.g. *Olea europaea* subsp. *cuspidata* and *Podocarpus falcatus*) in addition to reforestation;

5. Promote ecotourism around Dense Forest and encourage local people to take part in conservation work by creating benefit-sharing mechanism;

6. Develope and implement eco-sustainable projects and participatory forest management programmes with a primary goal of conserving the fast-eroding medicinal plants, endemic plant species of the District and their remnant reservoir (the Dense Forest);

7. Carry out more investigations on bioactive components of most-preferred medicinal plants and further studies on isolation and characterization of chemicals from *Embelia schimperi*, *Ocimum lamiifolium* and *Rubus steudneri* to identify the factors responsible for the observed high antimicrobial activities of these species;

8. More pharmaco-chemical studies on all medicinal plants with traditional use reports must be undertaken to ascertain claimed medicinal value and combine this with toxicity tests to ensure safe use of remedial plants;

9. Since dependence on traditional plant remedies to treat various ailments does not necessarily indicate an in-depth local understanding of root/scientific causes and modes of transmission of diseases, it is important to implement a continuous community health education programme (preferably led by the District's Health Office) with respect to the identified major human and livestock ailments in the area;

10. Design *in situ* and *ex situ* conservation strategies for medicinal plants of the District by giving prime attention to medicinal plants purposefully hunted for their remedial roots, and to those multipurpose medicinal plants with relatively high use value indices;

11. Promote community-based conservation and sustainable utilization of species programmes focussing on those species with high use preferences so as to maintain cultural and medicinal values of species in the area;

12. Attention has to be given by the District's Culture and Tourism Office to take responsibility in compiling, promoting and conserving of the millennia-old culture of using ancestral medical traditions by indigenous people in the District;

13. Promote in-depth investigation on marketable medicinal plants of the study area through successive longitudinal market surveys over a number of years together with value chain analyses of potential plants to come up with the real economic potential of medicinal plants;

14. Establish a traditional healers' association in the District and strengthen members by providing professional support and logistics as a basis to practice integration of modern and traditional healthcare systems; and

15. Establish medicinal plant nurseries by co-operating with the District's Agriculture and Rural Development Office so as to propagate seedlings of the most-preferred medicinal plants, followed by a concomitant distribution of seedlings to farmers as a possible means to conserve useful medicinal plant species.

REFERENCES

Abate Ayalew, Tamrat Bekele and Sebsebe Demissew (2006). The undifferentiated Afromontane forest of Denkoro in the central highland of Ethiopia: a floristic and structure analysis. *SINET: Ethiopian Journal of Science* 29, 45–56.

Abbink, J. (2002). Plant use among the Suri people of southern Ethiopia: a System of knowledge in danger? *Afrikanistische Arbeitspapiere* 70: 199-206.

Abebe Demissie (2001). Biodiversity conservation and sustainable use of medicinal plants: problems and prospects. In: *Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia*, Medhin Zewdu, Abebe Demissie (eds), Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia, 28 April –May 2001, pp. 56-64.

Abera Geyid, Dawit Abebe, Asfaw Debella, Zewdneh Makonnen, Frehiwot Aberra, Frehiwot Teka, Tesfaye Kebede, Kelbessa Urga, Kidist Yirsaw, Teklel Biza , Bisrat HaileMariam and Mulugeta Guta (2005). Screening of some medicinal plants of Ethiopia for their anti-microbial properties and chemical profiles. *Journal of Ethnopharmacology* 97: 421-427.

Abreham Assefa, Sebsebe Demissew and Zerihun Woldu (2013). Floristic composition, structure and regeneration status of Masha Forest, south-west Ethiopia. *African Journal of Ecology* 2013, 1-11.

Adolph, D., Blakeway, S., and Linquist, B.J. (1996). Ethnoveterinary Knowledge of the Dinka and Nuer in Southern Sudan: A study for the UNICEF operation Lifeline Sudan Southern Sector Livestock Program, December 1996, UNICEF, Nairobi, Kenya.

ADHO (2010/11). Annual report of Ankober District Health Office 2010/2011. Ankober. (unpublished).

Alem Habtu (2003). Ethnic Federalism in Ethiopia: background, present conditions and future prospects. Paper submitted to the second Ethiopian American Foundation (EAF) international symposium on contemporary development issues in Ethiopia. July11-12, 2003, Addis Ababa, Ethiopia. http://homepages.wmich.edu/asefa/ ConferenceandSeminar.papers/2003/. July 11-12, 2003, *Accessed* April 15, 2013.

Alemnew Alelign, Demel Teketay, Yonas Yemshaw and Edwards, S. (2007). Diversity and status of regeneration of woody plants on the peninsula of Zegie, north-western Ethiopia. *Tropical Ecology*, 2007 48(1): 37-49.

Alexiades, M.N. (1996). Collecting Ethnobotanical Data. An Introduction to Basic Concepts and Techniques. In: *Selected guidelines for Ethnobotanical Research*: *A Field Manual*, Alexiades, M. N. and Sheldon, J. W. (eds.), The New York Botanical Garden, Bronx, New York, pp. 53-94.

Alexiades, M.N. (2003). Ethnobotany in the third Millennium: expectations and unresolved issues. *Delpinoa* 45: 15-28.

Almeida, C.F.C.B.R., Ramos, M.A., Amorim, E.L.C. and Albuquerque, U.P. (2010). A comparison of knowledge about medicinal plants for three rural communities in the semi-arid region of northeast of Brazil. *Journal of Ethnopharmacology* 127:674-684.

Amare Getahun (1976). The role of wild plants in the native diet in Ethiopia. *Agro-Ecosystems* 1: 45-46.

Austin, M., Pausas, J. and Nicholls. A. (1996). Patterns of tree species richness in relation to environment in South-eastern New South Wales, Australia. *Australian Journal of Ecology* 21:164-165.

AWFPEDO (Ankober Woreda Finance, Planning and Economic Development Office) (2012). *The socio economic profile of Ankober District*, AWPEDO, Ankober, Gorabela.

Awino, O.S., Kiprono, P.C., Keronei, K.P., Kaberia, F., Obala, AA. (2008). Antimicrobial activity of 2,5-dihydroxy-3-methyl-1,4-benzoquinone from *Embelia schimperi*. *Journal of Biosciences* 63:47-50.

Ayantunde, A.A., Briejer, M., Hiernaux, P., Udo, H.M.J. and Tabo, R. (2008). Botanical knowledge and its differentiation by age, gender and ethnicity in southwestern Níger. *Journal of Human Ecology* 36:881-889.

Ayantunde, A.A., Hiernaux, H., Briejer, M., Henk, U. and Tabo, R. (2009). Uses of Local Plant Species by Agropastoralists in South-western Niger. *Ethnobotany Research & Applications* 7: 53–66.

Baldini, R. M. (2011). The contribution of Florentine collections to the knowledge of Flora of Ethiopia and Eritrea. *Acta Univ. Ups. Symb. Bot. Ups 35* (2): 161-171.

Balick, M.J. (1996). Transforming ethnobotany for the new millennium. *Annals of the Missouri Botanical Garden* 83: 58-66.

Balick, M.J. and Cox, P.A. (1996). *Plants, People and Culture*: *Science of Ethnobotany*. Scientific American Library, New York, USA.

Balunas M.J. and Kinghorn A.D. (2005). Drug discovery from medicinal plants. *Life Sciences* 78: 431 – 441.

Barbour, M.G., Burk, J.H. and Pitts, W.D. (1987). *Terrestrial Plant Ecology. Method of Sampling the Plant Community*. Menlo Park, CA: Benjamin Cummings Publishing Co.

Begossi, A., Hanazaki, N. and Tamashiro, J.Y. (2002). Medicinal plants in the Atlantic Forest (Brazil): knowledge, use and conservation. *Human Ecology* 30:281-299.

Berhane Mewa (2001). Promotion of medicinal plants through involvement of the private sector. In: *Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia*, Medhin Zewdu, Abebe Demissie (eds), Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia, 28 April –May 2001, pp. 168-175.

Belachew Desta (1993). Ethiopian traditional herbal drugs. Antimicrobial activity of 63 medicinal plants. *Journal of Ethnopharmacology,* 39: 129-39.

Berhanu Admassu (2011). *Primary animal healthcare in Ethiopia: The experience so far*. http://sites.tufts.edu/capeipst/files/2011/03/Admassu-Mombasa.pdf. *Accessed* October 3, 2013.

BirdLife International (2012). *Serinus ankoberensis*, IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. www.iucnredlist.org. Accessed 23 October 2013.

Bodeker, G. (2003). Traditional Medical Knowledge, Intellectual Property Rights and Benefit Sharing. www.cardozo.yu.edu/cjicl/pdf%20files/CA1219.PDF. Accessed 10 December 2009.

Bodeker, G., Bhat, K.K.S., Burley, J. and Vantommme, P. (eds.) (1997). Medicinal plants for forest conservation and healthcare (Non wood forest products series No.11). FAO, Rome.

Bøgh, H.O., Andreassen, J., Lemmich, J. (1996). Anthelmintic usage of extracts of *Embelia schimperi* from Tanzania. *Journal of Ethnopharmacol*ogy 50: 35-42.

Bolstad, P.V., Swank, W. and Vose, J. (1998). Predicting southern Appalachaian overstory vegetation with digital terrain data. *Landscape Ecology* 13:271-283.

Bompiani, S. (1891). Italian explorers in Africa. The religious tract society, 56 Paternoster Row, 65. St. Paul's Churchyard and 164 Piccadilly, London. 216pp.

Bongers, F., Poorter, L. and Hawthorne, W.D. (2009): The intermediate disturbance hypothesis applies to tropical forests, but disturbance contributes little to tree diversity. *Ecology Letters* 12(8):798-805.

Botha, C.J., Swan, G.E. and Van der Merwe, D. (2001). Use of ethnoveterinary medicinal plants in cattle by Setswana-speaking people in the Madikwe area of the North West Province of South Africa. *Journal of South African Veterinary Association* 72:189–196.

Bussmann, R.W. (2001). Succession and regeneration patterns of East African mountain forests. *Systematic and Geography of Plants* 71:957-974.

Bussmann, R.W., Gilbreath, G.G., Solio, J., Lutura, M., Lutuluo, R., Kunguru, K., Wood, N. and Mathenge, S.G. (2006). Plant use of the Maasai of Sekenani Valley, Maasai Mara, Kenya. *Journal of Ethnobiology and Ethnomedicine* 2006, 2:22.

Bussmann, R.W., Swartzinsky, P., Aserat Worede and Evangelista, P. (2011). Plant use in Odo-Bulu and Demaro, Bale region, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2011, 7:28.

Buwa, L.V. and van Staden, J. (2006). Antibacterial and antifungal activity of traditional medicinal plants used against venereal diseases in South Africa. *Journal of Ethnopharmacology* 103: 139-42.

Byg, A. and Balslev, H. (2001). Traditional knowledge of *Dypsis fibrosa* (Arecaceae) in eastern Madagascar. *Economic Botany* 55:263–275.

Cain, S.A. and Castro, G.M.O. (1959). *Manual of Vegetation Analyses*. Harper and Brothers, New York.

Carretero A.L.M. (2005). Useful plants and traditional knowledge in the Tucumano-Boliviano Forest. University of Aarhus, Denmark.

Castetter, E.F. (1944). The domain of ethnobiology. *American Naturalist* 78: 158-170.

Cecchi, D. A. (1886). Da Zeila Alle Frontiere Dela Caffa. Roma: Ermanno Loescher & Co.

Cetinkaya, G. (2009). Challenges for the maintenance of traditional knowledge in the Satoyama and Satoumi ecosystems, Noto peninsula, Japan. *Human Ecology Review* 16:27-40.

Chapman, J.D. and White, F. (1970). *The evergreen forests of Malawi*. Commonwealth Forestry Institute: University of Oxford, Lndon.

Chen, J., Song, B., Rudnicki, M., Moeur. M., Bible, K., North, M., Shaw, D.C., Franklin, J.F. and Braun, D.M. (2003). Spatial relationship of biomass and species distribution in an old-growth Pseudotsuga - Tsuga Forest. *Forest Science*, 50:364-375.

Chitra, M., Shyamala, D.C.S. and Sukmar, E. (2003). Antibacterial activity of embelin. *Fitoterapia* 74: 401-403.

Christoffersen L.P. and Mathur E.J. (2005). Bioprospecting ethics and benefits. *Industrial Biology* 1 (4): 255-259.

Coetzee, J.A. (1978). Phytogeographical aspects of the montane forests of the chain of mountains on the eastern side of Africa. *Erdwissenschaft Forschung*, 11: 482-494.

Collins, S., Martins, X., Mitchell, A., Teshome, A., Arnason, J.T. (2006). Quantitative ethnobotany of two East Timorese cultures. *Economic Botany* 60:347-361.

Condit, R., Hubbell, S.P., Lafrankie, J.V., Sukumar, R., Manokaran, N., Foster, R.B. and Ashton, P.S. (2002). Species-area and species-individual relationships for tropical trees: a comparison of three 50-ha plots. *Journal of Ecology* 84:549-562.

Cook, F.R.M. (1995). Economic botany data collection standard. Kew Botanical Gardens, UK.

Cos, P., Vlietinck A.J., Vanden Berghe, D., Maes, L. (2006). Anti-infective potential of natural products: How to develop a stronger *in vitro* 'proof- of- concept'. *Journal of Ethnopharmacology* 106:290-302.

Cotton, C.M. (1996). *Ethnobotany*: *Principles and Applications*. John Wiley and Sons, New York.

Cox, P.A. and Balick, M.J. (1994). The Ethnobotanical Approach to Drug Discovery. *Scientific American* June 60-65.

Cunningham, A.B. (1993). African medicinal plants, Setting priorities at the interface between conservation and primary healthcare. People and plants working paper 1, Paris, France: UNESCO.

Cunningham, A.B. (1996). People, Park and Plants use recommendations for multiple use zones and development alternatives around Bwindi: Impenetrable National Park, Uganda. In: *People and Plants*, *working paper 4,* Sample, A. (ed.), UNESCO, Paris pp.18-23.

Cunningham, A.B. (1997). Botanical inventories, traditional knowledge, and medicinal plants. In: *Conservation and Utilization of Medicinal Plants and Wild Relatives of Food Crops*, Sample A. (ed.), UNESCO, Nairobi, Kenya. pp.29-34.

Cunningham, A.B. and Mbenkum, F.T. (1993). Sustainability of Harvesting *Prunus africana* Bark in Cameroon. People and Plants working paper 2, Paris, France: UNESCO.

Cunningham, A.B., Jasper, P.J. and Hansen, L.C.B. (1992). The indigenous plant use program, Paris, France: Foundation for Research Development.

Curtis, J.T. and McIntosh, R.P. (1950). The interrelationship of certain analytic and synthetic phytosociological characters. *Ecology* 31:434–455.

Damtew Bekele, Zemede Asfaw, Beyene Petros and Habtie Tekie (2012). Ethnobotanical study of plants used for protection against insect bite and for the treatment of livestock health problems in rural areas of Akaki District, Eastern Shewa, Ethiopia. *Top class Journal of Herbal Medicine* 1:12-24.

Daniel Gamachu (1977). Aspects of Climate and Water Budget in Ethiopia. - Addis Ababa University Press, Addis Ababa.

Davis, A. and Wagner, J.R. (2003). Who knows? On the importance of identifying “Experts” when researching local ecological knowledge. *Human Ecology* 31:463-489.

Dawit Abebe (1986). Traditional medicine in Ethiopia: the attempts being made to promote it for effective and better utilisation. *SINET: Ethiopian Journal of Science* 9 (suppl.): 61-69.

Dawit Abebe (1996). The role of herbal remedies and the approaches towards their development. In: *Proceedings of the Workshop on Development Utilisation of Herbal Remedies in Ethiopia*. Ethiopian Health and Nutrition Institute, Addis Ababa, pp. 28-38.

Dawit Abebe (2001). The role of medicinal plants in healthcare coverage of Ethiopia, the possible benefits of integration. In: *Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia*, Medhin Zewdu, Abebe Demissie (eds), Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia, 28 April –May 2001, pp. 6-21.

Dawit Abebe and Ahadu Ayehu (1993). *Medicinal plants and Enigmatic Health practices of Northern Ethiopia*. B.S.P.E. Addis Ababa, Ethiopia.

Dawit Abebe and Istifanos Hagos (1991). Plants as primary source of drugs in the traditional health practices of Ethiopia. In: *Plant genetic Resources of Ethiopia,* Engles, J.M., Hawakes, J.G. and Melaku Worede (eds). Cambridge University Press pp.101-113.

Debela Hunde Feyssa, Njoka, J.T., Zemede Asfaw, Nyangito, M.M. (2012) Comparative Analysis of Indigenous Knowledge on Use and Management of Wild Edible Plants: The case of Central East Shewa of Ethiopia. *Ethnobotany Research & Applications* 10:287-304.

Debela Hunde, Zemede Asfaw and Ensermu Kelbessa (2006). Use of traditional medicinal plants by people of 'Boosat' sub district, Central Eastern Ethiopia. *Ethiopian Journal of Health Science* 16:141-155.

de Boer, H.J., Kool, A., Broberg, A., Mziray, W.R., Hedberg, I. and Levenfors, J.J. (2005). Anti-fungal and anti-bacterial activity of some herbal remedies from Tanzania. *Journal of Ethnopharmacology* 96 : 461–469.

de Boer, H.J., Lamxaya, V. and Björk, L. (2012). Comparing medicinal plant knowledge using similarity indices: A case of the Brou, Saek and Kry in Lao PDR. *Journal of Ethnopharmacology* 141: 481– 500.

Demel Teketay (1999). Past and present activities, achievements and constraints in forest genetic resources in Ethiopia. In: *The proceedings of the National Forest Genetic* *resources Conservation strategy Development work shop*, Addis Ababa, Ethiopia, June 21-22, 1999. pp. 49-72.

Demel Teketay (2000). Ranunculaceae. In: *Flora of Ethiopia and Eritrea. Volume 2 part 1: Magnoliaceae to Flacourtiaceae*, Edwards, S., Mesfin Tadesse, Sebsebe Demissew and Hedberg, I. (eds), The National Herbarium, Addis Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden, 2000, pp. 18-32.

Demel Teketay and Tamrat Bekele (1995). Floristic composition of Wof-Washa natural forest, Central Ethiopia: Implications for the conservation of biodiversity. *Feddes Repertorium* 106:127–147.

Demel Teketay, Feyera Senbeta, Maclachlan M., Milion Bekele, Barklund, P. (2010). *Edible Wild Plants in Ethiopia.* Addis Ababa University Press.

Dennis, F.R. (1998). The trade in medicinal plants in the United Kingdom. In: *Medicinal Plant Trade in Europe: Conservation and supply. Proceedings of 1st International Symposium on the Conservation of Medicinal Plants in Trade in Europe*, TRAFFIC- Europe (ed), Brussels, pp. 19-32.

Desawadi, P. (1991). The conservation of medicinal plants used in primary healthcare in Thailand. In: *Conservation of medicinal plants*, Akerele, O., Heywood, V., Synge, H. (eds), Cambridge University Press, Cambridge, pp. 253-258.

De Silva, T and Wettasinghe, D.T. (2004). Sri Lanka conservation and sustainable use of medicinal plants, Final evaluation. IUCN, The World Conservation Union, Sri Lanka.http://cmsdata.iucn.org/downloads/sri_lanka_conserv_sustain_use_med_plants.pdf. Accessed January 4, 2014.

Dessalegn Dessissa (2001). A preliminary economic valuation of medicinal plants in Ethiopia; threat, volume and price. In: *Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia*, Medhin Zewdu, Abebe Demissie (eds), Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia, 28 April –May 2001, pp. 107-119.

Devendrakumar, D. and Anbazhagan, M. (2012). Ethnoveterinary medicinal plants used in Perambalur District, Tamil Nadu. *Research in Plant Biology* 2(3):24-30.

Dhar, U., Rawal, R.S. and Upreti, J. (2000). Setting priorities for conservation of medicinal plants -a case study in the Indian Himalya. *Biological Conservation* 95: 57-65.

Dhillion, S.S., Ampornpan, L. and Austreng, I. (2003). Land-use and plant diversity in Ban Bung and Na Heao Forest Reserve. In *The Environment of Na Haeo, Thailand: biodiversity, non-timber products and conservation*. Ampornpan, L. and Dhillion, S.S. (eds), Craftsman Press Ltd., Bangkok, 2003: pp. 47–82.

Dickson, M., Gagnon, J.P. (2004). Key factors in the rising cost of new drug discovery and development. *Nature Reviews Drug Discovery* 3(5):417–429.

Document of The World Bank (2007). Implementation completion and results report, credit No. 3461, GEF Grant No. 27833 to the Federal Democratic Republic of Ethiopia for Conservation and Sustainable use of Medicinal Plants. Report No: ICR0000508. Sustainable Development Department Agriculture and Rural Development Africa Region, December 21, 2007.

Duke, J.A., Duke, P.K. and duCellier J.L. (2008). Duke's handbook of Medicinal plants of the Bible. CRC press, Taylor and Francis group, New York.

EEPFE (2008). Policies to increase forest cover in Ethiopia: based on a forest policy workshop, Addis Ababa, September 2007. Environmental Economics Policy Forum for Ethiopia. *Policy Brief* 2008,1- 4.

EFAP (1994). *Ethiopian Forestry Action Program*. Ministry of Natural Resources, Addis Ababa, Ethiopia.

Elujoba, A.A., Odeleye, O.M. and Ogunyemi, C.M. (2005). Traditional medicine development for medical and dental primary healthcare delivery system in Africa. *African Journal of Traditional Complementary and Alternative Medicines* 2: 46-61.

Endale Zatew and Beyene Yemane (2007). Millenium Ankober. Ankober District, Culture and Tourism Office, Gorabela.

Engelbrecht, B.M.J., Comita, L.S., Condit, R., Kursar, T.A., Tyree, M.T., Turner, B.L. and Hubbell, S.P. (2007). Drought sensitivity shapes species distribution patterns in tropical forests. *Nature* 447(3):80-83.

Ensermu Kelbessa, Sebsebe Demissew, Zerihun Woldu and Edwards, S. (1992). Some threatened Endemic Plants of Ethiopia. In: *The status of some plants in parts of tropical Africa.*, Edwards, S. and Zemede Asfaw (eds), NAPRECA, No. 2. Botany 2000, East and Central Africa, pp.35-55.

Ermias Lulekal, Ensermu Kelbessa, Tamrat Bekele, Haile Yineger (2008a). An ethnobotanical study of medicinal plants in Mana Angetu District, southeastern Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2008, 4:10.

Ermias Lulekal, Ensermu Kelbessa, Tamrat Bekele, Haile Yineger (2008b). Plant species composition and structure of the Mana Angetu moist montane forest, Southeastern Ethiopia. *Journal of East African Natural History* 97(2): 165-185.

Ermias Lulekal, Zemede Asfaw, Ensermu Kelbessa, Patrick Van Damme (2011). Wild edible plants in Ethiopia: a review on their potential to combat food insecurity. *Afrika Focus* 24:71-121

Eyasu Makonnen, Asfaw Debella, Dawit Abebe, Frehiwot Teka (2003a). Analgesic properties of some Ethiopian medicinal plants in different models of nociception in mice. *Phytotherapy Research* 17: 1108-1112.

Eyasu Makonnen, Asfaw Debella, Legesse Zerihun, Dawit Abebe, Frehiwot Teka (2003b). Anti-pyretic properties of the aqueous and ethanol extracts of the leaves of *Ocimum suave* and *Ocimum lamiifolium* in mice. *Journal of Ethnopharmacology* 88: 85-91.

Fabricant, D.S. and Farnsworth, N.R. (2001). The value of plants used in traditional medicine for drug discovery. *Environmental Health Perspectives* 109: 69-75.

FAO (2010a). Global forest resources assessment 2010, main report. FAO Forestry Paper 163, Food and Agriculture Organization of the United Nations, Rome.

FAO (2010b). Global Forest Resource Assessment. Country Report Ethiopia. FRA 2010/065. FAO, Rome.

FAOstat (2011). http://faostat3.fao.org/home/index.html#DOWNLOAD. *Accessed* September 4, 2013.

Farnsworth, N.R. (1994). Ethnopharmacology and Drug development. In: *Ethnobiology and the search for new drugs*, Ciba Foundation (ed), Wiley Chichester, Chicago, USA, pp. 42-59.

Farnsworth, N.R., Akerel, O. and Bingel, A.S. (1985). Medicinal plants in therapy. *Bulletin of the World Health Organization*. 63(6): 965-981.

Fassil Kibebew (2001). The status and availability of oral and written knowledge on traditional health care on traditional health care in Ethiopia. In: *Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia*, Medhin Zewdu, Abebe Demissie (eds), Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia, 28 April –May 2001, pp. 107-119.

Fekadu Fullas (2001). *Ethiopian Traditional Medicine*: *Common Medicinal Plants in Perspective*, Sioux City.

Fekadu Fullas (2010). Ethiopian Medicinal Plants in Veterinary Healthcare. A Mini-Review. *Ethiopian e-Journal for Research and Innovation Foresight*, 2:48-58.

Fekadu Gurmessa, Teshome Soromessa and Ensermu Kelbessa (2013). Floristic composition and community analysis of Komto Afromontane moist forest, East Wollega Zone, West Ethiopia. *Science Technology and Arts Research Journal* 2(2): 58-69.

Feyera Senbeta and Demel Teketay (2003). Diversity, community types and population structure of woody plants in Kimphee Forest, a virgin nature reserve in Southern Ethiopia. *Ethiopian Journal of Biological Sciences* 2(2):169–187.

Fisher, P. and Ward, A. (1994). Medicine in Europe: complementary medicine in Europe. *British Medical Journal* 1994, 309:107-111.

Fisseha Mesfin, Sebsebe Demissew, Tilahun Tekelaymanot (2009). An Ethnobotanical study of medicinal plants in Wonago Woreda, SNNPR, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2009, 5:28.

Ford, R.I. (1994). Ethnobotany: historical diversity and synthesis. In: *The Nature and Status of Ethnobotany* (Anthropological papers, Museum of Anthropology, University of Michigan No 67), Ford R.I. (ed), Ann Arbor, Michigan. pp. 33-50.

Friis, I. (1986). The forest vegetation of Ethiopia. *Symbolae Botanicae Upsaliensis* 26(2): 31-47.

Friis, I. (2006). Solanaceae. In: *Flora of Ethiopia and Eritrea. Volume 5: Gentianaceae to Cyclocheilaceae*, Hedberg, I., Ensermu Kelbessa, Edwards, S., Sebsebe Demissew and Persson, E. (eds), The National Herbarium, Addis Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden, 2006, pp. 103-160.

Friis, I., Rasmussen, F.N. and Vollesen, K. (1982). Studies in the Flora and Vegetation of Southwest Ethiopia. *Opera Botanica* 63: 8-70.

Friis I., Sebsebe Demissew, Van Bruegel, P. (2011). *Atlas of the Potential Vegetation of Ethiopia.* Addis Ababa: Addis Ababa University Press and Shama Books.

Gallo, F.R., Palazzino, G., Federici, E., Iurilli, R., Monache, F.D., Chifundera, K. and Galeffi, C. (2006). Oligomeric secoiridoid glucosides from *Jasminum abyssinicum*. *Phytochemistry*, 67, 504-510.

Ganora, R. (1929). Flora medica Etiopica. *Archivio Italiano di Scienze Mediche Tropicali e diParassitologia* 10:97-120.

Gazzaneo, L.R.S., Lucena, R.F.P. and Albuquerque, U.P. (2005). Knowledge and use of medicinal plants by local specialists in a region of Atlantic Forest in the state of Pernambuco (Northeastern Brazil). *Journal of Ethnobiology and Ethnomedicine* 2005, 1:9.

Gebremedhin Gebrezgabiher, Shewit Kalayou and Samson Sahle (2013). An ethno-veterinary survey of medicinal plants in Woredas of Tigray region, Northern Ethiopia. *International Journal of Biodiversity and Conservation* 5: 89-97.

Gelahun Abate (1989). *Etse Debdabe* (Ethiopian Traditional Medicine) (in Amharic). Addis Ababa University, Addis Ababa.

Gemedo Dalle, Maass, B.L., and Isselstein, J. (2005). Plant biodiversity and ethnobotany of Borana pastoralists in Southern Oromia, Ethiopia. *Economic Botany* 59: 43-65.

Gepts, P. (2004). *"Who Owns Biodiversity, and How Should the Owners Be Compensated?". Plant Physiology* 134: 1295–1307.

Getachew Addis, Dawit Abebe and Kelbessa Urga (2001). A survey of traditional medicinal plants in Shirka District, Arsi Zone, Ethiopia. *Ethiopian Pharmaceutical Journal* 19: 30-47.

Getachew Addis, Kelbessa Urga and Dawit Dikasso (2005). Ethnobotanical study of edible wild plants in some selected districts of Ethiopia. *Human Ecology* 33(1): 83-118.

Getachew Addis, Zemede Asfaw and Zerihun Woldu (2013a). Ethnobotany of wild and semi-wild edible plants of Konso ethnic community, South Ethiopia. *Journal of Ethnobotany Research and applications*, 11:121-141.

Getachew Addis, Zemede Asfaw and Zerihun Woldu (2013b). The role of wild and semi-wild edible plants to household food sovereignity in Hammar and Konso communities, South Ethiopia. *Journal of Ethnobotany Research and applications*, 11:251-271.

Getachew Belay, Yinebeb Tariku, Taddesse Kebede, Ariaya Hymete and Yalemtsehay Mekonnen (2011). Ethnopharmacological investigations of essential oils isolated from five Ethiopian medicinal plants against eleven pathogenic bacterial strains. *Phytopharmacology* 1(5): 133-143.

Getachew Tesfaye, Demel Teketay, Masresha Fetene and Beck, E. (2010). Regeneration of seven indigenous tree species in a dry Afromontane forest, southern Ethiopia. *Flora Morphology, Distribution, Functional Ecology of Plants*, 205: 135–143.

Gilbert, M.G. (1995). Euphorbiaceae. In: *Flora of Ethiopia and Eritrea. Volume 2 part 2: Canellaceae to Euphorbiaceae*, Edwards, S., Mesfin Tadesse and Hedberg, I. (eds), The National Herbarium, Addis Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden, 1995, pp. 265-380.

Gippoliti, S. (2005). Historical museology meets tropical biodiversity conservation. *Biodiversity and Conservation*,14: 3127-3134.

Girmay Zenebe, Mohammed Zerihun and Zewdie Solomon (2012). An ethnobotanical study of medicinal plants in Asgede Tsimbila District, Northwestern Tigray, Northern Ethiopia. *Ethnobotany Research & Applications* 10: 305-320.

Goyder, D., Albers, F., Gilbert, M., Liede, S. and Venter, J. (2003). Asclepiadaceae. In: *Flora of Ethiopia and Eritrea. Volume 4 part 1: Apiaceae to Dipsaceae*, Hedberg, I., Edwards, S., and Sileshi Nemomissa (eds), The National Herbarium, Addis Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden, 1995, pp. 99-193.

Grenier, L. (1998). Working With Indigenous Knowledge: A Guide for Researchers. Ottawa, Canada: International Development Research Centre (IDRC).

Griaule, M. (1928). Mythes, croyances et coutumes du Bégamder (Abyssinie). Paris: Sonderdruck.

Grubb, P.J., Lloyd, J.R., Pennington, J.D. and Whitmore, J.C. (1963). A comparison of montane and lowland rainforest in Ecuador. I . The forest structure, physiognomy, and floristics. *Ecology* 51: 567-601.

Grünwald, J. and Büttel, K. (1996). The European phytotherapeutics market. *Drugs Made in Germany* 39: 6-11.

Guinand, Y. and Dechassa Lemessa (2000). *Wild-food plants in Southern Ethiopia: Reflections on the role of famine-foods at a time of drought.* UNDP-EUE. Field mission report, Addis Ababa, 2000.

Gurib-Fakim, A. (2006). Traditions of yesterday and drugs of tomorrow. *Molecular Aspects of Medicine* 27: 1-93.

Haile Yineger, Delenasaw Yewhalaw and Demel Teketay (2008a). Ethnomedicinal plant knowledge and practice of the Oromo ethnic group in southwestern Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2008, 4:11.

Haile Yineger, Delenasaw Yewhalaw and Demel Teketay (2008b). Plants of Veterinary importance in Southwestern Ethiopia: The case of Gilgel Ghibe Area. *Forests, Trees and Livelihoods*, 2008, 18:165–181.

Haile Yineger, Ensermu Kelbessa, Tamrat Bekele and Ermias Lulekal (2008c). Floristic composition and structure of the dry Afromontane forest at Bale Mountains National Park, Ethiopia. *SINET: Ethiopian Journal of Science* 31(2):103–120.

Haile Yineger, Ensermu Kelbessa, Tamrat Bekele and Ermias Lulekal (2007). Ethnoveterinary medicinal plants at Bale Mountains National Park, Ethiopia. *Journal of ethnopharmacology* 112: 55-70.

Haileab Zegeye, Demel Teketay and Ensermu Kelbessa (2011). Diversity and regeneration status of woody species in Tara Gedam and Abebaye Forests, north-western Ethiopia. *Journal of Forestry Research* 22(3): 315–328.

Hailu Sharew (1982). An ecological study of forest in Jemjem, Sidamo. Msc. Thesis. Addis Ababa University

Hailu Tadeg, Endris Mohammed, Kaleab Asres and Tsige Gebre-Mariam (2005). Antimicrobial activities of some selected traditional Ethiopian medicinal plants used in the treatment of skin disorders. *Journal of Ethnopharmacology* 100, 168-75.

Hamilton, A.C. (1982). *Environmental history of East Africa (A study of the Quaternary)*. London, UK: Academic Press.

Hamilton, A.C. (2003). Medicinal Plants and Conservation: issues and approaches. International plants conservation unit, WWF-UK, Pandahouse, Catteshall Lane, UK.

Hamilton, A.C., Shengji, P., Kessy, J., Khan, A.A., Lagos-Witte, S. and Shinwari, Z.K. (2003). *The Purposes and Teaching of Applied Ethnobotany*. People and Plants Working Paper 11. WWF, Godalming.

Han, H., Jang, K, Song, J., Seol, A, Chung, W. Chung, J. (2011). The effects of site factors on herb species diversity in Kwangneung forest stands. Forest *Science and Technology* 7(1) 1–7.

Hareya Fassil (2003). "We do what we know": Local health knowledge and home-based medicinal plant use in Ethiopia. PhD Thesis, international development centre, Queen Elizabeth house, Oxford University.

Hedberg, O. (1951). Vegetation belts of the East African mountains. *Svensk Botanisk Tidskrift Utgifven af Svenska Botaniska Foreningen* 45: 140-202.

Hedberg, O. (1964). Features of Afroalpine plant ecology. *Acta Phytogeographica Suecica* 49: 1-144.

Hedberg, O. (1978). Introduction. In: *Systematic Botany, Plant utilization and Biosphere Conservation*, Hedberg, I. (ed), Almquist and Well International, Stockholm, Sweden.

Hedberg, O. (1989). Rosaceae. In: *Flora of Ethiopia. Volume 3: Pittosporaceae to Araliaceae*, Hedberg, I. and Edwards, S. (eds), The National Herbarium, Addis Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden, 1989, pp. 31-44.

Heinrich, M., Ankli, A., Frei, B., Weimann, C. and Sticher, O. (1998). Medicinal plants in Mexico: Healers' consensus and cultural importance. *Social Science and Medicine* 47:1859-1871.

Health Canada (2001). Perspectives on Complementary and Alternative Health Care. A Collection of Papers Prepared for Health Canada, Ottawa, Health Canada; 2001.

Hobhouse, H. (1992). *Seeds of Change: Five plants that transformed mankind*. Papermac, London.

Hodges, N. (2002). Pharmaceutical applications of microbiological techniques. In: *Pharmaceutics: The Science of Dosage Form Design*, Aulton, M.E. (ed), London: Harcourt Publishers Limited, pp: 62-70.

Höft, M., Barik, S.K. and Lykke. A.M. (1999). *Quantitative Ethnobotany: Application of Multivariate and Statistical Analyses in Ethnobotany*. People and Plants working paper 6.UNESCO, Paris.

Howard C. A., William P. N, Ivan L. R. (2006). Antimicrobial activity of dimethyl sulfoxide against *Escherichia coli, Pseudomonas aeruginosa*, and *Bacillus megaterium. Journal of Pharmaceutical Sciences* 58(7):836-839. DOI:10.1002/jps.2600580708.

http://allafrica.com/stories/200604110567.html - Ethiopia: Company begins Endod export to US. Accessed on 25/09/2009.

http://simienpark.org/?page_id=57. Simien Mountains National Park. The official website of the Simien Mountains National Park. *Accessed* on 1/04/ 2014.

http://www.cbd.int/abs .About the Nagoya Protocol. *Accessed* on 25/06/ 2014

http://www.eli.org/pdf/africa/adeniji.Pdf.- The African union and the African model law. Accessed on 27/10/2009.

http://www.tradeportalofindia.com/usrdata/ - Market Study Report on Medicinal Plants (MAPS). Accessed June 30, 2014

Hussain, A., Khan, M.N., Iqbal, Z. and Sajid, M.S. (2008). An account of the botanical anthelmintics used in traditional veterinary practices in Sahiwal District of Punjab, Pakistan. *Journal of Ethnopharmacology* 119:185–190.

Hussain, S., Jamil, M., Ullah, F., Khan, A., Arfan, M., Ahmad, S. and Khatoon, L. (2010). Antimicrobial and antioxidant activities of the plant *Heliotropium strigosum*. *African Journal of Biotechnology* 9: 7738-7743.

Ijeh, I.I. and Ejike, C.E.C. (2011). Current perspectives on the medicinal potentials of *Vernonia amygdalina* Del. *Journal of Medicinal Plants Research* 5: 1051-1061.

Jansen, P.C.M. (1981). *Spices, Condiments and Medicinal plants In Ethiopia, their Taxonomy and Agricultural Significance*. Centre for Agricultural Publishing and Documentation, Wageningen, Netherlands.

Jeffrey, C. (1995). Cucurbitaceae. In: *Flora of Ethiopia and Eritrea. Volume 2 part 2: Canellaceae to Euphorbiaceae,* Edwards, S., Mesfin Tadesse and Hedberg, I. (eds), The National Herbarium, Addis Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden, 1995, pp. 17-59.

Jin-Ming, K., Goh Ngoh, K., Chia L. and Chiatet, F. (2003). Recent Advances in Traditional plant Drugs and orchids. *Acta Pharmacologica. Sinica* 24(1): 7-21.

Jorgensen, J.H., Turnidge, J.D. and Washington, J.A. (1999). Antibacterial susceptibility tests: Dilution and disk diffusion methods. In: *Manual of Clinical Microbiology, 7th ed.,* Murray, P.R., Baron, E.J., Pfaller, M.A., Tenover, F.C., Yolken, R.H., (eds), ASM Press, Washington, pp.1526-1543.

Kamoga, D. (2010). Some pharmacological activities of selected medicinal plant species used for treating cattle diseases in Kabira sub-county, Rakai District, MSc. thesis submitted to the school of graduate studies Makerere University, Uganda (Unpublished).

Kebu Balemie and Fassil Kibebew (2006). Ethnobotanical study of wild edible plants in Derashe and Kucha Districts, South Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2006, 2: 53.

Kebu Balemie, Ensermu Kelbessa, Zemede Asfaw (2004). Indigenous medicinal plant utilization, management and threats in Fentalle area, Eastern Shewa, Ethiopia. *Ethiopian Journal of Biological Sciences* 3:37-58.

Kelly, K. (2009). *History of medicine*. Facts on file, New York, USA.

Kent, M. and Coker, P. (1992). *Vegetation Description and Analysis. A practical approach*. New York: John Wiley and Sons.

Ketema Tolossa, Etana Debela, Spiridoula, A., Adugna Tolera, Gebeyehu Ganga and Houdijk, J.G.M. (2013). Ethno-medicinal study of plants used for treatment of human and livestock ailments by traditional healers in South Omo, Southern Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2013, 9:32.

Khan, M.A. and Hussain, M. (2012). Ethnoveterinary medicinal uses of plants of Pooch Valley Azad, Kashmir. *Pakistan Journal of Weed Science Research* 18:495-507.

Kloos, H. (1976). Preliminary studies of traditional medicinal plants and plant products in Ethiopian markets. *Journal of the Ethiopian Pharmaceutical Association* 2: 18-28.

Kloucek, P., Polesny, Z., Svobodova, B., Vlkova, E. and Kokoska, L. (2005). Antibacterial screening of some Peruvian medicinal plants used in Calleria District. *Journal of Ethnopharmacology* 99:309-12.

Kokwaro, J.O. (1976). *Medicinal Plants of East Africa*. Nairobi: East African Literature Bureau.

Kumlachew Yeshitela and Tamrat Bekele (2002). Plant Community Analysis and Ecology of Afromontane and Transitional Rainforest Vegetation of Southwestern Ethiopia. *SINET: Ethiopian Journal of Science* 25(2): 155-175.

Laird, S.A. (1999). The botanical medicine industry. In: *The commercial use of biodiversity: access to genetic resources and benefit-sharing*, Tenkate, K. and Laird, S.A. (eds.), Earthscan, London.

Laird, S.A. (2002). *Biodiversity and traditional knowledge: equitable partnerships in practice*. Earthscan Publications ltd., London, UK.

Laird, S.A. and Pierce, A.R. (2002). Promoting sustainable and ethical botanicals: strategies to improve commercial raw material sourcing. Rainforest Alliance, New York.

Laird, S. A and Wynberg, R. (2008). Bioprospecting: securing a piece of the pie. World Conservation Magazine, 26 January 2008.

Lambert, J., Srivastava, J. and Vietmeyer, N. (1997). *Medicinal Plants: Rescuing a Global Heritage*. The World Bank, Washington, D.C.

Landa, P., Marsik, P, Havlik, J., Kloucek, P., Vanek, T. and Kokoska, L. (2009). Evaluation of Antimicrobial and Anti-Inflammatory Activities of Seed Extracts from Six *Nigella* Species. *Journal of Medicinal Food* 12 (2): 408–415.

Lange, D. (1998). Europe’s medicinal and aromatic plants: their use, trade and conservation. TRAFFIC Europe/International, Cambridge.

Lans. C. (2001). Creole Remedies. Case studies of ethnoveterinary medicine in Trinidad and Tobago. PhD Thesis, University of Wageningen, The Netherlands.

Legesse Wolde-Yohannes (2001). Study on traditional medicine, the case of endod and others: cultivation, application and health improvement. In: *Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia*, Medhin Zewdu, Abebe Demissie (eds), Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia, 28 April – May 2001, pp. 143-154.

Letchamo, W. and Craker, L.E. (1996). Cultivating and breeding of medicinal and aromatic plants (editorial). *Journal of Herbs, Spices & Medicinal Plants* 4: 1-2.

Lissanework Nigatu and Mesfin Tadesse (1989). An Ecological study of the vegetation of the Harenna Forest, Bale, Ethiopia. *SINET*. *Ethiopian Journal of Sciences* 12: 63-93.

Logan, W.E.M. (1946). *An introduction to the forests of Central and Southern Ethiopia*. London, UK: Imperial Forestry Institute, University of Oxford.

Luo, X., Jiang, Y., Fronczek, F.R., Lin, C., Izevbigie, E.B. and Lee, K.S. (2010). Isolation and structure determination of a sesquiterpene lactone (vernodalinol) from *Vernonia amygdalina* extracts. *Pharmaceutical Biology* 49: 464-70.

Lykke, A.M., Kristensen, M.K. and Ganaba, S. (2004): Valuation of local use and dynamics of 56 woody species in the Sahel. *Biodiversity and Conservation* 13:1961-1990.

Lynam, T., De Jong, W., Sheil, D., Kusumanto, T. and Evans, K. (2007). A review of tools for incorporating community knowledge, preferences, and values into decision making in natural resources management. *Ecology and Society* 12(1): 5.

Machocho, A.K., Kiprono, P.C., Grinberg, S. and Bittner, S. (2003). Pentacyclic triterpenoids from *Embelia schimperi*. *Phytochemistry* 62: 573-77.

Makonnen Bishaw (1991). Promoting traditional medicine in Ethiopia: a brief historical review of government policy. *Social Science and Medicine* 33: 193-200.

Mander, M., Bezabih Emana, Zemede Asfaw and Badassa Busa (2006). Marketing of Medicinal Plants in Ethiopia: A Survey of the Trade in Medicinal Plants (unpublished). A research report prepared by Sustainable Use of medicinal Plants Project, Institute of Biodiversity Conservation, Addis Ababa, Ethiopia.

Manguro, L.O.A., Okwiri, S.O. and Lemmen, P. (2006). Oleanene-type triterpenes of *Embelia schimperi* leaves. *Phytochemistry*, 67, 2641-50.

Manguro, L.O.A., Ugi, I. and Lemmen, P. (2004). Further flavonol glycosides of *Embelia schimperi* leaves. *Chemical Society of Ethiopia* 18: 51-57.

Mann, C. (2011). *1493: uncovering the new world Columbus created*. Knopf, New York.

Martin, G.J. (1995). *Ethnobotany: A method Manual*. Chapman and Hall, London.

Martínez, G.J. and Luján, M.C. (2011). Medicinal plants used for traditional veterinary in the Sierras de Córdoba (Argentina): An ethnobotanical comparison with human medicinal uses. *Journal of Ethnobiology and Ethnomedicine* 2011, 7:23.

Masresha Fetene and Yonas Feleke (2001). Growth and photosynthesis of seedlings of four tree species from a dry tropical Afromontane forest. *Journal of Tropical Ecology* 17(17):269-283.

Mathias-Mundy, E. and McCorkle, C.M. (1989). Ethnoveterinary medicine: An annotated bibliography. Bibliography in Technology and Social Change No.6. Ames: Iowa State University, Technology and social change Program.

McCorkle, C.M. (1986). An Introduction to Ethnoveterinary Research and Development. *Journal of Ethnobiology* 6 (1): 129-149.

McCune, B. and Mefford, M.J. (1999). PC-ORD. *Multivariate Analysis of Ecological Data. Window Version 5.0*. MjM software, Oregon: USA: Gleneden Beach.

McGown, J. (2006). Out of Africa Mysteries of Access and benefit sharing. Edmonds institute in cooperation with African center for biosafety, Richmond south Africa.

Medhin Zewdu, Tsige Gebre-Mariam and Kaleab Asres (2001). Global perspectives of medicinal plants. In: *Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia*, Medhin Zewdu, Abebe Demissie (eds), Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia, 28 April –May 2001, pp. 198-203.

Mengistu Fentahun and Hager, H. (2010). Integration of indigenous wild woody perennial edible fruit bearing species in the agricultural landscapes of Amhara region. *Agroforestry Systems* 78: 79-95.

Mesfin Goji, Tsige Gebre-Mariam, Kaleab Asres, Hirut Lemma, Negero Gemeda, Kidist Yirsaw. (2006). Screening of antimicrobial activities of some plants used traditionally in Ethiopia for the treatment of skin disorders. *Ethiopian Pharmaceutical Journal* 24: 130-135.

Mesfin Tadesse (1986). Some medicinal plants of central Shoa and southwestern Ethiopia. *SINET: Ethiopian Journal of Science* 9 (supplement): 143-167.

Mesfin Tadesse (2004). *Flora of Ethiopia and Eritrea, Part 2: Asteraceae (Compositae) Volume 4*. Addis Ababa, Ethiopia: The National Herbarium, Addis Ababa University; 2004.

Messeret Shiferaw (1996). The role of health professionals in the development of traditional medicine. In: *Proceedings of the Workshop on Development Utilisation of Herbal Remedies in Ethiopia*. Ethiopian Health and Nutrition Institute, Addis Ababa, pp. 15-18.

Microsoft Corporation (2007). *Microsoft Excel 2007*. Microsoft Corporation.

Midiwo, J.O. and Manguro, L.O.A. (1993). Polynuclear acetogenic pigments in the fruits of the Myrsinaceae. *BioChemiPhysics*, 2, 115-118.

Mirutse Giday and Gobena Ameni (2003). An ethnobotanical survey on plants of veterinary importance in two Woredas of Southern Tigray, Northern Ethiopia. *SINET: Ethiopian Journal of Science* 26: 123-136.

Mirutse Giday and Tilahun Teklehaymanot (2013). Ethnobotanicl study of plants used in management of livestock health problems by Afar people of Ada'ar District, Afar Regional State, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2013, 9:8.

Mirutse Giday, Tilahun Teklehaymanot, Abebe Animut and Yalemtsehay Mekonnen (2007). Medicinal plants of the Shinasha, Agew-awi and Amhara peoples in northwest Ethiopia. *Journal of Ethnopharmacology* 110: 516-525.

Mirutse Giday, Zemede Asfaw, Thomas Elmqvist and Zerihun Woldu (2003). An ethnobotanical study of medicinal plants used by the Zay people in Ethiopia. *Journal of Ethnopharmacology* 85: 43-52.

Mirutse Giday, Zemede Asfaw and Zerihun Woldu (2010). Ethnomedicinal study of plants used in Sheko ethnic group of Ethiopia. *Journal of Ethnopharmacology* 132:75-85.

Mirutse Giday, Zemede Asfaw, Zerihun Woldu and Tilahun Teklehaymanot (2009). Medicinal plant knowledge of the Bench Ethnic group of Ethiopia: an ethnobotanical investigation. *Journal of Ethnobiology and Ethnomedicine* 2009, 5:34.

Mittermeier, R.A., Gil, P.R., Hoffman, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoreux, J. and da Fonseca, G.A.B. (2005). *Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions*. Washington, Conservation International.

Mohr, P.A. (1971). *The Geology of Ethiopia*. 2nd. ed. Addis Ababa, Ethiopia: University College of Addis Ababa Press.

Monteiro, M.V.B., Bevilaqua, C.M.L., Palha, M.D.C., Braga, R.R., Schwanke, K., Rodrigues, S.T. and Lameira, O.A. (2011). Ethnoveterinary knowledge of the inhabitants of Marajo´ Island, Eastern Amazonia, Brazil. *Acta Amazonica* 41: 233–242.

Mordechai, A. (1969). Ethiopia: the era of the princess. Prentice hall press, New Jersey, USA. 234pp.

Mueller-Dombois, D. and Ellenberg, H. (1974). *Aims and Methods of Vegetation Ecology*. New York: Wiley and Sons; 1974.

Muthu, C., Ayyanar, M., Raja, N. and Ignacimuthu, S. (2006). Medicinal plants used by traditional healers in Kancheepuram District of Tamil Nadu, India. *Journal of Ethnobiology and Ethnomedicine* 2:43

Nasir Tajure Wabe, Mohammed Adem Mohammed and Nandikola Jaya Raju, (2011). An ethnobotanical survey of medicinal plants used in the Southeast Ethiopia used in traditional medicine. *Spatula DD* 1:153-158.

Njoroge, N.G. and Bussmann, R.W. (2006). Herbal usage and informant consensus in ethnoveterinary management of cattle diseases among the Kikuyus (Central Kenya). *Journal of Ethnopharmacology* 108: 332–339.

Oji, K.A. and Shafaghat, A. (2012). Constituents and antimicrobial activity of the essential oils from flower, leaf and stem of *Helichrysum armenium*. *Nat Prod Commun*, 7, 671-74.

Ozhatay, N., Koyuncu, M., Atay, S. and Byfield, A. (1998). The Trade in Wild medicinal plants in Turkey. In: *Medicinal plant trade in Europe :Conservation and Supply. Proceedings of the first international symposium on the conservation of medicinal plants in Trade in Europe,* TRAFFIC Europe (eds.), Brussels, pp. 5-18.

Paniagua, Z. (2005). Factors determining the knowledge and use of palms in the western Amazon, University of Aarhus, Denmark.

Pankhurst, R. (1976). Historical Reflections on the Traditional Ethiopian Pharmacopoeia. *Journal of Ethiopian Pharmaceutical Association* 2: 29-33.

Pankhurst, R. and Pearson, T. (1972). Remedius Prutky's 18th century account of Ethiopian taenicides and other medical treatment. *Ethiopian Medical Journal* 10:3-6.

Parrota, J.A. (2002). Restoration and management of degraded tropical forest landscapes. In: *Modern Trends in Applied Terresterial Ecology,* R. S., Ambashet and N.K., Ambashet (eds.) pp.135-148.

Pascaline, J., Charles, M., Lukhoba, C. and George, O. (2011). Phytochemical constituents of some medicinal plants used by the Nandis of South Nandi district, Kenya. *Journal of Animal and Plant Sci*ences 9: 1201-1210.

Pearce, N. (1831). *The Life and adventures of Nathaniel Pearce*, (Volume I), New Burlington Street, London: Henry Colburn and Richard Bentley.

Pen-gen, X. (1991). The Chinese Approach to Medicinal Plants-Their Utilization and Conservation. In: *Conservation of Medicinal Plants*, Akerele, O., Heywood, V. and Synge, H. (eds). Cambridge University Press, Cambridge, pp.45-60.

Petrovska, B.B. (2012). Historical review of medicinal plants' usage. *Pharmacognosy Review* 6:1-5.

Phillips, O.L. (1996). Some quantitative methods for analyzing ethnobotanical knowledge. In: *Selected Guidelines for Ethnobotanical Research: A Field Manual*, M.N. Alexiades (ed), The New York Botanical Garden Press, New York pp. 171-197.

Phillips, O. and Gentry, A.H. (1993a). The useful plants of Tambopata, Peru: I. Statistical hypotheses with a new quantitative technique. *Economic Botany* 47: 15-32.

Phillips, O. and Gentry, A.H. (1993b). The useful plants of Tambopata, Peru: II. Additional hypotheses testing in quantitative ethnobotany. *Economic Botany* 47: 33-43.

Pichi-Seremolli, R.E.G. (1957). Una carta geobotanica dell Africa orientale (Eritrea, Ethiopia, Somalia) *Webbia* 12:15-132.

Pierce, A.R. & Laird, S.A. (2003). In search of comprehensive standards for non-timber forest products in the botanicals trade. *International Forestry Reviews,* 1(2): 138–147.

Popma, J., Bongers, F. and Meave del Castillo, J. (1988). Patterns in the vertical structure of the lowland rainforest of Los Tuxtlas, Mexico. *Vegetatio* 74: 81 -91.

Quanash, N. (1988). Biocultural diversity and integrated health care in Madagascar. *Nature and Resources* 30:18-22.

Reichert, J.M. (2003). Trends in development and approval times for new therapeutics in the United States. *Nature Reviews Drug Discovery* 2(9): 695–702.

Rey, P.J., Julio, M. and Alcantara, M. (2000). Recruitment dynamics of a fleshy-fruited plant (*Olea europaea*): Connecting patterns of seed dispersal to seedling establishment. *Journal of Ecology* 88(4):622-633.

Reyes-García, V., Marti, N., McDade, T.W., Tanner, S. and Vadez, V. (2007). Concepts and methods in studies measuring individual ethnobotanical knowledge. *Journal of Ethnobiology* 27:108-203.

Rindos, D. (1984). *The Origins of Agriculture:* An evolutionary perspective. Cornell University. Orlando : Academic Press, INC.

Runyoro, D., Ngassapa, O., Vagionas, K., Aligiannis, N., Graikou, N. and Chinou, I. (2010). "Chemical composition and antimicrobial activity of the essential oils of four *Ocimum* species growing in Tanzania. *Food Chemistry*, 119, 311-316.

Ryding, O. (2006). Lamiaceae. In: *Flora of Ethiopia and Eritrea. Volume 5: Gentianaceae to Cyclocheilaceae*, Hedberg, I., Ensermu Kelbessa, Edwards, S., Sebsebe Demissew and Persson, E. (eds), The National Herbarium, Addis Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden, 2006, pp. 516-604.

Sader, H.S., Jones, R.N. and Silva, J.B. (2002). Skin and soft tissue infections in Latin American Medical Centers: Four-year assessment of the pathogen frequency and antimicrobial susceptibility patterns. *Diagnostic Microbiology and Infectious Diseases* 44: 281-88.

Samuelsson, G. (2004). *Drugs of Natural Origin: a Textbook of Pharmacognosy*, 5th Swedish Pharmaceutical Press, Stockholm.

Savithramma, N., Ankanna, S., Linga, R.M. and Saradvathi, J. (2012). Studies on antimicrobial efficacy of medicinal tuberous shrub *Talinum cuneifolium*. *Journal of Environmental Biology* 33: 775-780.

Schultes, R.E. (1979). The Amazonia as a source of new economic plants. *Economic Botany* 33: 259-266.

Sebsebe Demissew (1988). The floristic composition of Menagesha State Forest and the need to conserve such forests in Ethiopia. *Mountain Research and Development* 1988, 8: 243-247.

Sebsebe Demissew (1995). Myrsinaceae. In *Flora of Ethiopia and Eritrea, Volume 4 part 1, Apiaceae to Dipsacaceae*, Hedberg, I., Edwards, S., Sileshi Nemomissa (eds). The National Herbarium, Addis Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden; 1995, pp: 64-69.

Sebsebe Demissew and Ermias Dagne (2001). Basic and Applied research in medicinal Plants. In: *Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia*, Medhin Zewdu, Abebe Demissie (eds), Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia, 28 April –May 2001, pp. 29-33.

Sebsebe Demissew and Friis, I. (2009). Natural vegetation of the Flora area. In: *Flora of Ethiopia and Eritrea*. *Volume 8*, Hedberg, I., Friis, I. and Persson, E. (eds), The National Herbarium, Addis Ababa University, Addis Ababa; 2009:28-29.

Selvaraju, A., Ayyanar, M., Rathinakumar, S.S. and Sekar, T. (2011). Plants used in ethno-veterinary medicine by malayali tribals in Salem district of Tamil Nadu, India. *Medicinal Plants* 3:1-7.

Sharma, R., Manhas, R.K. and Magotra, R. (2012). Ethnoveterinary remedies of disease among milk yielding animals in Kathua, Jammu and Kashmir, India. *Journal of Ethnopharmacology* 141:265–272.

Sharrock, S. (2011). GSPC, Global Strategy for Plant Conservation. A Guide to the GSPC. All the Targets, Objectives and Facts. Botanic Gardens Conservation International, Richmond, UK.

Sheldon, J.M., Wood, J., Balick, S. and Laird, A. (1997). *Medicinal Plants: Can Utilization and Conservation Co-Exist?* New York.

Silva, F.D.S., Ramos, M.A., Hanazaki, N. and Albuquerque, U.P. (2011). Dynamics of traditional knowledge of medicinal plants in a rural community in the Brazilian semi-arid region. *Brazilian Journal of Pharmacognosy* 21:382-391.

Silvertown, J.W. and Doust, J.L. (1993). *Introduction to Plant Population Biology*. Oxford, United Kingdom: Blackwell Science.

Simon Shibru and Girma Balcha (2004). Composition, structure and regeneration status of woody species in Dindin natural forests, southeast Ethiopia: An implication for conservation*.* *Ethiopian Journal of Biological Sciences* 3:15-35.

Siswoyo, E.A.M., Zuhud, M. and Sitepu, D. (1994). Research program on development of medicinal plants in Indonesia. In: *Conservation and Use of Medicinal Plants diversity in Indonesia's tropical forests.*, E.A.M., Zuhud and Haryanto (eds), Bogor, Indonesia, pp.161-300.

Soejarto, D.D., Fong, H.H.S., Tan, G.T., Zhang, H.J., Ma, C.Y., Franzblau, S.G., Gyllenhaal, C., Riley, M.C., Kadushin, M.R., Pezzuto, J.M., Xuan, L.T., Hiep, N.T., Hung, N.V., Vu, B.M., Loc, P.K., Dac, L.X., Binh, L.T., Chien, N.Q., Hai, N.V., Bich, T.Q., Cuong, N.M., Southavong, B., Sydara, K., Bouamanivong, S., Ly, H.M., Thuy, T.V., Rose, W.C. and Dietzman, G.R. (2005). Ethnobotany/ethnopharmacology and mass bioprospecting: issues on intellectual property and benefit sharing. *Journal of Ethnopharmacology* 100: 15-22.

Solecki, R. (1975). Shanidar IV, a Neanderthal flower burial in northern Iraq. *Science* 190:880-881.

Sop, T.K., Oldeland, J., Bognounou, F., Schmiedel, U. and Thiombiano, A. (2012) Ethnobotanical knowledge and valuation of woody plants species: a comparative analysis of three ethnic groups from the sub-Sahel of Burkina Faso. *Environment Development and Sustainability* 14:627–649.

Srivastava, R. (2000). Studying the information needs of medicinal plant stake holders in Europe. Brussels, TRAFFIC Dispatches 15(5).

Stojanoski, N. (1999). Development of health culture in Veles and its region from the past to the end of the 20 th century. Veles: Society of science and art. pp. 13-34.

Subedi, A., Kunwar, B., Choi, Y., Dai, Y, van Andel, T., Chaudhary, R.P. and de Boer, H.J. (2013). Collection and trade of wild-harvested orchids in Nepal. *Journal of Ethnobiology and Ethnomedicine*, 2013, 9:64.

Sultana, B., Anwar, F., Ashraf, M. (2009). Effect of extraction solvent/technique on the antioxidant activity of selected medicinal plant extracts. *Molecules* 2009, 14: 2167-2180.

Tabuti, J.R.S., Lye, K.A. and Dhillion, S.S. (2003). Traditional herbal drugs of Bulamogi, Uganda: plants, use and administration. *Journal of Ethnopharmacology* 88:19-44.

Tadesse Woldemariam Gole, Borsch T, Denich M and Demel Teketay (2008). Floristic composition and environmental factors characterizing coffee forests in southwest Ethiopia. *Forest Ecology and Management* 255: 2138–2150.

Tadesse Woldemariam, Demel Teketay, Edwards, S. and Olsson, M. (2000). Woody plant and avian species diversity in a dry Afromontane forest on the central plateau of Ethiopia: Biological indicators for conservation. *Ethiopian Journal of Natural Resources* 2: 255-293.

Tamrat Bekele (1993). Vegetation ecology of remnant Afromontane forests on the Central Plateau of Shewa, Ethiopia. *Acta Phytogeographic Suecica.* 1993, 79: 1-59.

Tamrat Bekele (2005). Recruitment, survival and growth of *Olea europaea* subsp. *cuspidata* seedlings and juveniles in dry Afromontane forests of northern Ethiopia. *Tropical Ecology* 46:113-126.

Tchoumbougnang, F., Amvam Zollo, P.H., Avlessi, F., Alitonou, G.A., Sohounhloue, D.K., Ouamba, J.M., Tsomambet, A., Okemy-Andissa, N., Dagne, E., Agnaniet, H., Bessiere, J.M. and Menut, C. (2006). Variability in the chemical compositions of the essential oils of five *Ocimum* species from tropical African area. *Journal of Essential Oil Research* 18:194-199.

Teferi Flatie, Teferi Gedif, Kaleab Asres and Tsige Gebre-Mariam (2009). Ethnomedical survey of Berta ethnic group Assosa Zone, Benishangul-Gumuz regional state, mid-west Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2009, 5:14.

Teferi Gedif and Hahn, H. (2003). The use of medicinal plants in self-care in rural central Ethiopia. *Journal of Ethnopharmacology* 87: 155-161.

Tekletsadik Mekuria (1961). *YeEthiopia Tarik KeAtse Tewodros Iske Atse Hailesellasse* (in Amharic). Merha Tibebe Priniting Press, Addis Ababa. 315pp.

Tekwu, E.M., Pieme, A.C. and Beng, V.P. (2012). Investigations of antimicrobial activity of some Cameroonian medicinal plant extracts against bacteria and yeast with gastro-intestinal relevance. *Journal of Ethnopharmacology* 142:265-73.

Tesfaye Awas (2004). Conservation of medicinal plants in Ethiopia. In: *Proceedings of a National Workshop on Traditional Medicine in Ethiopia*. Ethiopian Health and Nutrition Institute, Addis Ababa, pp.99-105.

Tesfaye Awas, Tamrat Bekele, and Sebsebe Demissew (2001). An Ecological study of the Vegetation of Gambella region, Southwestern Ethiopia. *SINET: Ethiopian Journal of Science* 24 (2): 213-228.

Tesfaye Hailemariam Bekalo, Sebsebe Demissew Woodmatas, and Zemede Asfaw Woldemariam (2009). An ethnobotanical study of medicinal plants used by local people in the lowlands of Konta Special Woreda, southern nations, nationalities and peoples regional state, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2009, 5:26.

Teshale Sori, Merga Bekana, Girma Adugna and Ensermu Kelbessa (2004). Medicinal plants in the ethnoveterinary practices of Borana pastoralists, Southern Ethiopia. *International Journal of Applied Research in Veterinary Medicine* 2: 220-225.

Tessema Tanto, Mirutse Giday, Negusu Aklilu and Teshome Hunduma (2003). Medicinal Plants Biodiversity. National Biodiversity Strategy and Action Plan (NBSAP) Project (unpublished). Institute of Biodiversity Conservation and Research (IBCR), Addis Ababa, Ethiopia.

Theuretzbacher, U. (2012). Accelerating resistance, inadequate antibacterial drug pipelines and international responses. *International Journal of Antimicrobial Agents*, 39, 295–99.

Thomas, E. (2008). Quantitative Ethnobotanical Research on Knowledge and Use of Plants for Livelihood among Quechua, Yuracare, and Trinitario Communities in the Andes and Amazon Regions of Bolivia. PhD thesis, Ghent University.

Thulin, M. (1989). Fabaceae. In: *Flora of Ethiopia. Volume 3: Pittosporaceae to Araliaceae*, Hedberg, I. and Edwards, S. (eds), The National Herbarium, Addis

Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden, 1989, pp. 49-251

Tigist Wondimu, Zemede Asfaw and Ensermu Kelbessa (2006). Ethnobotanical study of food plants around ‘Dheeraa’ town, Arsi, Ethiopia. *SINET: Ethiopian Journal of Science* 29: 71-80.

Tigist Wondimu, Zemede Asfaw and Ensermu Kelbessa (2007). Ethnobotanical study of medicinal plants around 'Dheeraa' town, Arsi Zone, Ethiopia. *Journal of Ethnopharmacology*, 112:152-161.

Tilahun Teklehaymanot (2009). Ethnobotanical study of knowledge and medicinal plants use by people in Dek Island in Ethiopia. *Journal of Ethnopharmacology* 2009, 124:69-78.

Tilahun Teklehaymanot and Mirutse Giday (2007). Ethnobotanical study of medicinal plants used by people in Zegie peninsula, northwestern Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2007, 3: 12.

Tilahun Teklehaymanot and Mirutse Giday (2010). Ethnobotanical study of wild edible plants of Kara and Kewego semipastoralist people in Lower Omo River valley, Debub Omo Zone, SNNPR, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2010, 6:23.

Trommeter, M. (2005). Biodiversity and international stakes. *Ecological Economics* 53:573–583.

Trotter, R.T., and Logan, M.H. (1986). Informants consensus: a new approach for identifying potentially effective medicinal plants. In: *Plants in Indigenous Medicine and Diet* Etkin NL (ed). New York: Redgrave Publishing Company, Bedford Hill; pp:91-112.

Tsekpo, W.M.K. (1997). Application of Ethnobotany. In: *Conservation and Utilization of Indigenous Medicinal plants and Wild Relatives of food crops*, UNESCO, Nairobi, Kenya. pp.57-64.

Tsige Gebre-Mariam and Kaleab Asres (2001). Applied Research in medicinal plants. In: *Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia*, Medhin Zewdu, Abebe Demissie (eds), Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia, 28 April – May 2001, pp. 34-45.

Tsige Gebre-Mariam, Neubert, R., Schmidt, P.C., Wutzler, P. and Schmidtke, M. (2006). Antiviral activities of some Ethiopian medicinal plants used for the treatment of dermatological disorders. *Journal of Ethnopharmacol*ogy 104:182-87.

Uniyal, S.K., Singh, K.N., Jamwal, P. and Lal, B. (2006). Traditional use of medicinal plants among the tribal communities Chhota Bhangal, Western Himalaya. *Journal of Ethnobiology and Ethnomedicine* 2006, 2:14.

Urban, D., Miller, C., Halpin, P. and Stephenson N (2000). Forest gradient response in Sierran landscapes: the physical template. *Landscape Ecology*, 15: 603–620.

Uzoigwe, C.I. and Agwa, O.K. (2011). Antimicrobial activity of *Vernonia amygdalina* on selected urinary tract pathogens. *African Journal of Microbiological Research* 5: 1467-1472.

Valencia, R., Balslev, H., Paz, H. and Min˜o, C.G. (1994). High tree alpha-diversity in Amazonian Ecuador. *Biodiversity Conservation*, 3:21–28.

Van Andel, T., Mitchell, S., Volpato, G., Vandebroek, I., Swier, J., Ruysschaer, S., Jiménez, C.A.R. and Raes, N. (2012). In search of the perfect aphrodisiac: Parallel use of bitter tonics in West Africa and the Caribbean. *Journal of Ethnopharmacology* 143:840–850.

van der Maarel, E. (1979). Transformation of cover-abundance values in phytosociology and its effects on community similarity. *Vegetatio* 39:97-114.

van der Maarel, E., Espejel, I. and Moreno-Casasola, P. (1987). Two-step vegetation analysis based on very large data sets. *Vegetatio* 68: 139- 143.

Vandebroek, I., Reyes-Garcia, V., Albuquerque, U., Bussmann, R. and Pieroni, A. (2011). Local ecological knowledge: who cares? *Journal of Ethnobiology and Ethnomedicine* 7:35.

Vavilov, N. I. (1997). Five continents. International Plant Genetic Resources Institute, Rome, Italy, 198pp.

Vecchiato, N.L. (1993). Traditional medicine. In: *The Ecology of Health and Disease in Ethiopia*, H., Kloos, Z.A., Zein (eds), Westview Press, Boulder, pp. 157-178.

Verdcourt, B. (1989a). Melianthaceae. In *Flora of Ethiopia and Eritrea, Volume 3: Pittosporaceae to Araliaceae*. Hedberg, I. and Edwards, S. (eds), The National Herbarium, Addis Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden, 1989, pp. 511-513.

Verdcourt, B. (1989b). Hamamelidaceae. In *Flora of Ethiopia and Eritrea, Volume 3: Pittosporaceae to Araliaceae*, Hedberg, I. and Edwards, S. (eds), The National Herbarium, Addis Ababa, Ethiopia, and Department of Systematic Botany, Uppsala, Sweden; 1989, pp. 252-254.

Verpoorte, R., Choi, Y.H. and Kim, H.K. (2005). Ethnopharmacology and systems biology: A perfect holistic match. *Journal of Ethnopharmacology*,100: 53–56.

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, 23p.

Voeks, R.A. (2007). Are women reservoirs of traditional plant knowledge? Gender, ethnobotany and globalization in northeast Brazil. *Singapore Journal of Tropical Geography* 28:7-20.

Voeks, R.A. (2009) Traditions in Transition: African Diaspora ethnobotany in Lowland South America. In *Mobility and migration in indigenous Amazonia: contemporary ethnoecological perspectives,* Alexiades, M. (ed), London: Beghahn Books, pp:275–294.

Voeks, R.A. (2011). Ethnobotany. In: *The sage handbook of biogeography,* Millington, A., Blumler, M., MacDonald, G., Schickhoff, U. (eds), Sage Publications, London, pp: 493–509.

Voeks, R.A. and Leony, A. (2004). Forgetting the forest: assessing medicinal plant erosion in eastern Brazil. *Economic Botany* 58:294-306.

von Breitenbach, F. (1961). Forests and woodlands of Ethiopia. A geobotanical contribution to the knowledge of the principal plant communities of Ethiopia, with special regard to forestry. *Ethiopian Forestry Review*1:5-16.

Wadhwani, T., Desai, K., Patel, D., Lawani, D., Bahaley, P., Joshi, P., Kothari, V. (2008). Effect of various solvents on bacterial growth in context of determining MIC of various antimicrobials. *The Internet Journal of Microbiology*. 2008:7(1).

Wanzala, W., Zessin, K.H., Kyule, N.M., Baumann, M.P.O., Mathias, E. and Hassanali, A. (2005). Ethnoveterinary medicine: a critical review of its evolution, perception, understanding and the way forward. *Livestock Research for Rural Development.* 17 :119.

Weldesellassie Mequanint, Eyasu Makonnen and Kelbessa Urga (2011). *In vivo* anti-inflammatory activities of leaf extracts of *Ocimum lamiifolium* in mice model. *Journal of Ethnopharmacology* 134: 32-36.

Westphal, E. (1975). *Agricultural Systems in Ethiopia*. Centre for Agricultural Publication and Documentation, Wageningen.

White, F. (1978). The Afromontane Region. In: *Biogeography and ecology of Africa*, Werger, M.J.A. (ed), Junk: The Hague, 1978, pp. 463-513.

White, F. (1983). The Vegetation of Africa. A descriptive memoir to accompany the UNESCO/AETFAT/ UNIDO vegetation map of Africa. *Natural Resources Research* 20: 1-356.

Whittaker, R.J., Willis, K.J. and Field, R. (2003). Climatic–energetic explanations of diversity: a macroscopic perspective. In *Macroecology: concepts and consequences*, Blackburn, T.M. and Gaston, K.J. (eds), Cambridge University Press; Cambridge, 2003, pp. 107-129.

Williams, C., Davis, K. and Cheyne, P. (2003). *The CBD for Botanists: an Introduction to the Convention on Biological Diversity for People Working with Botanical Collections*. The Board of the Trustees of the Royal Botanical Gardens, Kew.

Winter, K. and McClatchey, W. (2008). Quantifying evolution of cultural interactions with plants: implications for managing diversity for resilience in social-ecological systems. *Functional Ecosystems and Communities* 2 (*Special issue 1*):1-10.

WHO (1976). African Traditional Medicine. Report of the Regional Expert Committee. AFRO Technical Report Series. No. 1. Brazzaville: World Health Organization.

WHO (1978). The promotion and development of traditional Medicine. Technical Report Series 622, World Health Organization, Geneva.

WHO (1996). Traditional Medicine. JVI-IO Fact Sheet: N. 134. Available: http://www.who.int/inf-fs/en/factl3l .html]. Accessed 12 December 2013.

WHO (1998). Report: Technical Briefing on Traditional Medicine. Forty-ninth Regional Committee Meeting, Manila, Philippines, 18 September 1998, Manila, WHO Regional Office for the Western Pacific; 1998.

WHO (2001). Planning for cost effective traditional health services in the new century- a discussion paper. *http://www.who.or.jp/tm/research/bkg/index.html.* Accessed 14 April 2009.

WHO (2002). *WHO Traditional Medicine Strategy 2002-2005*. World Health Organization (WHO), Geneva.

WHO (2008). Traditional medicine. Fact Sheet, no 134, 2008. Available at http://www.who.int/mediacentre/factsheets/fs134/en/. Accessed on 17 September 2012.

Yitbarek Habtamu, Tadesse Eguale, Alehegne Wubete and Takele Sori (2010). *In vitro* antimicrobial activity of selected Ethiopian medicinal plants against some bacteria of veterinary importance. *African Journal of Microbiology Research* 4 (12): 1230-1234.

Zemede Asfaw (2001). The role of home gardens in the production and conservation of medicinal plants. In: *Proceedings of Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia*, Medhin Zewdu, Abebe Demissie (eds), Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia, 28 April – May 2001, pp. 76-91.

Zemede Asfaw and Ayele Nigatu (1995). Home gardens in Ethiopia: characteristics and plant diversity. SINET: *Ethiopian Journal of Science* 18: 235-266.

Zerihun Woldu (1999). Forest in the vegetation types of Ethiopia and their status in the geographical context. In: *The proceedings of the National Forest Genetic resources Conservation strategy Development work shop*. Addis Ababa, Ethiopia, June 21-22, 1999, pp. 1-36.

Zerihun Woldu and Mesfin Tadesse (1990). The status of the vegetation in the lake region of the Rift Valley of Ethiopia and possibilities of its recovery. *SINET: Ethiopian Journal of Science* 392: 97-120.

Zerihun Woldu, Feoli, E. and Lissanework Nigatu (1989). Partitioning an elevation gradient of vegetation from Southeastern Ethiopia By Probabilistic methods. *Vegetatio.*18: 189-198.

Zollman, C. and Vickers, A. J. (2000). *ABC of Complementary Medicine.* BMJ Books, London.

APPENDICES

Appendix 1. Floristic list of Dense Forest, Ankober District

No	Scientific name	Family	Local name	Growth form*	Voucher No: ErmiasLX
1	***Acacia abyssinica* Hochst. ex Benth. subsp. *abyssinica***	Fabaceae	Girar	T	826
2	***Achyranthes aspera* L.**	Amaranthaceae	Telenj	H	104
3	***Acmella caulirhiza* Del.**	Asteraceae		H	827
4	***Acokanthera schimperi* (A.DC.) Schweinf.**	Apocynaceae	Merenz	T	100
5	***Aeonium leucoblepharum* Webb ex A. Rich.**	Crassulaceae	Yefeyel Dabo	H	885
6	***Allophylus abyssinicus* (Hochst.) Radlk.**	Sapindaceae	Imbis	T	829
7	***Anthemis tigreensis* J. Gay ex A. Rich.**	Asteraceae		H	830
8	***Apodytes dimidiata* E.Mey.ex Arn**	Icacinaceae	Yetemenja Inchet/Donga	T	887
9	***Arisaema schimperianum* Schott.**	Araceae	Amoch	H	587
10	***Asparagus africanus* Lam.**	Asparagaceae	Serite	S	189
11	***Asplenium aethiopicum* (Kunth) mett**.	Aspleniaceae		H	593
12	*Asplenium protensum* Schrad.	Aspleniaceae		H	914
13	***Berberis holstii* Engl.**	Berberidaceae	Yeset Af	H	831
14	***Bersama abyssinica* Fresen.**	Melianthaceae	Azamir	T	173
15	*Buddleja davidii* Franch.	Loganiaceae	Anfar	S	915
16	***Buddleja polystachya* Fresen.**	Loganiaceae	Anfar	S	542
17	***Calpurnia aurea* (Ait.) Benth.**	Fabaceae	Digita	S	76
18	***Carissa spinarum* L.**	Apocynaceae	Agam	S	16
19	***Cassipourea malosana* (Baker) Alston**	Rhizophoraceae	Werer	T	832

Appendix 1. contd.

No	Scientific name	Family	Local name	Growth form*	Voucher No: ErmiasLX
20	***Celtis africana* Burm.f.**	Ulmaceae	Kewt	T	833
21	*Cerastium octandrum* A. Rich.	Caryophyllaceae		H	916
22	*Ceropegia cufodontis* Chiov.	Asclepiadaceae		C	487
23	***Chamaecrista mimosoides* (L.) Greene**	Fabaceae	Yeayt Gomen	H	834
24	***Chenopodium ambrosioides* L.**	Chenopodiaceae	Gundan Abir	S	4
25	*Cisium englerianum* O. Hoffm.**	Asteraceae	Koshele	H	917
26	***Cissampelos mucronata* A. Rich.**	Menispermaceae	Ingochit hareg	C	888
27	***Clematis hirsuta* Perr. & Guill.**	Ranunculaceae	Azo Hareg	C	18
28	***Clutia abyssinica* Jaub. & Spach**	Euphorbiaceae	Feyele Fej	S	10
29	*Conyza bonariensis* (L.) Cronq.	Asteraceae		H	918
30	*Conyza schimperi* Sch. Bip. ex A. Rich.	Asteraceae		H	926
31	***Crassocephalum macropappum* (Sch. Bip. ex A. Rich.) S. Moore****	Asteraceae		H	835
32	*Crassula schimperi* Fisch. & Mey.	Crassulaceae		H	925
33	***Crotalaria incana* L.**	Fabaceae		S	836
34	***Croton macrostachyus* Del.**	Euphorbiaceae	Bisana	T	17
35	***Cyathula cylindrica* Moq.**	Amaranthaceae	Yedem Abnet	H	837
36	***Cynoglossum coeruleum* Hochst.**	Boraginaceae	Chegogot	H	66
37	*Cyperus atroviridis* C.B. Cl.	Cyperaceae	Gramta	H	924
38	***Cyperus bulbosus* Vahl**	Cyperaceae	Ingicha	H	839
39	***Debregeasia saeneb* (Forssk.) Hepper & Wood**	Urticaceae	Wenz admek	S	890
40	***Desmodium repandum* (V ahl) DC.**	Fabaceae		H	840

Appendix 1. contd

No	Scientific name	Family	Local name	Growth form*	Voucher No: ErmiasLX
41	***Desmodium velutinum* (Willd.) DC.**	Fabaceae		H	11
42	*Diphananthe schimperiana* (A. Rich.) Summerh	Orchidaceae		E	923
43	***Discopodium penninervium* Hochst.**	Solanaceae	Ameraro	T	606
44	*Disperis anthoceros* Rchb.f.	Orchidaceae		H	548
45	***Dodonaea angustifolia* L. f.**	Sapindaceae	Kitkita	S	20
46	***Dombeya torrida* (J. F. Gmel.) P. Bamps**	Sterculiaceae	Wulkifa	T	841
47	***Dovyalis abyssinica* (A. Rich.) Warb.**	Flacourtiaceae	Koshim	T	536
48	***Dracaena afromontana* Mildbr.**	Dracaenaceae	Merko	S	892
49	***Dregea schimperi* (Decne.) Bullock**	Asclepiadaceae	Yedikula Kend	C	798
50	*Droguetia iners* (Forssk.) Schweinf.	Urticaceae		H	922
51	***Ehretia cymosa* Thonn.**	Boraginaceae	Game	T	843
52	***Ekebergia capensis* Sparrm.**	Meliaceae	Ilol	T	844
53	***Embelia schimperi* Vatke**	Myrsinaceae	Inkoko	C	505
54	***Epilobium hirsutum* L.**	Onagraceae	Limich	H	845
55	***Erica arborea* L.**	Ericaceae	Asta	S	846
56	***Euclea divinorum* Hiern**	Ebenaceae	Dedeho	T	14
57	***Ficus sur* Forssk.**	Moraceae	Shola	T	822
58	***Galiniera saxifraga* (Hochst.) Bridson**	Rubiaceae	Tota Kula	T	849
59	***Galium aparinoides* Forssk.**	Rubiaceae	Ashkit	H	884
60	***Geranium arabicum* Forssk.**	Geraniaceae		H	883
61	***Gomphocarpus fruticosus* (L.) Ait. F**.	Asclepiadaceae	Ash hareg	H	133
62	*Gouania longispicata* Engl.	Rhamnaceae		H	567

Appendix 1. contd.

No	Scientific name	Family	Local name	Growth form*	Voucher No: ErmiasLX
63	***Guizotia scabra* (Vis.) Chiov.**	Asteraceae	Mech	H	878
64	***Hagenia abyssinica* (Bruce) J.F. Gmel.**	Rosaceae	Koso	T	598
65	***Halleria lucida* L.**	Scrophulariaceae	Mesenqero	T	880
66	***Haplocarpha schimperi* (Sch. Bip.) Beauv.**	Asteraceae	Getim	H	879
67	*Hebenstretia angolensis* Rolfe	Scrophulariaceae		S	921
68	*Helichrysum forsskahlii* (J.F. Gmel.) Hilliard & Burtt	Asteraceae		H	919
69	*Helichrysum schimperi* (Sch. Bip. exA. Rich.) Moeser	Asteraceae		H	913
70	*Helinus mystacinus* (Ait) E. Mey. ex Steud.	Rhamnaceae		H	912
71	*Heteromorpha arborescens* (Spreng.) Cham. & Schlecht.	Apiaceae		H	30
72	*Hibiscus aponeurus* Sprague & Hutch.	Malvaceae		S	911
73	***Hypericum quartinianum* A. Rich.**	Guttiferae	Ameja	S	889
74	***Hypericum revolutum* Vahl**	Guttiferae	Amja	T	872
75	***Hypoestes aristata* (Vahl) Soland.**	Acanthaceae	Telenj	H	599
76	***Hypoestes forskaolii* (Vahl) R. Br.**	Acanthaceae	Tay Beder	H	506
77	*Ilex mitis* (L.) Radlk.	Aquifoliaceae	Misar Genfo	T	430
78	***Impatiens tinctoria* A. Rich.**	Balsaminaceae	Gishrit	H	620
79	*Indigofera spicata* Forssk.	Fabaceae		S	166
80	***Inula confertiflora* A. Rich.****	Asteraceae	Woynagift	S	877
81	***Ipomoea obscura* (L.) ker-Gawl.**	Convolvulaceae		H	876
82	***Jasminium abyssinicum* Hochst.**	Oleaceae	Abita	C	577
83	***Jasminium grandiflorum* L.**	Oleaceae		C	875
84	***Juniperus procera* L.**	Cupressaceae	Yeabesha Tsid	T	874

Appendix 1. contd

No	Scientific name	Family	Local name	Growth form*	Voucher No: ErmiasLX
85	***Kalanchoe petitiana* A. Rich.**	Crassulaceae	Indahula	H	94
86	***Kniphofia foliosa* Hochst.****	Asphodelaceae	Abelbila	S	869
87	***Laggera tomentosa* Sch.-Bip.****	Asteraceae	Keskeso	S	881
88	***Lobelia gibberroa* Hemsl.**	Lobeliaceae	Gibira	S	554
89	*Loxogramme lanceolata* (Sw.) Presl.	Polypodiaceae		S	571
90	***Maesa lanceolata* Forssk.**	Myrsinaceae	Kelewa	T	42
91	***Maytenus arbutifolia* (A. Rich.) Wilczek**	Celastraceae	Atat	T	47
92	***Maytenus undata* (Thunb.) Blakelock**	Celastraceae	Damot woyra	T	868
93	*Merendera schimperiana* Hochst	Colchicaceae		H	910
94	***Microglossa pyrifolia* (Lam.) Kuntze**	Asteraceae		H	144
95	***Momordica foetida* Schumach.**	Cucurbitaceae	Yamora Misa	S	867
96	***Myrica salicifolia* A. Rich.**	Myricaceae		T	866
97	***Myrsine africana* L.**	Myrsinaceae	Kechemo	T	49
98	*Myrsine melanophloeos* (L.) R. Br.	Myrsinaceae	Woyel	T	909
99	***Nuxia congesta* R. Br. ex Fresen.**	Loganiaceae	Askwar	T	897
100	***Ocimum urticifolium* Roth**	Lamiaceae		H	69
101	*Oenanthe palustris* (Chiov.) Norman	Apiaceae	Gudey	H	908
102	*Olea capensis* L. subsp. *macrocarpa* (C.H. Wright) Verdc.	Oleaceae	Wegeda	T	423
103	***Olea europaea* L. subsp. *cuspidata* (Wall. ex G.Don) Cif.**	Oleaceae	Woyra	T	19
104	***Olinia rochetiana* A. Juss.**	Oliniaceae	Tife	T	102
105	*Oplismenus hirtellus* (L.) P. Beauv.	Poaceae	Yeqoq Sar	H	907
106	***Osyris quadripartita* Decn.**	Santalaceae	Keret	T	211

Appendix 1. contd.

No	Scientific name	Family	Local name	Growth form*	Voucher No : ErmiasLX
107	***Pavetta abyssinica* Fresen.**	Rubiaceae	Seged achawach	T	485
108	*Pelargonium glechomoides* Hochst.	Geraniaceae		H	657
109	***Pennisetum sphacelatum* (Nees) Th. Dur. & Schinz**	Poaceae	Seged achawach	H	862
110	***Pentas lanceolata* (Forssk.) Deflers**	Rubiaceae	Yejib Mirkuz	S	213
111	*Peperomia abyssinica* Miq.	Piperaceae		H	444
112	***Periploca linearifolia* Quaart.-Dill. & A. Rich.**	Asclepiadaceae	Imbouayder	C	83
113	***Persicaria senegalensis* (Meisn.) Miyabe**	Polygonaceae	Aluma	H	861
114	*Phagnalon abyssinicum* Sch. Bip. ex A. Rich.	Asteraceae		H	906
115	***Phytolacca dodecandra* L' Herit.**	Phytolaccaceae	Indod	S	243
116	***Plantago lanceolata* L.**	Plantaginaceae	Wusha milas	H	860
117	***Plantago palmata* Hook.f.**	Plantaginaceae	Wusha milas tiliku	H	895
118	*Plectocephalus varians* (A. Rich.) C. Jeff. ex Cuf.	Asteraceae		H	905
119	***Plectranthus lactiflorus* (L.) Agnew**	Lamiaceae	Ayderkush	H	859
120	***Podocarpus falcatus* (Thunb.) Mirb.**	Podocarpaceae	Zigba	T	197
121	***Polyscias fulva* (Hiern) Harms**	Araliaceae	Yezingero wonber	T	823
122	***Premna schimperii* Engl.**	Lamiaceae	Chocho	S	252
123	***Prunus africana* (Hook. f.) Kalkm.**	Rosaceae	Tikur Inchet	T	439
124	*Pteris cretica* L.	Pteridaceae		H	904
125	***Pterolobium stellatum* (Forssk.) Brenan**	Fabaceae	Kontir	S	46
126	***Ranunculus multifidus* Forssk**	Ranunculaceae	Etse siol	H	858
127	***Rhamnus prinoides* L'Herit.**	Rhamnaceae	Gesho	S	607

Appendix 1. contd.

No	Scientific name	Family	Local name	Growth form*	Voucher No: ErmiasLX
128	***Rhus vulgaris* Meikle**	Anacardiaceae	Kimo	T	857
129	***Ricinus communis* L.**	Euphorbiaceae	Gulo	S	33
130	***Rosa abyssinica* Lindley**	Rosaceae	Kega	S	852
131	***Rubus steudneri* Schweinf.**	Rosaceae	Injori	S	242
132	***Rumex nepalensis* Spreng.**	Polygonaceae	Lut	H	24
133	***Scabiosa columbaria* L.**	Dipsacaceae		H	855
134	***Sida schimperiana* Hochst. ex A. Rich.**	Malvaceae	Garda	S	153
135	***Smilax aspera* L.**	Smilacaceae	Ashkla hareg	C	853
136	***Solanecio gigas* (Vatke) C. Jeffrey****	Asteraceae	Dengorita	T	531
137	***Solanum anguivi* Lam.**	Solanaceae	Imbuay	S	565
138	***Solanum marginatum* L.f.**	Solanaceae	Imbuay	S	205
139	*Sonchus aspera* (L.) Hill.	Asteraceae		H	903
140	*Sonchus bipontini* Ascher.	Asteraceae		H	902
141	***Stephania abyssinica* (Dill. & A. Rich.) Walp.**	Menispermaceae	Yeait hareg	H	130
142	*Tagetes minuta* L.	Asteraceae	Zewde Arem	H	901
143	*Teclea nobilis* Del.	Rutaceae	Atesa	T	440
144	***Thalictrum rhynchocarpum* Dill. & Rich.**	Ranunculaceae	Sire bizu	H	535
145	***Thymus schimperi* Ronniger**	Lamiaceae	Tosigne	H	826
146	***Toddalia asiatica* Lam.**	Rutaceae	Gumare	T	97
147	*Torilis arvensis* (Hudson) Link	Apiaceae		H	900
148	***Trichocladus ellipticus* Eckl. & Zeyh.**	Hamamelidaceae	Abil wuha	T	896
149	***Trifolium semipilosum* Fresen.**	Fabaceae		H	825

Appendix 1. contd.

No	Scientific name	Family	Local name	Growth form*	Voucher No ErmiasLX
150	***Triumfetta brachyceras* K. Schum.**	Tiliaceae	Leba Giraf	S	886
151	*Turraea holstii* Gürke	Meliaceae	Shiro Inchet	T	899
152	***Urera hypselodendron* (A. Rich.) Wedd.**	Urticaceae	Lankuso	C	538
153	***Urtica simensis* L. ****	Urticaceae	Sama	H	824
154	*Usnea africana* Motyka	Parmeliaceaea A Lichen		E	898
155	***Verbascum sinaiticum* Benth. in DC.**	Scrophulariaceae	Yeahya Joro	H	852
156	***Vernonia amygdalina* Del.**	Asteraceae	Girawa	T	22
157	***Woodfordia uniflora* (A. Rich.) Koehne**	Lythraceae		S	181
158	***Zehneria scabra* (Linn.f.) Sond.**	Cucurbitaceae	Nech Hareg	C	851

* Growth form T=Tree, S=Shrub, H= Herb, C= Climber, E= Epiphyte

** Endemic species

N:B- Species in **Bold** are used for one or more traditional medicinal uses in the District

Appendix 2. List of medicinal plants used for human ailments: scientific name; family; local name; growth form; ailment treated; plant parts used; condition of plant part uses; methods of preparation and application, route of administration , plant part mixed with and voucher number.

Key: Growth form Tree (T); Shrub (S); Herb (H); Climber (C). Part used (Leaf, L; Root, R; Stem wood, St; Fruit, Fr; Bark, B; Root bark, RB; Stem bark, SB; Flower, Fl; Bulb, Bu; Rhizome, Rh; Latex, Lat). Conditions of part used (CPU) (Dry, D; Fresh, F). Methods of preparation and application (MPAP), 1. Boil and drink the decoction when cool; 2. Grind and paint the powder or crushed part ; 3. Grind, paste the crushed part and tie ; 4. Extract the juice/oil/latex and pour or paint it; 5. Crush, homogenize with cold water and drink; 6. Hold with teeth; 7. Crush, heat/ burn or boil the part and inhale its smoke or steam; 8. Crush and sniff the freshly crushed part; 9. Eat the part; 10. Boil and do steam bath; 11. Drink the concoction; 12. Boil the part and paint the decoction. Route of Administration; (RA) (Oral, O; Dermal, De; Nasal, Na; Optical, Op; Auricular, Au; Anal, An.)

No	Scientific name	Family	Local name	Growth form	Ailment treated (***)	Part used	CPU	MPAP	RA.	PMW	Voucher no ErmiasL X
1	Hochst. ex Benth. subsp.	Fabaceae	Girar	T	Chancroid ( )	R	F/D	1	O		826
2	L.	Amaranthaceae	Telenj	H	Minor bleeding ( )	L	F	3	De		104
					Omphalitis ( )	L	F	3	De		
					Epistaxis ( )	L	F	4	Na		827
3	Del.	Asteraceae		H	Gonorrhoea ( )	Fl&L	F/D	1	O		

						Toothache ( )	Fl	F	6	O		
						Epiglottitis ( )	Fl&L	F	1	O		
						Impotence( )	Fl&L	F	1	O		
						Tonsillitis ( )	Fl	F	1	O		
4		(A.DC.) Schweinf.	Apocynaceae	Merenz	S	Gonorrhoea	R	F	1	O		100
5	L.*		Alliaceae	Nech Shinkurt	H	Herpes zoster ( )	Bu	F	4	De	24	828
						Atopic eczema ( )	Bu	F	4	De		
						Ringworm ( )	Bu	F	4	De		
						Asthma (difficulty in breathing, wheezing and shortness of breath)	Bu	F/D	11	O	91	
						Common cold ( )	Bu	F/D	1	O		

					Dandruff ( )	Bu	F	4	De	
					Pneumonia ( )	Bu	F/D	1	O	
					Coughing ( )	Bu	F/D	11	O	
					Malaria ( )	Bu	F/D	9	O	
6	(Hochst.) Radlk.	Sapindaceae	Imbis	T	Hepatitis ( )	R	F	1	O	829
7	J. Gay ex A. Rich.	Asteraceae		H	Rabies ( )	R	F	1	O	830
					Evil spirit ( )	R	F/D	7	Na	
8	Schott.	Araceae	Amoch	H	Scabies ( )	R	F	2	De	587
					Ringworm	R	F	2	De	
					Skin lesion ( )	R	F	2	De	

9	Lam.	Asparagaceae	Yeset Kest	S	Impotence	R	F/D	1	O		189
					Gonorrhoea	R	F/D	1	O	4	
					Scabies	R	F	2	De		
					Atopic eczema	R	F	2	De		
					Epilepsy ( )	R,L,SB	F/D	7	Na		
					Bone fracture ( )	St	F	3	De		
					Chancroid	R	F	1	O	4	
					Skin lesion	R	F	2	De		
10	(Kunth) mett.	Aspleniaceae		H	Headache	R	F	7	Na		593
					Epilepsy	R, L	F	7	Na		
11	Engl.	Berberidaceae	Yeset Af	H	Hemorrhoids ( )	R	F	4	De	82	831
					Jaundice ( )	R	F	1	O		
12	Fresen.	Melianthaceae	Azamir	T	Diarrhoea ( )	L	F	1	O		173
					Constipation ( )	L	F	1	O		

					Ascariasis ( )	Se	F	1	O	
13	Fresen.	Loganiaceae	Anfar	S	Evil eye ( )	R	F	7	Na	542
14	(Baker) Alston	Rhizophoraceae	Werer	T	Menstrual disorder ( )	SB	F	1	O	832
15	(Ait.) Benth.	Fabaceae	Digita	S	Diarrhoea	R	F	1	O	76
					Constipation	R	F	1	O	
					Scabies	L	F	2	De	
					Toothache	R	F	6	O	
					Ascariasis	L	F	1	O	
					Sore	R	F	4	De	
					Epiglottitis	R	F	1	O	
					Giardiasis ( )	R	F	1	O	
16	L.*	Solanaceae	Mitmita	S	Retained placenta ( )	R	F/D	1	O	204
17	L.*	Caricaceae	Papaya	T	Taeniasis ( )	Se	F	9	O	40
					abdominal Dryness (	Se	F	9	O	

					)						
					Gastritis (						
					)	Se	F	9	O		
					Constipation	se	F	9	O		
18	L.	Apocynaceae	Agam	S	Diarrhoea	R	F	5	O		16
					Constipation	R	F	1	O		
					Taeniasis	R	F/D	5	O		
					Evil spirit	R	F/D	7	Na		
					Headache	L	F	7	Na		
					Snake bite (						
					)	R	F	1	O		
					Rheumatism (						
					)	R	F	1	O		
19	(Vahl) Forssk. ex Endl.*	Celastraceae	Chat	S	Chancroid	R	F/D	1	O		26
					Impotence	R	F/D	1	O		
20	Burm.f.	Ulmaceae	Kewt	T	Evil eye	RB	F	7	Na		833
					Rheumatism	L	F	4	De	44	
					Cystitis (						
21	(L.) Greene	Fabaceae	Yeayt Gomen	H	)	L	F	1	O		834

22	L.	Chenopodiaceae	Gundan Abir	S	Evil eye	L	F	8	Na		4
23	(L.) Burm.f.*	Rutaceae	Lomi	S	Epistaxis	Fr & L	F	4	Na		155
					Minor bleeding	Fr & L	F	4	De		
24	Perr. & Guill.	Ranunculaceae	Azo Hareg	C	Diarrhoea	L	F	5	O		18
					Taeniasis	R	F/D	5	O		
					Constipation	R	F/D	5	O		
					Atopic eczema	L	F	4	De		
					Mumps ( )	L	F	4	Au		
					Ringworm	L	F	4	De		
					Herpes zoster	L	F	4	De	5	
					Otorrhea ( )	L	F	4	Au		
					Conjunctivitis ( )	L	F	4	Op		
					Gastritis	R	F/D	5	O		
					Leishmaniasis ( )	L	F	4	De		
25	Jaub. and Spach.	Euphorbiaceae	Fiyele Fej	S	Bloody diarrhoea	R	F/D	1	O		10
					Taeniasis	R	F/D	1	O		
					Constipation	R	F/D	1	O		
					Fever	L	F	1	O		
					Gastritis	R	F/D	1	O		

					Malaise (feeling of discomfort, fever, loss of appetite)	L	F	1	O	
26	L.*	Rubiaceae	Bunna	S	Chancroid	R	F	1	O	12
27	(Sch. Bip. ex A. Rich.) S. Moore**	Asteraceae		H	Evil spirit	R	F/D	7	Na	835
28	L.	Fabaceae		S	Wound	R	F	3	De	836
29	Del.	Euphorbiaceae	Bisana	T	Tinea versicolor ( )	L	F	4	De	17
					Atopic eczema	L	F	4	De	
					Sore	L	F	2	De	
					Allergic rushes on skin	L	F	4	De	
30	A. Rich.	Cucurbitaceae	Yemdr Imbuay	H	Evil spirit	L	F/D	7	Na	68
					Rabies	Fr	F	1	O	
31	L.*	Cucurbitaceae	Duba	H	Hepatitis	Se	F/D	1	O	96
32	Moq.	Amaranthaceae	Yedem Abnet	H	Epistaxis	L	F	4	Na	837
					Minor bleeding	L	F	3	De	
33	(DC ex Nees) Stapf*	Poaceae	Tej Sar	H	Chicken pox ( )	L	F/D	10	De	838
34	Hochst.	Boraginaceae	Chegogot	H	Fever	R, L	F	1	O	66
					Malaise	R, L	F	1	O	
35	Vahl	Cyperaceae	Ingicha	H	Jaundice	R	F	5	O	839

36	L.	Solanaceae	Astenagir	S	Dandruff	L	F	2	De		241
					Atopic eczema	L	F	2	De		
					Skin lesion	L	F	2	De		
37	(V ahl) DC.	Fabaceae		H	Epilepsy	R	F/D	7	Na		840
38	(Willd.) DC.	Fabaceae		H	Snake bite	R	F	1	O		11
39	Hochst.	Solanaceae	Ameraro	S	Snake bite	R	F	1	O		606
40	L. f.	Sapindaceae	Kitkita	S	Diarrhoea	R	F	1	O		20
					Taeniasis	R	F/D	1	O		
					Constipation	R	F/D	1	O		
					Ringworm	R	F	2	De		
					Skin lesion	R	F	2	De		
					Sore	L	F	3	De		
41	(J. F. Gmel.) P. Bamps	Sterculiaceae	Wulkifa	T	Snake bite	R	F	1	O		841
42	(A. Rich.) Warb.	Flacourtiaceae	Koshim	S	Menstrual disorder	R	F/D	1	O		536
43	Engl.	Dracenaceae	Itse Patos	T	Hepatitis	R	F/D	1	O		426
44	(Dec.) Bull.	Asclepiadaceae		C	Rheumatism	R	F	4	De	20	798
					Gout ( )	R	F	4	De		
45	Mesfin**	Asteraceae	Kebericho	S	Evil eye	R	F/D	7	Na		842
					Evil spirit	R	F/D	7	Na		
					Malaise	R	F	1	O		
					Fever	R	F	1	O		
46	Thonn.	Boraginaceae	Game	T	Retained placenta	R	F	1	O		843
47	Sparrm.	Meliaceae	Ilol	T	Menstrual	SB	F/D	1	O		844

					disorder					
48	Vatke	Myrsinaceae	Inkoko	T	Diarrhoea	Fr	F/D	5	O	505
					Taeniasis	Fr	F/D	5	O	
					Constipation	Fr	F/D	5	O	
					Ascariasis	Fr	F/D	5	O	
49	L.	Onagraceae	Limich	H	Chicken pox	R	F	4	De	845
50	L.	Ericaceae	Asta	S	Lymphadenopathy ( )	R	F	1	O	846
51	Schwinef.**	Fabaceae	Korch	T	Stabbing pain ( )	R	F	1	O	247
52	Labill.	Myrtaceae	Bahir Zaf	T	Common cold	L	F	7	Na	847
					Coughing	L	F	7	Na	
					Pneumonia	L	F	7	Na	
					Gout	L	F	10	De	
					Headache	L	F	7	Na	
53	Hiern	Ebenaceae	Dedeho	T	Gonorrhoea	R	F/D	1	O	14
					Pyelonephritis ( )	SB	F	1	O	
					Impotence	R	F/D	1	O	
					Malaise	R	F	10	De	
					Fever	R	F	10	De	
					Chancroid	R	F/D	1	O	
54	Forssk.	Moraceae	Shola	T	Impotence	R	F	4	De	822
55	Miller*	Apiaceae	Insilal	H	Epistaxis	L	F	4	Na	848
					Lymphadenopathy	L	F	4	De	

56	(Hochst.) Bridson	Rubiaceae	Tota Kula	T	Pyelonephritis	R	F	1	O		849
					Gonorrhoea	R	F/D	1	O		
57	Forssk.	Rubiaceae	Ashkit	H	Lymphadenopathy	R	F	1	O		884
58	Forssk.	Geraniaceae		H	Evil eye	R	F	1	O		883
59	(L.) Ait. F.	Asclepiadaceae	Ash Hareg	C	Gout	R	F	1	O	66	133
60	Cass*	Asteraceae	Noug	H	Common Cold	Se	F/D	1	O		882
					Asthma	Se	F/D	1	O		
					Coughing	Se	F/D	1	O		
61	(Vis.) Chiov.	Asteraceae	Mech	H	Conjunctivitis	Fl	F	4	Op		878
					Mumps	Fl	F	4	Au		
62	(Bruce) J.F. Gmel.	Rosaceae	Koso	T	Taeniasis	Fl	F/D	5	O		598
					Ascariasis Amoebiasis (	Fl	F/D	5	O		
					)	Fl	F/D	5	O		
					Constipation	Fl	F/D	5	O		
63	L.	Scrophulariaceae	Mesenqero	T	Evil eye	R	F	7	Na		880
64	(Sch. Bip.) Beauv.	Asteraceae	Getim	H	Hemorrhoids	R	F	4	An		879
					Lymphadenopathy	R	F	4	De		
65	(Spreng.) Cham. & Schlecht.	Apiaceae		H	Evil spirit	R	F/D	7	Na		30
66	Vahl	Guttiferae	Amja	T	Otorrhea	Fl	F	4	Au		872
					Mumps	Fl	F	4	Au		
67	(Vahl) Soland.	Acanthaceae	Telenj	H	Gout	L	F	12	De		599
					Headache Anaemia (	R	F/D	7	Na		
68	(Vahl) R. Br.	Acanthaceae	Tay Beder	H		L	F	1	O		506

					)						
69	A. Rich.	Balsaminaceae	Gishrit	H	Gout	R	F	12	De		620
					Rheumatism	R	F	12	De		
					Dandruff	R	F	12	De		
					Tinea versicolor	R	F	12	De		
					Skin infection	R	F	12	De		
70	A. Rich.**	Asteraceae	Woynagift	S	Leprosy ( )	Fl	F	4	De		877
					Asthma	L	F	1	O	5	
					Common cold	L	F	1	O		
					Coughing	L	F	1	O		
71	(L.) ker-Gawl.	Convolvulaceae		H	Hemorrhoids	L	F	2	An		876
72	Hochst.	Oleaceae	Abita	c	Bloody diarrhoea	L	F	1	O		577
					Taeniasis	L	F	5	O		
					Gastritis	L	F	5	O		
					Constipation	Fl	F	5	O		
					Wound	R	F	12	De		
73	L.	Oleaceae		C	Hemorrhoids	Fl	F	2	An	76, 99	875
					Jaundice	Fl	F	1	O		
					Mumps	L	F	4	Au		
					Conjunctivitis	L	F	4	Op		
74	L.	Cupressaceae	Yeabesha Tsid	T	Evil spirit	R	F/D	7	Na		874
75	(Hochst. ex Nees) T. Anders.	Acanthaceae	Sensel	S	Epiglottitis	R	F	1	O		506
					Tonsillitis	R	F	1	O		

76	A. Rich.	Crassulaceae	Indahula	H	Hemorrhoids	L	F	2	An	73,99	94
					Bone fracture	L	F	4	De		
77	Hochst.**	Asphodelaceae	Abelbila	S	Evil spirit	R	D	7	Na		869
78	Sch.-Bip.**	Asteraceae	Keskeso	S	Hemorrhoids	R	F	2	An		881
79	(Burm.f.) Iwarsson	Lamiaceae	Ras Kimir	S	Nausea	L	F	5	O		871
80	L.*	Brassicaceae	Feto	H	Malaise	Se	F/D	1	O		870
					Tonsillitis	Se	F/D	5	O		
					Gingivitis ( )	Se	F/D	6	O		
					Fever	Se	F/D	1	O		
					Malaise	Se	F/D	2	De		
					Epiglottitis	Se	F/D	1	O		
					Wound	Se	F/D	3	De		
81	L.*	Linaceae	Telba	H	Retained placenta	Se	F/D	5	O		873
82	Hemsl.	Lobeliaceae	Gibira	S	Topical ulcer ( )	Lat	F	4	De	11	554
					Tinea versicolor	Lat	F	4	De		
					Skin lesion	Lat	F	4	De		
83	Forssk.	Myrsinaceae	Kelewa	S	Diarrhoea	L	F	1	O		42
					Constipation	R	F/D	1	O		
					Taeniasis	Fr	F	5	O		
84	(A. Rich.) Wilczek	Celastraceae	Atat	T	Lymphadenopathy	R	F	1	O		47
85	(Thunb.) Blakelock	Celastraceae	Damot woyra	T	Headache	R	F	7	Na		868
86	(Lam.) Kuntze	Asteraceae		H	Menstrual disorder	L	F	1	O		144
87	Schumach.	Cucurbitaceae	Yamora	S	Constipation	R	F	1	O		867

			Misa								
					Malaise	R, L	F	10	De		
					Gastritis	R	F	1	O		
					Taeniasis	Fr	F/D	1	O		
					Fever	R, L	F	10	De		
					Ascariasis	Fr	F/D	5	O		
88	A. Rich.	Myricaceae		S	Vomiting and Nausea	R	F	1	O		866
89	L.	Myrsinaceae	Kechemo	T	Diabetes mellitus ( )	Fr	F	5	O		49
90	L. *	Solanaceae	Timbaho	S	Epilepsy	R, L	F	8	Na		246
91	L.*	Ranunculaceae	Tikur Azmud	H	Asthma	Se	F/D	11	O	5	865
92	Hochst.*	Lamiaceae	Dama kesse	H	Malaise	L	F	5	O		864
					Otorrhea	L	F	4	Au		
					Conjunctivitis	L	F	4	Op		
					Fever	L	F	12	De		
93	Roth	Lamiaceae	Dama kesse	H	Headache	L	F	5	O		69
94	L. subsp. (Wall. ex G.Don) Cif.	Oleaceae	Woyra	T	Leprosy	Fr	F	4	De		19
					Atopic eczema	Fr	F	4	De		
					Mumps	Fr	F	4	Au		
					Tonsillitis	Fr	F	4	O		
					Ringworm	St & L	F	4	De		

					Tinea versicolor	St & L	F	4	De		
					Otorrhea	Fr	F	4	Au		
					Toothache	St	F	6	O		
95	A. Juss.	Oliniaceae	Tife	T	Diarrhoea	R	D	1	O		102
					Constipation	R	D	1	O		
					Epilepsy	R	F/D	7	Na		
96	(L.) Miller	Cactaceae	Beles	S	Cystitis	St	F	1	O		863
97	Decn.	Santalaceae	Keret	S	Topical ulcer	R	F	2	De		211
					Tinea versicolor	R	F	2	De		
98	(Nees) Th. Dur. & Schinz	Poaceae	Seged achawach	H	Gout	L	F	12	De		862
99	Quaart.-Dill. & A. Rich.	Asclepiadaceae	Imbouayder	C	Hemorrhoids	R	F	4	An	73, 76	83
					Hemorrage ( )	R	F	3	De		
100	(Meisn.) Miyabe	Polygonaceae	Aluma	H	Jaundice	L	F	1	O		861
101	L' Herit.	Phytolaccaceae	Indod	S	Gonorrhoea	R	D	1	O		243
					Syphilis ( )	R	D	1	O		
					Pyelonephritis	R	D	1	O		
102	L.	Plantaginaceae	Wusha milas	H	Hemorrage	L	F	3	De		860
103	(L.) Agnew	Lamiaceae	Ayderkush	H	Rabies	L	F/D	11	O	101	859
					Menstrual disorder	R, L	F	12	De		
104	(Thunb.) Mirb.	Podocarpaceae	Zigba	T	Evil spirit	R	D	7	Na		197
					Bone fracture	R	F	3	De	131	

105	Engl.	Lamiaceae	Chocho	S	Evil spirit	R	F/D	7	Na	202
106	(Hook. f.) Kalkm.	Rosaceae	Tikur Inchet	T	Syphilis	RB	F	1	O	439
					Gonorrhoea	RB	F	1	O	
107	(Forssk.) Brenan	Fabaceae	Kontir	S	Evil eye	R	F	7	Na	46
108	Forssk	Ranunculaceae	Etse siol	H	Hemorrhoids	R	F	2	An	858
					Snake bite	R	F/D	5	O	
					Lymphadenopathy	R	F	4	De	
					Jaundice	R	F/D	5	O	
					Wound	L	F	3	De	
109	L'Herit.*	Rhamnaceae	Gesho	S	Epiglottitis	L	F	4	O	607
					Tonsillitis	L	F	4	O	
110	Meikle	Anacardiaceae	Kimo	T	Retained placenta	R	F	1	O	857
111	L.*	Euphorbiaceae	Gulo	S	Hemorrhoids	Fr	F	4	An	33
					Rheumatism	Fr	F	12	De	
112	Lindley	Rosaceae	Kega	S	Jaundice	R	F	1	O	856
					Constipation	R	F	1	O	
113	Schweinf.	Rosaceae	Injori	S	Diarrhoea	R	F	5	O	242
					Gastritis	R	F	5	O	
					Constipation	R	F/D	5	O	
114	Spreng.	Polygonaceae	Lut	H	Diarrhoea	R	F/D	1	O	24
					Constipation	R	F/D	1	O	
115	L.*	Rutaceae	Tena adam	S	Common Cold	Fr & L	F	1	O	37
116	L.	Dipsacaceae		H	Stabbing pain	R, L	F	1	O	855
117	Hochst. ex A. Rich.	Malvaceae	Garda	S	Fever	R	F	1	O	153
118	steud ex. Rich	Caryophyllaceae	Wegert	H	Headache	R	F/D	7	Na	854
					Evil eye	R	F/D	7	Na	

					Chancroid	R	F	1	O	
					Impotence	R	F	1	O	
					Gonorrhoea	R	F	1	O	
119	L.	Smilacaceae	Ashkla hareg	C	Nausea	Fr	F	5	O	853
					Hepatitis	Fr	F	5	O	
120	(Vatke) C. Jeffrey**	Asteraceae	Dengorita	T	Evil spirit	R	F	7	Na	531
121	Lam.	Solanaceae	Imbuay	S	Scabies	Fr	F	4	De	565
					Dandruff	Fr	F	4	De	
					Atopic eczema	Fr	F	4	De	
122	L.f.	Solanaceae	Imbuay	S	Rabies	R	D	1	O	205
123	(Dill. & A. Rich.) Walp.	Menispermaceae	Yeait hareg	H	Evil eye	R	F	7	Na	130
					Malaise	R	F	1	O	
124	Dill. & Rich.	Ranunculaceae	Sire bizu	H	Diarrhoea	R	F	5	O	535
					Taeniasis	R	F/D	5	O	
					Mumps	R	F	4	Au	
					Ascariasis	R	F/D	5	O	
					Constipation	R	F/D	5	O	
					Otorrhea	R	F	4	Au	
125	Ronniger	Lamiaceae	Tosigne	H	Hypertension	L	F	1	O	826
126	Lam.	Rutaceae	Gumare	T	Hepatitis	Fl	F	1	O	97
127	Fresen.	Fabaceae		H	Hepatitis	R	F/D	5	O	825
128	(A. Rich.) Wedd.	Urticaceae	Lankuso	C	Chancroid	R, L	F	1	O	538
					Cystitis	R	F/D	5	O	
129	L.**	Urticaceae	Sama	H	Chicken pox	L	D	9	De	824
130	Benth. in DC.	Scrophulariaceae	Yeahya Joro	H	Diarrhoea	L	F	1	O	852
					Constipation	R	F/D	5	O	

131	Del.	Asteraceae	Girawa	T	Diarrhoea	L	F	1	O	22
					Taeniasis	L	F	5	O	
					Ascariasis	L	F	5	O	
132	(L.) Dun	Solanaceae	Gizawa	S	Headache	R	F/D	7	Na	206
					Evil eye	R	F/D	7	Na	
					Gonorrhoea	R	F	1	O	
					Syphilis	R	F	1	O	
					Malaise	R	F/D	7	Na	
					Fever	R	F	7	Na	
133	(A. Rich.) Koehne	Lythraceae		S	Evil spirit	R	F	1	Na	181
134	(Linn.f.) Sond.	Cucurbitaceae	Nech Hareg	C	Diarrhoea	L	F	5	O	851
					Malaise	R,L,St	F	10	De	
					Mumps	R	F	4	Au	
					Fever	R,L,St	F	10	De	
					Taeniasis	L	F	5	O	
					Constipation	R	F/D	5	O	
					Conjunctivitis	L	F	4	Op	
135	Roscoe*	Zingiberaceae	Zingibil	H	Common Cold	Rh	F/D	1	O	850
					Constipation	Rh	F/D	1	O	
					Coughing	Rh	F/D	1	O	
					Diarrhoea	Rh	F/D	5	O	
					Asthma	Rh	F/D	1	O	

Key *Cultivated medicinal plant species ** Endemic species *** ailments *traditional interpretation indicated within brackets*

Appendix 3. List of ethnoveterinary medicinal plants used for treatment of livestock ailments**:** scientific name; family; local name; growth form; ailment treated; plant parts used; condition of plant part uses; methods of preparation and application, route of administration , plant part mixed with and voucher number.

Key: Growth form Tree (T); Shrub (S); Herb (H); Climber (C). Part used (Leaf, L; Root, R; Stem wood, St; Fruit, Fr; Bark, B; Root bark, RB; Stem bark, SB; Flower, Fl; Bulb, Bu; Rhizome, Rh; Latex, Lat). Conditions of part used (CPU) (Dry, D; Fresh, F). Methods of preparation and application (MPAP), 1. Boil, keep to cool for some time and let the animal drink the decoction; 2. Grind and cover surface of diseased parts with the powder; 3. Grind and paste the crushed part 4. Extract the juice/oil/latex and pour or paint it; 5. Pound, homogenize with cold water and allow the animal to drink it or pour it on infected part. Route of Administration; (RA) (Oral, O; Dermal, De; Nasal, Na; Optical, Op)

Scientific name	**Family**	**Local (Amharic) name**	**Growth form**	**Ailment treated (*Traditional interpretation****)**	**Part used**	**CPU**	**MP AP**	**RA**	**Part Mixed With**	**Voucher No ErmiasLX**
Achyranthes aspera L.	Amaranthaceae	Telenj	H	Nasal infection (*sore on/in nasal cavity*)	R	F	5	Na		104
				Ophthalmic infection (*redness of eye or sore around eye lids*)	L	F	4	Op		
				Minor bleeding (*bleeding due to minor injuries*)	L	F	3	De		
Aeonium leucoblepharum Webb ex A. Richard	Crassulaceae	Yefeyel Dabo	H	Sore	L	F	2	De		885
				Retained placenta/fetal membrane(*part of placenta remained in womb*)	L	F	5	O		
Allium sativum L*.	Alliaceae	Nech Shinkurt	H	Blackleg (*lame acttle with a swelling muscle, blood stained discharge from mouth, anus and nostril*)	BU	F/D	5	O	8, 11	828

				Dermatophilosis (*pyramidal shaped crust on skin with lesion*)	BU	F/D	2	De		
				Mange (*itching bald lesions on legs and body of diseased animal, loss of hair*)	BU	F/D	2	De		
				Scabies (	BU	F/D	2	De		
				Ringworm (	BU	F/D	2	De		
				Parasitic leech (*infestation of a cattle by leeches from ponds or rivers*)	BU	F/D	5	Na		
				Lice infestation in chicken (*Infestation of chicken by many lice*)	BU	F	4	De		
				Helminthiasis (*passing of worms with stool/dung*)	L	F	5	O		
Apodytes dimidiata E.Mey.ex Arn	Icacinaceae	Yetemenja Inchet/Donga	T	Rabies ( )	SB	F	5	O	5	887
				African horse sickness (*swelling of eyes and/or head, discharge from nose*)	SB	F	5	O		
Asparagus africanus Lam.	Asparagaceae	Seritie	S	Coccidiosis (*watery feaces with clots of blood*)	R	F	1	O	7	189

Calotropis procera (Ait.) Aitf	Asclepiadaceae	Kimbo	S	Mange	R	F	4	De			894
Calpurnia aurea (Ait.) Benth.	Fabaceae	Digita	S	Tick infestation	L	F	4	De			76
				Helminthiasis	L	F	5	O			
				Snake bite( )	R	F	5	O	3, 11		
				Sore	L	F/D	3	De			
				Parasitic leech	RB	F/D	5	Na			
Carissa spinarum L.	Apocynaceae	Agam	S	Helminthiasis	R	F	4	O			16
				Parasitic leech	L	F	4	De			
Cissampelos mucronata A. Rich.	Menispermaceae	Ingochit hareg	C	Cowdriosis (*head pressing, coughing, nasal discharge*)	P	F	5	O		14	888
				CBPP (*dry cough and heavy nasal discharge, loss of appetite*)	P	F	5	O		40	
Clematis hirsuta Perr. & Guill.	Ranunculaceae	Azo hareg	C	Blackleg	R	F	5	O	3, 8		18
				Pleuropneumoniasis (*cough and nasal discharge)*	L	F	5	O			
Clutia abyssinica Jaub. & Spach	Euphorbiaceae	Feyele Fej	S	Bloody diarrhoea	L	F	5	O			10
				Nasal infection	R	F	5	O			
				Ophthalmic infection	L	F	4	O			
				Mucal diarrhoea	R	F	5	O			
				Bloat (distended left abdomen and no longer grazing)	L	F	5	O			
Croton macrostachyus Del.	Euphorbiaceae	Bisana	T	Ringworm	L	F	4	O			17
				Dermatophilosis	L	F	4	O			

				Mange	L	F	4	O		
				Scabies	L	F	4	O		
				Wound	L	F	4	O		
				Minor bleeding	L	F	3	O		
				Sore	L	F/D	3	O		
Cucumis ficifolius A. Rich.	Cucurbitaceae	Yemdr Imbuay	H	Coccidiosis	Fr, R	F/D	1	O		68
				Cowdriosis	R	F	5	O	3	
				Hepatitis	Fr	F/D	5	O		
				Wound	L&R	F	3	O		
Debregeasia saeneb (Forssk.) Hepper & Wood	Urticaceae	Wenz admek	S	Mange	R	F	2	O		890
				Lumpy skin disease (*fever, nodules on skin, enlarged glands, and emaciation*)	R	F	2	O		
				Scabies	R	F	2	O		
Discopodium penninervium Hochst.	Solanaceae	Ameraro	S	Blackleg	L	F	5	O		606
				Wound	L	F	2	O		
				Minor bleeding	L	F	3	O		
Dodonaea angustifolia L. f.	Sapindaceae	Kitkita	S	Bloat	RB	F/D	5	O		20
				Sudden diarrhoea	R	F	5	O		
				Ringworm	R	F	2	O		
				Scabies	R	F	2	O		
Dracaena afromontana Mildbr.	Dracaenaceae	Merko	S	Blackleg	R	F	5	O		892
				Scabies	R	F	2	O		
				Dermatophilosis	R	F	4	O		
Dregea schimperi (Decne.) Bullock	Asclepiadaceae	Yedikula Kend	C	Snake bite	R	F	5	O		798
				Wound	L	F	4	O		

Embelia schimperi Vatke	Myrsinaceae	Inkoko	C	Bloat	Fr	F/D	5	O		505
				Mucal diarrhoea	Fr	F	5	O		
				Bloody diarrhoea	Fr	F/D	5	O	4	
Gomphocarpus fruticosus (L.) Ait. F.	Asclepiadaceae	Ashkla Hareg	H	Bloat	P	F	5	O	51	133
				Poor appetite	R	F	5	O		
				Sudden diarrhoea	Fr, R	F/D	5	O		
Hypericum quartinianum A. Rich.	Guttiferae	Ameja	S	Snake bite	R	F	5	O		889
				Minor bleeding	R	F	4	O		
Hypoestes aristata (Vahl.) Soland.	Acanthaceae	Telenj	H	Wound	L	F	3	O		599
				Minor bleeding	L	F	3	O		
Inula confertiflora A. Rich.**	Asteraceae	Woynagift	S	Lumpy skin disease	L	F	5	O		877
				Mange	R	F	4	O		
				Ringworm	R	F	4	O		
Juniperus procera L.	Cupressaceae	Yeabesha Tsid	T	Retained placenta/fetal membrane	R	F	5	O		874
Leonotis ocymifolia (Burm.f.) Iwarsson	Lamiaceae	Ras Kimir	S	Anthrax (*fever, lack of rumination, difficulty of breathing and uncoordinated movement*)	R	F	5	O	26, 27	871
				Blackleg	L	F	5	O		
Maesa lanceolata Forssk.	Myrsinaceae	Kelewa	S	Mange	Fr	F	4	O		42
				Tick infestation	L	F	4	O		
				Dermatophilosis	Fr	F	2	O		
				Helminthiasis	Fr	F	5	O		
				Parasitic Leech	Fr	F	5	O		
Nuxia congesta R. Br. ex Fresen.	Loganiaceae	Askwar	T	Calf pneumonia	L	F	5	O		897

				Cowdriosis	SB	F	5	O		
				CBPP	SB	F	5	O	9	
Ocimum lamiifolium Hochst.*	Lamiaceae	Dama Kessie	S	Bloat	L	F	5	O		864
				Mucal diarrhoea	L	F	5	O		
				Poor appetite	L	F	5	O		
				Bloody diarrhoea	L	F	5	O		
Olea europaea L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	Oleaceae	Woyra	T	Mange	St	F	4	O	21, 41	19
				Ringworm	R	F	2	O		
				Lumpy skin disease	R	F	2	O		
Pavetta abyssinica Fresen.	Rubiaceae	Seged achawach	S	Blackleg	SB	F	5	O		485
				Broken limb in calf	SB	F	3	O		
Pentas lanceolata (Forssk.) Deflers.	Rubiaceae	Yejib Mirkuz	S	Anthrax	R	F	5	O	30	213
Phytolacca dodecandra L' Herit.	Phytolaccaceae	Indod	S	Parasitic Leech	L	F	5	O		243
				Mange	R	F	2	O		
				Helminthiasis	R	F	5	O		
				Lice infestation in chicken	L	F	4	O		
				Lumpy skin disease	R	F	2	O		
Plantago lanceolata L.	Plantaginaceae	Wusha milas tinishu	H	Rabies	R	F	5	O		860
Plantago palmata Hook.f.	Plantaginaceae	Wusha milas tiliku	H	Rabies	R	F	5	O		895
Podocarpus falcatus (Thunb.) Mirb.	Podocarpaceae	Zigba	T	Ringworm	SB	F	2	O		197
				Mange	SB	F	2	O		
Polyscias fulva (Hiern) Harms	Araliaceae	Yezingero wonber	T	Minor bleeding	L	F	2	O		823
Ranunculus multifidus Forssk.	Ranunculaceae		H	Dermatophilosis	R	F	4	O		858

Ricinus communis L.	Euphorbiaceae	Gulo	S	Mange	Fr	F	4	O	21,33	33
				Scabies	Fr	F	4	O		
				Ringworm	Fr	F	4	O		
				Retained placenta/fetal membrane	R	F	5	O		
Rubus steudneri Schweinf.	Rosaceae	Amoch	S	Bloat	LT	F	5	O		242
				Mucal diarrhoea	R	F	5	O		
				Bloody diarrhoea	R	F	5	O	32	
				Blackleg	R	F/D	5	O		
*Senecio myriocephalus Sch. Bip. exA. Rich.***	Asteraceae	Sibut	S	Pasteurellosis (*lowered head and ears, depression, high fever and nasa discharge*)	R	F	5	O		891
Sida schimperiana Hochst. ex A. Rich.	Malvaceae	Garda	S	African horse sickness	R	F	5	O		153
Smilax aspera L.	Smilacaceae	Ashkla hareg	C	Snake bite	L	F	5	O		853
Solanecio gigas (Vatke) C. Jeffrey**	Asteraceae	Dengorita	T	Hepatitis	L	F	5	O		531
Stephania abyssinica (Dill. & A. Rich.) Walp.	Menispermaceae	Yeait hareg	H	CBPP	L	F	5	O		130
				Calf pneumonia	L	F	5	O		
Tephrosia interrupta Hochst. & Steud ex Engl.	Fabaceae	Gerengere	S	Coccidiosis	R	F	1	O	30	893
Thalictrum rhynchocarpum Dill. & Rich.	Ranunculaceae	Sire bizu	H	African horse sickness	R	F	5	O		535
Trichocladus ellipticus Eckl. & Zeyh.	Hamamelidaceae	Abil wuha	T	Ophthalmic infection	L	F	4	O		896
				African horse sickness	R	F	5	O		
Triumfetta brachyceras K. Schum.	Tiliaceae	Leba Giraf	S	Ringworm	R	F/D	2	O		886
				Dermatophilosis	R	F	2	O		
Vernonia amygdalina Del.	Asteraceae	Girawa	T	Retained placenta/fetal membrane	R	F	5	O		22

				CBPP	L	F	5	O		
Withania somnifera (L.) Dun.	Solanaceae	Gizewa	S	Blackleg	R	F/D	5	O		206
Zingiber officinale Roscoe*	Zingiberaceae	Zingibil	H	Bloat	Rh	F/D	5	O		
				Bloody diarrhoea	Rh	F/D	5	O	22	850
				Poor appetite	Rh	F/D	5	O		
				Mucal diarrhoea	Rh	F/D	5	O		

*Cultivated **Endemicspecies *** *ailments traditional interpretation indicated within brackets*

Appendix 4. Ethnobotanical data on medicinal plants selected for antimicrobial tests

Scientific name	**Family**	**Part used**	**Extract yield (%)**	**Locally used in the study area to treat**	**Ethnomedicinal use reports from other regions in Ethiopia**
Bersama abyssinica	Melianthaceae	leaves and twigs	33.50	diarrhoea, constipation	ascariasis (Ermias Lulekal *et al*., 2008a), febrile illness (Fisseha Mesfin *et al*., 2009)
Calpurnia aurea	Fabaceae	root	19.50	diarrhoea, toothache, epiglottis and wound	fungal infection (Tigist Wondimu *et al*., 2007), dysentery (Tilahun Teklehaymanot and Mirutse Giday, 2007), amoebiasis (Mirutse Giday *et al*., 2009), ophthalmia (HaileYineger *et al*., 2008a)
Carissa spinarum	Apocynaceae	root	14.50	constipation, rheumatism, headache, evil spirit	gingivitis (Dawit Abebe, 1986), bleeding (Mirutse Giday *et al*., 2007), nasal infection (Haile Yineger *et al*, 2008a)
Clematis hirsuta	Ranunculaceae	leaves	30.00	eczema, mumps, ringworm, diarrhoea	wound (Mirutse Giday *et al*., 2007), otorrhea (Haile Yineger *et al*, 2008a)
Clutia abyssinica	Euphorbiaceae	root	9.50	bloody diarrhoea, gastritis, constipation	skin infection, diarrhoea (Ermias Lulekal *et al*., 2008a)

Appendix 4. contd.

Scientific name	**Family**	**Part used**	**Extract yield (%)**	**Locally used in the study area to treat**	**Ethnomedicinal reports from other regions in Ethiopia**
Croton macrostachyus	Euphorbiaceae	leaves and twigs	21.00	Tinea versicolor, diarrhoea, eczema, allergic rushes	athlete's foot (Dawit Abebe, 1986), eczema (Teferi Gedif and Hahn, 2003), diarrhoea, allergies (Haile Yineger *et al*., 2008a), gonorrhoea (Mirutse Giday *et al*., 2007)
Cyathula cylindrica	Amaranthaceae	roots	14.00	epistaxis, minor bleeding	rabies (Bussmann *et al*., 2011)
Dodonaea angustifolia	Sapindaceae	leaves	28.50	skin lesion, ringworm, diarrhoea, constipation	haemorrohids and sore (Ermias Lulekal *et al*., 2008a), allergies (Haile Yineger *et al*., 2008a), malaria (Mirutse Giday *et al*., 2007)
Embelia schimperi	Myrsinaceae	seeds/fruit	25.50	taeniasis, diarrhoea, ascariasis, constipation	tape worm (Mirutse Giday *et al*., 2007, Teferi Gedif and Hahn, 2003), leprosy (Fisseha Mesfin *et al*., 2009)
		leaves and twigs	38.50		
Jasminum abyssinicum	Oleaceae	leaves	7.00	bloody diarrhoea, gastritis and constipation	tonsillitis (Amare Getahun, 1976), skin infection (Mesfin Goji *et al*., 2006)
Maesa lanceolata	Myrsinaceae	leaves and twigs	27.15	diarrhoea and constipation	skin infection (Ermias Lulekal *et al*., 2008a)
Olinia rochetiana	Oliniaceae	leaves	38.00	eczema, diarrhoea	stabbing pain (Dawit Abebe, 1986)

Appendix 4. contd.

Scientific name	Family	Part used	Extract yield (%)	Locally used in the study area to treat	Ethnobotanical reports from other regions in Ethiopia
Ocimum lamiifolium	Lamiaceae	leaves	11.5	malaise, otorrhea and eye infection	malaise (Mirutse Giday *et al*., 2009; Tsige Gebre-Mariam *et al*., 2006), sore (Tilahun Teklehaymanot and Mirutse Giday, 2007), bloody diarrhoea (Teferi Gedif and Hahn, 2003)
Rubus steudneri	Rosaceae	roots	32.82	gastritis, diarrhoea and constipation	headache (Ermias Lulekal *et al*., 2008a), rheumatism (Haile Yineger *et al*., 2008a)
		leaves and twigs	23.00		
Rumex nepalensis	Polygonaceae	roots	19.25	constipation, bloody diarrhoea	diarrhoea (Ermias Lulekal *et al*., 2008a; Mirutse Giday *et al*, 2009), wound (Mirutse Giday *et al*., 2007; Fisseha Mesfin *et al*., 2009), tonsillitis (Dawit Abebe, 1986), amoebiasis (Teferi Gedif and Hahn, 2003)
		leaves and twigs	8.11		
Thalictrum rhynchocarpum	Ranunculaceae	roots	17.50	mumps, ottorhea, ascariasis	stabbing pain (Ermias Lulekal *et al*., 2008a), eczema (Haile Yineger *et al*., 2008a)
Verbascum sinaiticum	Scrophulariaceae	leaves	44.50	diarrhoea and constipation	sore (Tilahun Teklehaymanot and Mirutse Giday, 2007), diarrhoea (Dawit Abebe, 1986)
Vernonia amygdalina	Asteraceae	flowers	18.75	taeniasis, ascariasis, constipation	skin rash (Teferi Gedif and Hahn, 2003) malaise (Mirutse Giday *et al*., 2009), purgative (Amare Getahun, 1976), tonsillitis (Tilahun Teklehaymanot and Mirutse Giday, 2007), ascariasis (Mirutse Giday *et al*., 2007)
		leaves and twigs	17.5		
Zehneria scabra	Cucurbitaceae	leaves and twigs	16.9	malaise, common cold, coughing	malaise (Dawit Abebe, 1986; Tilahun Teklehaymanot and Mirutse Giday, 2007), malaria (Mirutse Giday *et al*., 2007), diarrhoea (Teferi Gedif and Hahn, 2003)

Appendix 5. Density of trees and shrubs with DBH > 2 cm, 10 cm and 20 cm in Dense Forest

	DBH > 2 cm		**DBH > 10 cm**		**DBH > 20 cm**	
Species	*Individuals/ha*	%	*Individuals/ha*	%	*Individuals/ha*	%
Acacia abyssinica Hochst. ex Benth. subsp. *abyssinica*	0.22	5.00	0.22	6.00	0.22	8.00
Acokanthera schimperi (A.DC.) Schweinf.	0.44	9.00	0.44	0.11	0.22	8.00
Allophylus abyssinicus (Hochst.) Radlk.	42.48	8.89	40.74	10.31	38.56	14.56
Apodytes dimidiata E.Mey.ex Arn	0.22	5.00	0.00	0.00	0.00	0.00
Bersama abyssinica Fresen.	47.06	9.84	37.04	9.37	19.17	7.24
Cassipourea malosana (Baker) Alston	0.65	0.14	0.65	0.17	0.65	0.25
Celtis africana Burm.f.	1.96	0.41	1.96	0.50	1.74	0.66
Croton macrostachyus Del.	4.58	0.96	4.14	1.05	1.53	0.58
Discopodium penninervium Hochst.	29.63	6.20	18.95	4.80	4.58	1.73
Dombeya torrida (J. F. Gmel.) P. Bamps	5.88	1.23	5.88	1.49	5.88	2.22

Appendix 5. contd.

Species	DBH > 2 cm		DBH > 10 cm		DBH > 20 cm	
	Individuals/ha	%	Individuals/ha	%	Individuals/ha	%
Dovyalis abyssinica (A. Rich.) Warb.	6.32	1.32	3.92	0.99	1.74	0.66
Ehretia cymosa Thonn.	0.22	5.00	0.00	0.00	0.00	0.00
Ekebergia capensis Sparrm.	4.58	0.96	4.14	1.05	2.83	1.07
Euclea divinorum Hiern	0.22	5.00	0.00	0.00	0.00	0.00
Ficus sur Forssk.	5.01	1.05	4.36	1.10	3.92	1.48
Galiniera saxifraga(Hochst.) Bridson	23.31	4.88	22.00	5.57	18.30	6.91
Hagenia abyssinica (Bruce) J.F. Gmel.	4.79	1.00	4.14	1.05	2.18	0.82
Halleria lucida L.	0.44	9.00	0.44	0.11	0.00	0.00
Hypericum revolutum Vahl	0.87	0.18	0.22	6.00	0.22	8.00
Ilex mitis (L.) Radlk.*	4.79	1.00	4.79	1.21	4.79	1.81
Juniperus procera L.	7.19	1.50	7.19	1.82	6.75	2.55

* Species with no traditional medicinal report in the study area

Appendix 5. contd.

Species	DBH > 2 cm		DBH > 10 cm		DBH > 20 cm	
	Individuals/ha	%	Individuals/ha	%	Individuals/ha	%
Maesa lanceolata Forssk.	58.61	12.26	51.42	13.01	27.89	10.53
Maytenus arbutifolia (A. Rich.) Wilczek	28.54	5.97	24.84	6.28	12.20	4.61
Maytenus undata (Thunb.) Blakelock	1.53	0.32	0.65	0.17	0.65	0.25
Myrica salicifolia A. Rich.	2.61	0.55	2.61	0.66	2.61	0.99
Myrsine africana L.	15.03	3.14	1.31	0.33	0.00	0.00
Myrsine melanophloeos (L.) R. Br.*	4.36	0.91	3.92	0.99	3.92	1.48
Nuxia congesta R. Br. ex Fresen.	10.24	2.14	10.24	2.59	9.15	3.45
Olea capensis. subsp. *macrocarpa* (C.H. Wright) Verdc.*	4.14	0.87	4.14	1.05	4.14	1.56
Olea europaea subsp. *cuspidata* (Wall. ex G.Don)	48.15	17.00	48.15	12.18	47.06	17.76
Olinia rochetiana A. Juss.	3.92	0.82	3.92	0.99	3.05	1.15

* Species with no medicinal report in the study area

Appendix 5 contd.

Species	DBH > 2 cm		DBH > 10 cm		DBH > 20 cm	
	Individuals/ha	%	Individuals/ha	%	Individuals/ha	%
Osyris quadripartita Decn.	2.61	0.55	2.61	0.66	0.87	0.33
Pavetta abyssinica Fresen.	3.05	0.64	2.18	0.55	0.87	0.33
Podocarpus falcatus (Thunb.) Mirb.	81.92	17.14	58.39	14.77	31.81	12.01
Polyscias fulva(Hiern) Harms	2.40	0.50	2.40	0.61	1.74	0.66
Prunus africana (Hook. f.) Kalkm.	5.23	1.09	5.23	1.32	1.53	0.58
Rhus vulgaris Meikle	0.44	9.00	0.00	0.00	0.00	0.00
Teclea nobilis Del.*	0.65	0.14	0.00	0.00	0.00	0.00
Trichocladus ellipticus Eckl. & Zeyh.	11.55	2.42	12.00	2.54	3.05	1.15
Turraea holstii Gürke*	2.18	0.46	1.96	0.50	1.09	0.41
Total	**478.00**	100.00	**395.20**	100.00	**264.92**	100.00

* Species with no traditional medicinal report in the study area

Appendix 6. Percentage distribution of tree species across DBH classes in Dense Forest

	DBH class (cm)						
Species name	**2-10**	**10-20**	**20-50**	**50-80**	**80-110**	**110-140**	**>140**
Allophylus abyssinicus (Hochst.) Radlk.	2.1	1.7	12.5	25.8	18.2	4.9	1.6
Podocarpus falcatus (Thunb.) Mirb.	28.4	20.4	12.7	6.5	5.9	12.2	30.1
Olea europaea L. subsp. *cuspidata* (Wall. ex G.Don) Cif.		0.8	2.3	9.3	34.5	70.7	42.3
Juniperus procera L.		0.3	0.5		2.5	3.7	16.3
Ficus sur Forssk.	0.8	0.3	1.3	1.6	1.5		3.3
Olinia rochetiana A. Juss.		0.7	1.4		1.0		3.3
Bersama abyssinica Fresen.	12.1	13.7	10.2	8.1	4.4		1.6
Myrica salicifolia A. Rich.				0.8	3.0	2.4	1.6
Maesa lanceolata Forssk.	8.7	18.1	11.1	21.8	4.4	3.7	
Olea capensis L. subsp. *macrocarpa* (C.H. Wright) Verdc.			1.6	2.4	1.0	2.4	
Dombeya torrida (J. F. Gmel.) P. Bamps				2.4	10.3		
Nuxia congesta R. Br. ex Fresen.		0.8	2.5	5.2	7.4		
Ekebergia capensis Sparrm.	0.5	1.0	1.1	1.2	2.0		
Ilex mitis (L.) Radlk.			0.9	3.6	3.9		
Galiniera saxifraga(Hochst.) Bridson	1.6	2.8	12.7	5.2			
Myrsine melanophloeos (L.) R. Br.	0.5		2.5	1.6			
Croton macrostachyus Del.	0.5	2.0	1.1	0.4			
Osyris quadripartita Decn.		1.3	0.4	0.8			
Pavetta abyssinica Fresen.	1.1	1.0	0.4	0.8			

Appendix 6. contd.

Species name	**DBH class (cm)**						
	2-10	**10-20**	**20-50**	**50-80**	**80-110**	**110-140**	**>140**
Celtis africana Burm.f.		0.2	0.9	1.2			
Maytenus arbutifolia (A. Rich.) Wilczek	4.5	9.7	9.8	0.4			
Prunus africana (Hook. f.) Kalkm.		2.8	1.1	0.4			
Turraea holstii Gürke	0.3	0.7	0.7	0.4			
Discopodium penninervium Hochst.	12.9	11.0	3.8				
Trichocladus ellipticus Eckl. & Zeyh.	1.8	5.4	2.5				
Hagenia abyssinica (Bruce) J.F. Gmel.	0.8	1.5	1.8				
Dovyalis abyssinica (A. Rich.) Warb.	2.9	1.7	1.4				
Acacia abyssinica Hochst. ex Benth.			0.2				
Acokanthera schimperi (A.DC.) Schweinf.		0.2	0.2				
Polyscias fulva(Hiern) Harms		0.5	1.4				
Maytenus undata (Thunb.) Blakelock	1.1		0.5				
Hypericum revolutum Vahl	0.8		0.2				
Cassipourea malosana (Baker) Alston			0.5				
Myrsine africana L.	16.6	1.0					
Halleria lucida L.		0.3					
Apodytes dimidiata E.Mey.ex Arn	0.3						
Ehretia cymosa Thonn.	0.3						
Euclea divinorum Hiern	0.3						
Rhus vulgaris Meikle	0.5						
Teclea nobilis Del.	0.8						

Appendix 7. Basal area (m^2/ha) of trees and their contribution (%) in Dense Forest

Species name	**BA (m^2/ha)**	**Percent contribution**
Allophylus abyssinicus (Hochst.) Radlk.	2.9	4.34
Bersama abyssinica Fresen.	2.2	3.34
Cassipourea malosana (Baker) Alston	0.1	0.12
Celtis africana Burm.f.	0.3	0.50
Croton macrostachyus Del.	0.2	0.32
Discopodium penninervium Hochst.	0.6	0.89
Dombeya torrida (J. F. Gmel.) P. Bamps	0.9	1.34
Dovyalis abyssinica (A. Rich.) Warb.	0.2	0.29
Ekebergia capensis Sparrm.	0.9	1.36
Ficus sur Forssk.	3.1	4.68
Galiniera saxifraga (Hochst.) Bridson	1.3	2.01
Hagenia abyssinica (Bruce) J.F. Gmel.	0.1	0.13
Ilex mitis (L.) Radlk.	1.3	2.01
Juniperus procera L.	8.4	12.70
Maesa lanceolata Forssk.	1.6	2.34
Maytenus arbutifolia (A. Rich.) Wilczek	0.1	0.14
Maytenus undata (Thunb.) Blakelock	0.1	0.11
Myrica salicifolia A. Rich.	0.9	1.34
Nuxia congesta R. Br. ex Fresen.	1.8	2.67
Olea capensis L. subsp. *macrocarpa* (C.H. Wright) Verdc.	1.1	1.67
Olea europaea L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	22.2	33.42
Olinia rochetiana A. Juss.	1.4	2.11
Osyris quadripartita Decn.	0.2	0.34

Appendix 7. contd.

Species name	**BA (m^2/ha)**	Percent contribution
Pavetta abyssinica Fresen.	0.1	0.15
Podocarpus falcatus (Thunb.) Mirb.	13.8	20.72
Polyscias fulva (Hiern) Harms	0.2	0.34
Prunus africana (Hook. f.) Kalkm.	0.0	0.00
Trichocladus ellipticus Eckl. & Zeyh.	0.3	0.46
Turraea holstii Gürke	0.1	0.19
Total	**66.5**	**100.00**

Appendix 8. Frequency of tree and shrub species with DBH > 2 cm in Dense Forest

Scientific name	**Percent Frequency**	**Relative Frequency**
Acacia abyssinica Hochst. ex Benth. subsp. *abyssinica*	1.96	0.18
Acokanthera schimperi (A.DC.) Schweinf.	1.96	0.18
Allophylus abyssinicus (Hochst.) Radlk.	74.51	6.85
Apodytes dimidiata E.Mey.ex Arn	1.96	0.18
Bersama abyssinica Fresen.	86.27	7.93
Cassipourea malosana (Baker) Alston	3.92	0.36
Celtis africana Burm.f.	5.88	0.54
Croton macrostachyus Del.	15.69	1.44
Discopodium penninervium Hochst.	72.55	6.67
Dombeya torrida (J. F. Gmel.) P. Bamps	5.88	0.54
Dovyalis abyssinica (A. Rich.) Warb.	56.86	5.23
Ehretia cymosa Thonn.	1.96	0.18
Ekebergia capensis Sparrm.	23.53	2.16
Euclea divinorum Hiern	1.96	0.18
Ficus sur Forssk.	11.76	1.08
Galiniera saxifraga (Hochst.) Bridson	52.94	4.87
Hagenia abyssinica (Bruce) J.F. Gmel.	5.88	0.54
Halleria lucida L.	3.92	0.36
Hypericum revolutum Vahl	7.84	0.72
Ilex mitis (L.) Radlk.	15.69	1.44
Juniperus procera L.	35.29	3.24
Maesa lanceolata Forssk.	90.20	8.29
Maytenus arbutifolia (A. Rich.) Wilczek	78.43	7.21

Appendix 8. contd.

Scientific name	**Percent Frequency**	**Relative Frequency**
Maytenus undata (Thunb.) Blakelock	7.84	0.72
Myrica salicifolia A. Rich.	7.84	0.72
Myrsine africana L.	39.22	3.60
Myrsine melanophloeos (L.) R. Br.	13.73	1.26
Nuxia congesta R. Br. ex Fresen.	21.57	1.98
Olea capensis L. subsp. *macrocarpa* (C.H. Wright) Verdc.	17.65	1.62
Olea europaea L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	78.43	7.21
Olinia rochetiana A. Juss.	15.69	1.44
Osyris quadripartita Decn.	21.57	1.98
Pavetta abyssinica Fresen.	31.37	2.88
Podocarpus falcatus (Thunb.) Mirb.	84.31	7.75
Polyscias fulva(Hiern) Harms	11.76	1.08
Prunus africana (Hook. f.) Kalkm.	17.65	1.62
Rhus vulgaris Meikle	5.88	0.54
Solanecio gigas (Vatke) C. Jeffrey	23.53	2.16
Teclea nobilis Del.	3.92	0.36
Toddalia asiatica Lam.	1.96	0.18
Trichocladus ellipticus Eckl. & Zeyh.	3.92	0.36
Turraea holstii Gürke	7.84	0.72
Vernonia amygdalina Del.	15.69	1.44

Appendix 9. Medicinal plants of Ankober District most-cited under forage use category

No	Scientific name	Family	Local name	Growth form	Voucher No ErmiasLX
1	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	Girar	T	826
2	*Achyranthes aspera* L.	Amaranthaceae	Telenj	H	104
3	*Acmella caulirhiza* Del.	Asteraceae		H	827
4	*Allophylus abyssinicus* (Hochst.) Radlk.	Sapindaceae	Imbis	T	829
5	*Anthemis tigreensis* J. Gay ex A. Rich.	Asteraceae		H	830
6	*Apodytes dimidiata* E.Mey.ex Arn	Icacinaceae	Yetemenja Inchet/Donga	T	887
7	*Arisaema schimperianum* Schott.	Araceae	Amoch	H	587
8	*Asparagus africanus* Lam.	Asparagaceae	Serite	S	189
9	*Asplenium aethiopicum* (Kunth) mett.	Aspleniaceae		H	593
10	*Berberis holstii* Engl.	Berberidaceae	Yeset Af	H	831
11	*Bersama abyssinica* Fresen.	Melianthaceae	Azamir	T	173
12	*Buddleja polystachya* Fresen.	Loganiaceae	Anfar	S	542
13	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	Digita	S	76
14	*Carica papaya* L.	Caricaceae	Papaya	T	40
15	*Carissa spinarum* L.	Apocynaceae	Agam	S	16
16	*Cassipourea malosana* (Baker) Alston	Rhizophoraceae	Werer	T	832
17	*Catha edulis* (Vahl) Forssk. ex Endl.	Celasteraceae	Chat	S	26
18	*Celtis africana* Burm. f.	Ulmaceae	Kewt	T	833
19	*Chamaecrista mimosoides* (L.) Greene	Fabaceae	Yeayt Gomen	H	834
20	*Cissampelos mucronata* A. Rich.	Menispermaceae	Ingochit hareg	C	888
21	*Clematis hirsuta* Perr. & Guill.	Ranunculaceae	Azo Hareg	C	18

No	Scientific name	Family	Local name	Growth form	Voucher No ErmiasLX
22	*Clutia abyssinica* Jaub. & Spach	Euphorbiaceae	Feyele Fej	S	10
23	*Coffea arabica* L.	Rubiaceae	Bunna	S	12
24	*Crassocephalum macropappum* (Sch. Bip. ex A. Rich.) S. Moore	Asteraceae		H	835
25	*Crotalaria incana* L.	Fabaceae		S	836
26	*Croton macrostachyus* Del.	Euphorbiaceae	Bisana	T	17
27	*Cucurbita pepo* L.	Cucurbitaceae	Duba	H	96
28	*Cyathula cylindrica* Moq.	Amaranthaceae	Yedem Abnet	H	837
29	*Cymbopogon citratus* (DC ex Nees) Stapf	Fabaceae	Tej Sar	H	838
30	*Cyperus bulbosus* Vahl	Cyperaceae	Ingicha	H	839
31	*Dovyalis abyssinica* (A. Rich.) Warb.	Flacourtiaceae	Koshim	T	536
32	*Ehretia cymosa* Thonn.	Boraginaceae	Game	T	843
33	*Ekebergia capensis* Sparrm.	Meliaceae	Ilol	T	844
34	*Embelia schimperi* Vatke	Myrsinaceae	Inkoko	C	505
35	*Epilobium hirsutum* L.	Onagraceae	Limich	H	845
36	*Erica arborea* L.	Ericaceae	Asta	S	846
37	*Euclea divinorum* Hiern	Ebenaceae	Dedeho	T	14
38	*Foeniculum vulgare* Miller	Apiaceae	Insilal	H	848
39	*Galiniera saxifraga* (Hochst.) Bridson	Rubiaceae	Tota Kula	T	849
40	*Geranium arabicum* Forssk.	Geraniaceae		H	883
41	*Gomphocarpus fruticosus* (L.) Ait. F.	Asclepiadaceae	Ash hareg	H	133
42	*Guizotia abyssinca* Cass	Asteraceae	Noug	H	882
43	*Guizotia scabra* (Vis.) Chiov.	Asteraceae	Mech	H	878
44	*Hagenia abyssinica* (Bruce) J.F. Gmel.	Rosaceae	Koso	T	598
45	*Halleria lucida* L.	Scrophulariaceae	Mesenqero	T	880

No	Scientific name	Family	Local name	Growth form	Voucher No ErmiasLX
46	*Haplocarpha schimperi* (Sch. Bip.) Beauv.	Asteraceae	Getim	H	879
47	*Hypericum quartinianum* A. Rich.	Guttiferae	Ameja	S	889
48	*Hypericum revolutum* Vahl	Guttiferae	Amja	T	872
49	*Hypoestes aristata* (Vahl) Soland.	Acanthaceae	Telenj	H	599
50	*Hypoestes forskaolii* (Vahl) R. Br.	Acanthaceae	Tay Beder	H	506
51	*Jasminium abyssinicum* Hochst.	Oleaceae	Abita	C	577
52	*Jasminium grandiflorum* L.	Oleaceae		C	875
53	*Juniperus procera* L.**	Cupressaceae	Yeabesha Tsid	T	874
54	*Laggera tomentosa* Sch.-Bip.	Asteraceae	Keskeso	S	881
55	*Leonotis ocymifolia* (Burm.f.) Iwarsson	Lamiaceae	Ras Kimir	S	871
56	*Linum usitatissimum* L.	Linaceae	Telba	H	873
58	*Maesa lanceolata* Forssk.	Myrsinaceae	Kelewa	T	42
59	*Maytenus arbutifolia* (A. Rich.) Wilczek	Celastraceae	Atat	T	47
60	*Maytenus undata* (Thunb.) Blakelock	Celastraceae	Damot woyra	T	868
61	*Momordica foetida* Schumach.	Cucurbitaceae	Yamora Misa	S	867
62	*Myrica salicifolia* A. Rich.	Myricaceae		T	866
63	*Myrsine africana* L.	Myrsinaceae	Kechemo	T	49
64	*Nuxia congesta* R. Br. ex Fresen.	Loganiaceae	Askwar	T	897
65	*Ocimum lamiifolium* Hochst.	Lamiaceae	Dama kesse	H	864
66	*Ocimum urticifolium* Roth	Lamiaceae	Dama kesse	H	69
67	*Olea europaea* L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	Oleaceae	Woyra	T	19
68	*Persicaria senegalensis* (Meisn.) Miyabe	Polygonaceae	Aluma	H	861
69	*Plantago lanceolata* L.	Plantaginaceae	Wusha milas	H	860

No	Scientific name	Family	Local name	Growth form	Voucher No ErmiasLX
70	*Plantago palmata* Hook.f.	Plantaginaceae	Wusha milas tiliku	H	895
71	*Plectranthus lactiflorus* (L.) Agnew	Lamiaceae	Ayderkush	H	859
72	*Podocarpus falcatus* (Thunb.) Mirb.**	Podocarpaceae	Zigba	T	197
73	*Prunus africana* (Hook. f.) Kalkm.	Rosaceae	Tikur Inchet	T	439
74	*Ranunculus multifidus* Forssk	Ranunculaceae	Etse siol	H	858
75	*Rhamnus prinoides* L'Herit.	Rhamnaceae	Gesho	S	607
76	*Rosa abyssinica* Lindley	Rosaceae	Kega	S	852
77	*Rubus steudneri* Schweinf.	Rosaceae	Injori	S	242
78	*Rumex nepalensis* Spreng.	Polygonaceae	Lut	H	24
79	*Ruta chalepensis* L.	Rutaceae	Tena adam	S	37
80	*Scabiosa columbaria* L.	Dipsacaceae		H	855
81	*Senecio myriocephalus Sch. Bip. exA. Rich.*	Asteraceae	Sibut	S	891
82	*Sida schimperiana* Hochst. ex A. Rich.	Malvaceae	Garda	S	153
83	*Silene macrosolen* steud ex. Rich	Caryophyllaceae	Wegert	H	854
84	*Smilax aspera* L.	Smilacaceae	Ashkla hareg	C	853
85	*Stephania abyssinica* (Dill. & A. Rich.) Walp.	Menispermaceae	Yeait hareg	H	130
86	*Tephrosia interrupta* Hochst. & Steud ex Engl.	Fabaceae	Gerengere	S	893
87	*Thalictrum rhynchocarpum* Dill. & Rich.	Ranunculaceae	Sire bizu	H	535
88	*Thymus schimperi* Ronniger	Lamiaceae	Tosigne	H	826
89	*Urera hypselodendron* (A. Rich.) Wedd.	Urticaceae	Lankuso	C	538
90	*Vernonia amygdalina* Del.	Asteraceae	Girawa	T	22
91	*Zehneria scabra* (Linn.f.) Sond.	Cucurbitaceae	Nech Hareg	C	851

** Feed for livestock at younger stage, not for bee forage . Species cited by at least 15 % of participants (n = 352) for forage uses are included

Appendix 10. Medicinal plants of Ankober District most-cited for material uses

No	Scientific name	Family	Local name	*Most cited material uses /most preferred to make	Voucher No ErmiasLX
1	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	Girar	handle for farm tools, drum, mortar	826
2	*Allophylus abyssinicus* (Hochst.) Radlk.	Sapindaceae	Imbis	door , farm tool special for yoke (*kenbe*r), local construction	829
3	*Apodytes dimidiata* E.Mey.ex Arn	Icacinaceae	Yetemenja Inchet/Donga	Pole for local house construction	887
4	*Buddleja polystachya* Fresen.	Loganiaceae	Anfar	farm tool (special for *digir*)	542
5	*Cassipourea malosana* (Baker) Alston	Rhizophoraceae	Werer	pole for house construction	832
6	*Celtis africana* Burm.f.	Ulmaceae	Kewt	handle for farm tools and house construction	833
7	*Clematis hirsuta* Perr. & Guill.	Ranunculaceae	Azo Hareg	tie woods together for local house construction/*Memageria*/	18
8	*Discopodium penninervium* Hochst.	Solanaceae	Ameraro	farm tools (recommended for *digir*)	606
9	*Dodonaea angustifolia* L. f.	Sapindaceae	Kitkita	basket, handle for farm tools, walking stick	20
10	*Dombeya torrida* (J. F. Gmel.) P. Bamps	Sterculiaceae	Wulkifa	local house construction, making chair, table, farm tools	841
11	*Ehretia cymosa* Thonn.	Boraginaceae	Game	furniture, local construction	843
12	*Ekebergia capensis* Sparrm.	Meliaceae	Ilol	chair, table, shelves , handle for farm tools, foot for local chair	844
13	*Erythrina brucei* Schwinef.	Fabaceae	Korch	traditional beehives, drums, and mortars	247
14	*Eucalyptus globulus* Labill.	Myrtaceae	Bahir Zaf	local house construction, handle for axe& shovel , pole, fresh bark uses for tying poles together/memageria/, local chair, foot for table, foot for bed	847
15	*Euclea divinorum* Hiern	Ebenaceae	Dedeho	handle for farm tools	14
16	*Galiniera saxifraga* (Hochst.) Bridson	Rubiaceae	Tota Kula	local house construction, making farm tool/ recommended for *mofer*/	849
17	*Gomphocarpus fruticosus* (L.) Ait. F.	Asclepiadaceae	Ash Hareg	Basket	133
18	*Hagenia abyssinica* (Bruce) J.F. Gmel.	Rosaceae	Koso	local bed, chair, door and plywood	598
19	*Hypericum revolutum* Vahl	Guttiferae	Amja	local house construction	872
20	*Juniperus procera* L.	Cupressaceae	Yeabesha Tsid	coffin, bed, box, chair, table, door, cupboard, shelves, pole, stool	874
21	*Maesa lanceolata* Forssk.	Myrsinaceae	Kelewa	farm tools (special for digir) Lumber/bench, table and box	42

22	*Maytenus arbutifolia* (A. Rich.) Wilczek	Celastraceae	Atat	pole for local construction /*mage*r/, handle for axe and shovel	47
23	*Maytenus undata* (Thunb.) Blakelock	Celastraceae	Damot woyra	handle for axe and shovel, pole for local construction	868
24	*Myrica salicifolia* A. Rich.	Myricaceae	Shinet	local house construction	866
25	*Myrsine africana* L.	Myrsinaceae	Kechemo	traditional tooth brush, house construction/special for *mager*/	49
26	*Olea europaea* L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	Oleaceae	Woyra	drum, traditional tooth brush, door, windows, table, chair, traditional walking sticks, agricultural tool/*mofe*r/, handle for axe	19
27	*Olinia rochetiana* A. Juss.	Oliniaceae	Tife	walking stick and local house construction	102
28	*Periploca linearifolia* Quaart.-Dill. & A. Rich.	Asclepiadaceae	Imbouayder	ropes/from stem bark/	83
29	*Podocarpus falcatus* (Thunb.) Mirb.	Podocarpaceae	Zigba	box, bed, bench, table, door, windows, traditional stool/*Berchuma*/ agricultural tool/special for yoke/ , drum, pole	197
30	*Polyscias fulva* (Hiern) Harms	Araliaceae	Yezingero wonber	wooden boxes, benches, chair	823
31	*Prunus africana* (Hook. f.) Kalkm.	Rosaceae	Tikur Inchet	local house construction, pestle , mortar, door, windows	439
32	*Rhus vulgaris* Meikle	Anacardiaceae	Kimo	local house construction, handle for farm tool	857
33	*Smilax aspera* L.	Smilacaceae	Ashkla hareg	tying poles together during local house construction/*mager*/	853
34	*Woodfordia uniflora* (A. Rich.) Koehne	Lythraceae	Dambit	handle for farm tools	181

* Only species cited by at least 15 % of participants (n = 352) for similar material uses are included

Appendix 11. Medicinal plants of Ankober District most-cited for making charcoal

No	Scientific name*	Family	Local name	Voucher No ErmiasLX
1	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	Girar	826
2	*Buddleja polystachya* Fresen.	Loganiaceae	Anfar	542
3	*Croton macrostachyus* Del.	Euphorbiaceae	Bisana	17
4	*Dodonaea angustifolia* L. f.	Sapindaceae	Kitkita	20
5	*Erica arborea* L.	Ericaceae	Asta	846
6	*Eucalyptus globulus* Labill.	Myrtaceae	Bahir Zaf	847
7	*Hypericum quartinianum* A. Rich.	Guttiferae	Ameja	889
8	*Nuxia congesta* R. Br. ex Fresen.	Loganiaceae	Askwar	897
9	*Olea europaea* L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	Oleaceae	Woyra	19
10	*Premna schimperii* Engl.	Lamiaceae	Chocho	202
11	*Prunus africana* (Hook. f.) Kalkm.	Rosaceae	Tikur Inchet	439
12	*Vernonia amygdalina* Del.	Asteraceae	Girawa	22

* Only species cited by at least 15 % of participants (n = 352) for charcoal making are included

Appendix 12. Medicinal plants of Ankober District most-cited for social uses

No	Scientific name	Family	Local name	Uses	Part used	Voucher No ErmiasLX
1	*Acokanthera schimperi* (A.DC.) Schweinf.	Apocynaceae	Merenz	fumigating local drink/*tella*/ containers	stem and leaves	100
2	*Catha edulis* (Vahl) Forssk. ex Endl.	Celastraceae	Chat	stimulant	leaves	26
3	*Clutia abyssinica* Jaub. and Spach.	Euphorbiaceae	Fiyele Fej	traditional torch (*Chibo*) for religious ceremonies	stem and leaves	10
4	*Coffea arabica* L.	Rubiaceae	Bunna	stimulant	fruit and leaves	12
5	*Cymbopogon citratus* (DC ex Nees) Stapf	Poaceae	Tej Sar	ritual ceremonies at church	leaves	838
6	*Cyperus bulbosus* Vahl	Cyperaceae	Ingicha	New year ceremonies	leaves	839
7	*arborea* L.	Guttiferae	Asta	traditional torch (*Chibo*)/ for religious ceremonies	stem and leaves	846
8	*Eucalyptus globulus* Labill.	Myrtaceae	Bahir Zaf	local torch and *demera*	stem and leaves	847
9	*Ficus sur* Forssk.	Moraceae	Shola	local meetings for local rituals/*Adbar*/	whole	822
10	*Impatiens tinctoria* A. Rich.	Balsaminaceae	Gishrit	dye for colouring hand and feet	Tuber	620
11	*Laggera tomentosa* Sch.-Bip.	Asteraceae	Keskeso	fumigating milk containers	stem and leaves	881
12	*Maesa lanceolata* Forssk.	Myrsinaceae	Kelewa	cover for baking local bread	leaves	42
13	*Nicotiana tabacum* L.	Solanaceae	Timbaho	stimulant	leaves	246
14	*Phytolacca dodecandra* L' Herit.	Phytolaccaceae	Indod	local soap	fruit	243
15	*Ricinus communis* L.	Euphorbiaceae	Gulo	softening local leather products	Oil	33

* Only species cited by at least 15 % of participants (n = 352) for similar social uses are included

Appendix 13. Medicinal plants of Ankober District most-cited for environmental uses

No	Scientific name	Family	Local name	Growth form	Uses	Part used	Voucher No ErmiasLX
1	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	Girar	T	shade, dry fence, soil improvement	Whole	826
2	*Allophylus abyssinicus* (Hochst.) Radlk.	Sapindaceae	Imbis	T	dry fence	Wood	829
3	*Apodytes dimidiata* E. Mey. ex Arn	Icacinaceae	Yetemenja Inchet/Donga	T	ornamental	Whole	887
4	*Bersama abyssinica* Fresen.	Melianthaceae	Azamir	T	live fence	Whole	173
5	*Carissa spinarum* L.	Apocynaceae	Agam	S	live fence	Whole	16
6	*Croton macrostachyus* Del.	Euphorbiaceae	Bisana	T	soil improvement/ mulch	leaves and twigs	17
7	*Discopodium penninervium* Hochst.	Solanaceae	Ameraro	S	live fence	Whole	606
8	*Dovyalis abyssinica* (A. Rich.) Warb.	Flacourtiaceae	Koshim	S	live fence	Whole	536
9	*Erica arborea* L.	Ericaceae	Asta	S	dry fence using cut branches	Wood	846
10	*Erythrina brucei* Schwinef.	Fabaceae	Korch	T	live fence, erosion control	Whole	247
11	*Eucalyptus globulus* Labill.	Myrtaceae	Bahir Zaf	T	dry and live fencing, erosion control	Whole	847
12	*Euclea divinorum* Hiern	Ebenaceae	Dedeho	T	live fence	Whole	14
13	*Ficus sur* Forssk.	Moraceae	Shola	T	Shade	Whole	822
14	*Hagenia abyssinica* (Bruce) J.F. Gmel.	Rosaceae	Koso	T	soil improvement/ mulch	leaves and twigs	598
15	Juniperus procera L.	Cupressaceae	Yeabesha Tsid	T	ornamental, hedges	Whole	874

Appendix 13. contd.

No	Scientific name	Family	Local name	Growth form	Uses	Part used	Voucher No ErmiasLX
16	*Justicia schimperiana* (Hochst. ex Nees) T. Anders.	Acanthaceae	Sensel	S	live fence	Whole	506
17	*Maesa lanceolata* Forssk.	Myrsinaceae	Kelewa	S	dry and live fencing	Whole	42
18	*Maytenus arbutifolia* (A. Rich.) Wilczek	Celastraceae	Atat	T	dry and live fencing	Whole	47
19	*Maytenus undata* (Thunb.) Blakelock	Celastraceae	Damot woyra	T	dry and live fencing	Whole	868
20	*Nuxia congesta* R. Br. ex Fresen.	Loganiaceae	Askwar	T	live fence	Whole	897
21	*Pavetta abyssinica* Fresen.	Rubiaceae	Seged achawach	S	soil improvement/ mulch	leaves and twigs	485
22	*Podocarpus falcatus* (Thunb.) Mirb.	Podocarpaceae	Zigba	T	shade	Whole	197
23	*Polyscias fulva* (Hiern) Harms	Araliaceae	Yezingero wonber	T	soil improvement/ mulch	leaves and twigs	823
24	*Prunus africana* (Hook. f.) Kalkm.	Rosaceae	Tikur Inchet	T	soil improvement	leaves and twigs	439
25	*Rosa abyssinica* Lindley	Rosaceae	Kega	S	live fence	Whole	856
26	*Vernonia amygdalina* Del.	Asteraceae	Girawa	T	live fence	Whole	22

* Only species cited by at least 15 % of participants (n = 352) for similar environmental uses are included

Appendix 14. Semi-structured interview questions employed in the research project, Ankober District

1. Name of the respondent
2. Respondent's gender
3. Marital status of the respondent: Married/widowed/divorced/single (Underline)
4. Age of the respondent
5. Educational status: Read and write? (Yes/No) Underline
   Indicate level/grade completed
6. Locality: Detailed description of locality (including Woreda/District and kebele)
7. What are the main human health problems/diseases at your locality?
8. What are the main livestock health problems/diseases at your locality?
9. How do you diagnose each disease/health problem?
10. Symptom(s) of the disease/health problem
11. How do you control/prevent health problems/diseases?
12. How do you treat human health problems/diseases?
13. How do you treat livestock health problems/diseases?
14. Which plant(s) do you use for treating that particular health problem/disease?
15. Local name(s) of the plant(s)
16. Botanical name(s) to be filled in by the researcher
17. Family name(s) to be completed by the researcher
18. Growth form: Tree/shrub/herb/liana/epiphyte/semi-parasite/parasite/aquatic
19. Brief description of the plant (by investigator/enumerator), including height, flower color, mature fruit color, mature seed color and other unique features

20. Habitat: Wild or cultivated, if wild specific habitat_________and vegetation type__________________

21. How widespread is/are the medicinal plant(s)? Easily obtained from home garden/surrounding areas/far away places (how far?___) / purchased [if purchased from individual at household/market (indicate name of individual/market place)]

22. Plant part used in medicine: Root/stem/root bark/stem bark/leaves/small twigs with leaves/flowers/fruit/seed/whole (Underline). Others__________.

23. Used alone, mixed with water or other materials, concoction/decoction (Underline): Other___________________

24. How plant parts are used: Fresh only/dried only/ fresh or dried (Underline). Other________

25. Preparation for medicinal use: Crushed/crushed and powdered/extracted with cold water/ boiled (juice/latex) (Underline). Other_________

26. Dose/amount

27. Does the dose differ among males, females, children, elders, pregnant women?

28. Any noticeable adverse/side effect(s)

29. Any antidotes for adverse/side effect(s)

30. How do you preserve traditional medicine?

31. Any restriction or taboo in collecting medicinal plants

32. Are medicinal plant marketed/marketable?

33. For what other purposes do you use traditional medicinal plants? Food/firewood/charcoal/house construction/forage/etc.

34. Are there any threats to the medicinal plants? List out the main threats, starting with the most serious threat

35. How do you conserve traditional medicinal plants?

36. How is the knowledge on traditional medicine passed to a family member/younger generation?

37. How does modernization interfere with traditional medicinal knowledge?

IDENTIFICATION:

Name of: Survey Area/Woreda_______________

Peasant Association or Kebele_______________

Community/Village_______________

Interviewer/facilitator______________

Date/Month/Year: ______________

Time: From______a.m./p.m. to ______a.m./p.m.

Appendix 15. Photographs illustrating field activities in Ankober District

a. Data collection trip to Dense

b. Interviewing an informant at Aliu Amba

c. Interviewing a woman informant at Gorgo

d. collection at Dense Forest

e. at Gorgo market

f. Back from field, specimen on donkey's back

Appendix 16. Photographs illustrating some common medicinal plants of Ankober District

Vatke b. (Bruce) J.F. Gmel.

A. Rich. d. L. f.

e. L' Herit f. L.

Appendix 17. Photographs illustrating some medicinal plants sold in open markets of Ankober District

in an open market (Gorabela) b. in the market (Gorgo)

in open market (Gorgo) d. (Zego)

Appendix 18. Photograph illustrating deforestation in Dense Forest

Appendix 19. Photographs illustrating some aspects of the laboratory activity at the laboratory of ethnobotany and ethnopharmacology, CULS, Prague

a. Weighing and grinding medicinal plant specimen using Grindomix (GM100, Retsch Germany)

b. Collecting and weighing specimen's powder and extracting it using laboratory shaker

c. Filtering, evaporating and collecting final extracts

d.Testing plant extracts against 12 different microbial strains