PLANT DIVERSITY, ETHNOBOTANY AND BARCODING OF MEDICINAL AND COSMETIC PLANTS IN KALU AND BATI DISTRICTS OF AMHARA REGION, ETHIOPIA

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A Thesis Submitted to the Department of Plant Biology and Biodiversity Management Presented in Fulfilment of the Requirements for the Degree of Doctor of Philosophy (Biology: Plant Biology and Biodiversity Management)

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This is to certify that the thesis prepared by **Nurya Abdurhman Birhanu**, entitled: "*Plant diversity, Ethnobotany and Barcoding of Medicinal and Cosmetic Plants in Kalu and Bati Districts of Amhara Region, Ethiopia"* and submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy (Biology: Plant Biology and Biodiversity Management) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

Plant diversity, Ethnobotany and Barcoding of Medicinal and Cosmetic Plants in Kalu and Bati Districts of Amhara Region, Ethiopia

Nurya Abdurhman, PhD Dissertation

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The study was conducted in Kalu and Bati Districts, South Wollo Zone of Amhara Region, Ethiopia. It was aimed at documenting plant diversity in selected forest patches, ethnobotany and barcoding of medicinal and cosmetic plants. Vegetation data were collected from 50 and 30 sampling plots (20 m × 20 m) for Anabe and Gerfa-ourene forest patches respectively using transect method. For shrubs and herbs 5 m x 5 m and 1 m x 1 m subplots were laid within each quadrat respectively. Ethnobotanical data were collected by administering semi-structured interviews with randomly sampled 300 informants, through direct field observation, 20 focus group discussion and in eight local markets. For DNA barcoding sequences, samples were collected both in voucher form and by silica gel and analyzed at the laboratory of Natural History Museum, University Of Oslo, Norway. Agglomerative hierarchical classification with the application of R-computer programing (R Version 3.0.2) was used to identify plant communities. Simple preference ranking, direct matrix ranking, informant consensus factor (ICF) and fidelity level (FL) were calculated to analyze the ethnobotanical data. Genomic DNA was extracted from silica-gel-dried leaves, voucher specimens and powdered medicinal plant samples to generate barcodes for ITS, rbcL and matK using specific primers and PCR amplification. All barcode sequences were queried using NCBI BLAST to cross-check morphological identifications. From Anabe and Gerfa-ourene forest patches a total of 128 plant species which belong to 114 genera and 60 families were recorded. From the total, 108 of the plant species representing 97 genera and 52 families were collected from Anabe Forest patch whereas 84 plant species representing 75 genera and 46 families were from Gerfa-ourene Forest patch. From the hierarchical cluster analysis, the vegetation in Anabe and Gerfa-ourene Forest patches were classified in to three plant community types each. The ethnobotanical study in Kalu District revealed 129 medicinal plant species that belong to 108 genera and 59 families. In Bati District, however, 94 traditional medicinal plant species belonging to 78 genera and 49 families were reported. The majority of human remedy preparations were from leaves (43% in Kalu and 29% in Bati) followed by roots (11% in kalu and 17% in Bati) and the highest ICF values were recorded for back pain in humans in both districts (0.94 in Kalu, 0.96 in Bati). The highest FL values of human medicinal plants were recorded for *Withania somnifera* (93.5%) in Kalu District, and *Terminalia brownii* (95.96%) in Bati District. About 30.34% of the medicinal plants in both districts were cited for women's health problems and for herbal cosmetics.The amplified products were used for sequencing and 154 samples were sequenced for three barcode regions (ITS, rbcL and matK). BLAST was used to compare sample sequences to the reference database and sequencing success was high for rbcL (97.4%) and ITS (96.1%), but lower for matK (76.0%). Anabe and Gerfa-ourene Forest patches are rich in species composition having 128 plant species which belong to 114 genera and 60 families. Both districts are rich in their medicinal plant composition having 145 medicinal plant species that belong to 116 genera and 62 families. Kalu and Bati Districts are rich in "women's plants" and herbs used as cosmetics (44 species, which belong to 39 genera and 31 families). DNA barcoding method was attempted for identifying 154 medicinal and cosmetics plant materials including from markets with high percentage of success.

Key words: Bati, DNA barcoding, ethnobotany, ITS, Kalu, matK, rbcL.

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Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

ANRS	Amhara National Regional State
BWARDO	Bati Wereda Agriculture and Rural Development Office
CBD	Convention on Biological Diversity
CHF	Canadian Hunger Foundation
CSA	Central Statistical Agency
CTAB	Cetyl trimethyl ammonium bromide
DBH	Density at Breast Height
DNA	Deoxyribonucleic acid
EBI	Ethiopian Biodiversity Institute
EFAP	Ethiopian Forests Action Program
EPA	Environmental Protection Authority
FAO	Food and Agricultural Organization of the United Nations
FL	Fidelity Level Index
GPS	Geographical Positioning System
IBC	Institute of Biodiversity Conservation
ICF	Informant Consensus Factor
IK	Indigenous Knowledge
ITS	Internal transcribed spacer
KWARDO	Kalu Wereda Agriculture and Rural Development Office
MA	Millennium Ecosystem Assessment
matK	maturase kinase
NCBI	National Center for Biotechnology Information
TM	Traditional Medicine
rbcL	Ribulose bisphosphate carboxylase large chain
WHO	World Health Organization

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Biodiversity (biological diversity) denotes the variety of life at genetic, organismic and ecological levels; and studies are also underway to include cultural biodiversity as a fourth component (Whittaker, 1975; Jeffries, 2005; Niles, 2009). Biodiversity has been given a comprehensive and a more inclusive definition, by the Convention on Biological Diversity (CBD, 1992) as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".

Biodiversity plays a key role in ecosystem functioning and has been widely used as an indicator of ecosystem health (FAO, 2005). It also provides four main services which are, supporting (nutrient cycling, soil formation, primary production), provisioning (food, fresh water, wood and fiber, fuel), regulating (climate regulation, flood regulation, disease regulation, water purification), and cultural (aesthetic, spiritual, educational, recreational) (MA, 2005).

Although biodiversity is understood as a main factor for the sustainability of life, biodiversity loss is one of the greatest environmental crises. The growing human population and the demand for natural resources have put great pressure on the biodiversity wealth of the world through deforestation, habitat fragmentation, and overexploitation of species (Terborgh and van Schaik 1997; Noss, 1999). Besides these global factors, lack of technical knowledge and awareness, and political instability have made the problem worse in many developing countries (Ayyad, 2003).

Plant diversity being a part of biological diversity, which holds the genes and species of plants, refers to the number of plants within a given area. Plant diversity is the variability among living plants from all sources, including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within plant species, between species and of ecosystems. Plant-diversity is one of the major groups of biological diversity and it can be affected by different biotic and abiotic factors. The plant communities and their component species are exposed to changes in the environmental, physical, biological, technological, economic or social factors (Frankel *et al.,* 1995).

In Ethiopia, accelerated deforestation and habitat fragmentation that arise largely due to the conversion of forests to other agricultural land-use types and the overutilization of forest resources to satisfy the food and energy requirements of the increasing population are main environmental concerns (Machado *et al*., 1998; Friis *et al*., 2001). With annual forest clearance of about 150,000 to 200,000 ha (Mogaka *et al*., 2001), the forest cover of Ethiopia was reduced to 16% during the 1950s, and to 2.7% by 1989 (Campbell, 1991; EFAP, 1994). The average forest decline between 1990 and 2000 in Ethiopia was 1% (FAO, 2007). Between 2000 and 2005, this value declined by 1.1%, which exceeds the average value of East Africa (0.97), total Africa (0.62), and the world (0.18 %) (FAO, 2007). Natural forests as defined earlier in Ethiopia mainly occur in the south-western part of the country, while the forests that originally existed in central and northern Ethiopia have almost disappeared (EFAP, 1994; Feoli *et al*., 2002). In addition, continued exploitation of natural forests without giving due consideration to their propagation, domestication and cultivation has resulted in a vicious cycle where increased forest destruction continued (Zewge Teklehaimanot and Healey, 2001).Therefore, studying both plant diversity and ethnobotany is essential to investigate the current status of the vegetation cover of remnant forest patches and the indigenous knowledge of the people for conservation and their

use purposes. Contemporary studies of ethnobotany emphasize the need to conserve the biological diversity as well as its associated indigenous knowledge (Rossato, 1999).

Human interaction with the plant and natural environment is very strong, and ethnobotanical studies are essential to document and analyze these direct interrelations between humans and plants (Martin, 1995; Balick and Cox, 1996). Ethnobotanical investigations document the knowledge on the plants used by people and totality of the cultural interaction of people with plants. It also tries to realize how local people have traditionally used plants for various purposes and how they incorporated plants into their cultural tradition and religion (Balick and Cox, 1996). From the earliest times, humankind has used plants in attempting to cure diseases and related physical sufferings. People in all ages have had some knowledge of medicinal plants, derived as a result of trial and error (Hill, 1989) experimentation, which is considered the earliest form of investigation. Thus, application of ethnobotanical methods in areas where such interaction had been profound helps to bring out the biocultural knowledge that has been cumulating since ancient times.

Ethiopian people, like in many developing countries, mostly rely on ethnomedicinal knowledge to treat different diseases of humans and livestock and more than 95 % of the material used for such purpose is of plant origin (Dawit Abebe and Ahadu Ayhehu, 1993). Hence, the major reasons behind why medicinal plants are demanded in Ethiopia relate to culturally linked traditions, and the trust the communities have in medicinal values of traditional medicinal plants and the relatively low cost in using them (Endashaw Bekele, 2007). Ethiopia is ethnically and linguistically diverse, with about 80 different languages spoken in the country (Gebremedhin Simon, 2006 and Hudson, 2004) which have in turn contributed to the high diversity of traditional knowledge and practices of the people which, among others, includes the use of

medicinal plants to cure different ailments and give protection from the causative agents. Hence, in Ethiopia, plants have been used both in the prevention and cure of various diseases of humans and domestic animals from time immemorial (Mirutse Giday and Gobena Ameni, 2003). Dawit Abebe and Ahadu Ayhehu (1993) reported that 80% of the Ethiopian population depends on traditional medicine for their healthcare while more recently, Mander *et al*., (2006) reported survey results that showed about 68% of the Ethiopian population are users of traditional herbal medicine.

Ethiopia is ethnically diverse and due to this each communities has its own set of unique ethnomedicinal knowledge and practices associated with traditional medicinal plants. Such diversity offers an opportunity to explore and conduct extensive ethnobotanical research. Although the country has rich and diverse ethnolinguistic groups, still there is a wide gap of knowledge about ethnobotanical data and information from various parts. Other related useful plants of the people including those mostly associated with women's health and body care, traditional plant-based perfumes, cosmetics (Fetlework Ketsela, 1995), spices and fragrant plants are also treated in the same way. On the other dimension, loss of overall biodiversity and that of the traditional medicinal and cosmetic plants due to natural and anthropogenic factors and limited integration of traditional practices with modern science are also the other problems that prevail in the study area. Traditional home gardening in the conservation and management of medically important plant species by indigenous people of the districts is not recognized though such practices are varying from one area to the other one. However, some important medicinal plants have been planted as live fence plants and observed as fragments in and around the farm lands. Furthermore, the current environmental degradation appears to put the bio-cultural diversity at risk of erosion. It is estimated that 150,000 to 200,000 hectares of forestland is cleared per annum in Ethiopia for various reasons (Mogaka *et al*., 2001) resulting in declining of

natural vegetation cover. Similarly, due to acculturation, few young people are interested in learning about traditional medicine (Mirutse Giday *et al.*, 2003) and thus ethnomedicinal knowledge is increasingly eroded. Other factors such as lack of support to ethnomedicinal practices and integration with formal healthcare would result in declined practice of traditional medicine.

Other serious problems of traditional medicinal and cosmetic plants, basically those on the marketplace, are about their preparation. Mainly when prepared in the form of powder or other processed biomaterials they may be prone to contaminants. Hence, this problem needs to be checked and solved in order to protect consumers from health risks associated with product substitution and contamination (Newmaster *et al*., 2013). Thus, the checking process will be done, if and only if the plants are identified using DNA barcoding method.

DNA barcoding is a relatively new method which has been developed to provide rapid, accurate and automatable species identification using standardized DNA sequences as tags (Hebert *et al*., 2003; Taberlet *et al*., 2007). It works by matching sequence data from a query sample (an unknown specimen) to a reference sequence (from a voucher specimen) (Schori and Showalter, 2011). Currently there are no plant morphological character in place for identifying the species of the various processed ingredients used in herbal products. Because the diagnostic morphological features of the plants on which the current Linnaean taxonomic system is based cannot typically be assessed from powdered or otherwise processed biomaterials. As a result, the marketplace is prone to contamination and possible product substitution, which dilute the effectiveness of otherwise useful remedies, lowering the perceived value of all related products because of a lack of consumer confidence in them (Newmaster *et al*. 2013).

Similar to other regions of Ethiopia, particularly people living in Kalu and Bati districts have traditional practices which they preserved for centuries and have been transferred for generations through oral tradition to treat both human and livestock ailments. Therefore, this study fulfils the identified gaps by documenting medicinally important plants of humans and livestock with the goals of contributing to their conservation, development and sustainable utilization in to the foreseeable future. Moreover, this study documents plants which are important for beautification, and attempted to include identification of traditional medicinal and cosmetic plants of the two districts using the molecular techniques of DNA barcoding. For this dissertation, Kalu and Bati districts were selected firstly because the places are rich in ethnomedicinal plants and secondly because there is an active tradition of using traditional herbal medicine for healing purpose and plant-based cosmetics for beautification by the surrounding community. While the latter tradition is either absent or fading away in other parts of the country.

1.2. Statement of the Problem

In the study area, complete collection, identification and documentation of ethnobotanical works have not yet been made. Moreover, most of the natural vegetation and forests of the study area have been severely degraded mainly by human impact. Hence, the natural vegetation has been largely removed and the land has been mostly converted to agricultural landscapes. As a result, the area is dominated by the cereal crop cultivation being common and frequently seen and which may be heading to mono-cropped fields; a trend that will put the bio-cultural diversity at risk of erosion.

The necessary positive effect of women's plants on the health and body care of women in the area is not always noticeable and the effects of such practices are not clearly documented from an ethnobotanical perspective. Consequently, there is a lack of data on the plants used for

medicinal and body care purposes. Therefore, this study aims to contribute to a better understanding about the composition of the vegetation; diversity of medicinal plants and their uses as understood by the local people, and the traditional management practices in the area.

It also targets to address gaps on documenting the ethnobotanical data of women's plants and the associated practices through an ethnobotanical survey. This research also tried to identify the traditional medicinal and cosmetic plant species using DNA barcodes to make baseline data available for better authentication and initiate the beginning of a future barcode library for the medicinal and cosmetic plants of Ethiopia.

1.3. Research questions, hypotheses and objectives

1.3.1. Research questions

The following main research questions were addressed in this study:

- What are the species composition and plant community types that occur in Anabe and Gerfa-ourene forest patches?
- Are there plants which are medicinally important as well as for application in the traditional plant-based cosmetics for body care and beautification?
- What are the traditional medicinal plants used by people in Kalu and Bati districts to treat human and/or livestock ailments?
- What is the local perspective of the people on "women's plants"; how do women manage their own health through their traditional knowledge on the use of medicinal plants?
- What are the quick and modern technology-assisted ways of correctly identifying traditional medicinal and cosmetic plants?

1.3.2. Research hypotheses

The following three main hypotheses were tested using both field and laboratory data:

I. There is high species diversity in Anabe and Gerfa-ourene forest patches and they are important as the main source of traditional medicinal plants for people in Kalu and Bati districts;
II. There are a number of medicinal plants in the study area which are used to treat different human and livestock ailments; and
III. There are various "women's plants" which are medicinally important and used for body care and beautification in the study area.

1.3.3. Research objectives

1.3.3.1. General objective

The general objective of this study focuses on documenting plant diversity in selected forest patches, ethnobotany and barcoding of medicinal and cosmetic plants in Kalu and Bati districts of Amhara Region, Ethiopia.

1.3.3.2. Specific objectives

Based on the general objective stated above, this research has the following specific objectives.

- To describe the floristic composition and plant communities of Anabe and Gerfa-ourene forest patches;
- To identify the traditional medicinal plants (MPs) and cosmetic plants of the study area used by the local people for the treatment of human and livestock ailments along with their other uses;
- To describe the perceptions, plant knowledge and use practices related to women's health and body care as plant-based cosmetics;

- To generate DNA barcode sequences of traditional medicinal and cosmetic plant species and to test DNA barcoding as a method to authenticate and test purity of medicinal plant materials and cosmetic stuff transacted at local markets (roots, stems, fruits, seeds, flowers, powders);

CHAPTER TWO

2. LITRATURE REVIEW

2.1. Vegetation types of Ethiopia

Vegetation types are reservoirs of useful plant that supply medicinal, food, cosmetic and other products used by local communities for various purposes. Ethiopia, being located in the horn of Africa, is known for its diverse landscapes which range from the highest areas of Ras Dashen (4555 m.a.s.l.) to the lowest and hottest place of Dallol (116 m.b.s.l.). As a result of the Great Rift Valley which divides the country from northeast to southwest, highlands isolated by dry areas have been formed. This resulted in various ecosystems and climatic zones which gave rise to diverse flora and fauna with considerable degree of endemism (IBC, 2005; Friis *et al*., 2010).

The vegetation of Ethiopia is classified into various types and subtypes. As the recent study indicated, there are 12 major vegetation types (Friis *et al*., 2010). These are (1) Desert and semi-desert scrubland (DSS), (2) *Acacia-Comiphora* woodland and bushland (ACB), (3) Wooded grassland of the western Gambela region (WGG), (4) *Combretum-Terminalia* woodland and wooded grassland (CTW), (5) Dry evergreen Afromontane forest and grassland complex (DAF), (6) Moist evergreen Afromontane forest (MAF), (7) Transitional rainforest (TRF), (8) Ericaceous belt (EB), (9) Afroalpine belt (AA), (10) Riverine vegetation (RV), (11) Fresh water lakes, lakeshores, marshes, swamps and flood plains vegetation (FLV), and (12) Salt-water lakes, lakeshores, salt marshes and pan vegetation (SLV). The descriptions of each vegetation type and subtype is provided in Friis *et al*. (2010) and based on this classification the selected forest patches (Anabe and Gerfa-ourene forest patches) in Kalu and Bati districts have been classified as DAF.

2.1.1. Dry evergreen Afromontane forest and grassland complex (DAF) vegetation

The Dry evergreen Afromontane Forest and grassland complex (DAF) vegetation type is characterizes by a complex system of successions involving extensive grasslands rich in legumes, shrubs and small to large-sized trees to closed forest with a canopy of several strata occurring between (1600-) 1900-3300 m. This type of vegetation covers much of highland areas and mountainous chains of Ethiopia. The areas with Dry evergreen Afromontane forest have canopies usually dominated by *Juniperus procera*, *Podocarpus falcatus*, *Olea europaea* subsp. *Cuspidata*, *Apodytes dimidiate*, *Prunus africana*, *Acacia abyssinica* and *Acacia negrii* (Friis, 1992; Tamrat Bekele, 1993; Zerihun Woldu, 1999; NBSAP, 2005; Friis *et al*., 2010).

The DAF is subdivided into four distinct subtypes. These are (a) Undifferentiated Afromontane forest, (b) Dry single-dominant Afromontane forest of the Ethiopian highlands, (c) Afromontane woodland, wooded grassland and grassland, and (d) Transition between Afromontane vegetation and *Acacia-Commiphora* bushland on the eastern escarpment (Friis *et al*., 2010). A number of studies in the Dry Evergreen Afromontane Forests have been conducted. Some of them are, Menagesha-Suba and Wof-Washa forests in central highlands of Shewa by Sebsebe Demissew (1988); Tamrat Bekele (1993); Demel Teketay and Tamrat Bekele (1995), Shashemene-Munessa forest (Gemedo Dalle and Masresha Fetene, 2004; Gemedo Dalle, 2015), North Gondar Church forests (Alemayehu Wassie *et al*., 2005), Zege Peninsula forest (Alemnew Alelign *et al*., 2007), Tara Gedam forest (Haileab Zegeye *et al*., 2011), Zengena forest (Desalegn Tadele *et al*., 2013) and Kuandisha forest (Abiyot Berhanu *et al*., 2017).

2.2. The science of ethnobotany

Ethnobotany is referring to the study of direct interrelations between humans and plants (Martin, 1995; Balick and Cox, 1996). Human beings use plants to fight diseases, eat as food, treat and feed their animals, construct houses and perform other activities including spiritual/ritual practices and with recent usage for aesthetic purposes. Investigations in ethnobotany document the knowledge on cultural interaction of people with plants. It also tries to find out how local people have traditionally used plants for various purposes and how they incorporated plants into their cultural traditions and religious practices (Balick and Cox, 1996).

2.3. Medicinal plants in Ethiopia

In Ethiopia, plants have been used traditionally as a source of medicine since ancient times to treat various ailments affecting humans and their domestic animals (Miruste Giday *et al.*, 2003). Early documentation was made by foreign explorers, and resident religious scholars such as *Debteras* (Mesfin Taddese, 1986). People in Ethiopia, like people in other developing countries have their own ways of therapeutic practices for various health problems. The curative methods and associated practices of the people are diverse and the traditional healing system is described as medico-religious (Mekonen Bishaw, 1991; Dawit Abebe and Ahadu Ayehu, 1993; Fekadu Fullas, 2003; Kebede Deribe *et al*., 2006). Such medico-religious therapeutic practices with close interaction of Christian, Islamic and other religions in the country, occasionally shows features related to magic, beliefs and faith. Hence, traditional medicine is practiced not only with the healing of ailments, but also with the protection and promotion of human physical, spiritual, social, mental and material wellbeing too (Mekonen Bishaw, 1991; Kebede Deribe *et al.*, 2006).

In Ethiopia people mostly rely on ethnomedicinal knowledge to treat different diseases and 68% of the population depends on traditional medicine for their healthcare (Mander *et al*., 2006). Reasons behind the demand for medicinal plants in Ethiopia are related to culturally linked traditions, the trust the communities have in medicinal values of traditional medicine and the relatively low cost in using them (Dawit Abebe, 2001; Endashaw Bekele, 2007). Thus, in Ethiopia, plants have been used both in the prevention and treatment of various diseases of humans and domestic animals from time immemorial (Mirutse Giday and Gobena Ameni, 2003). Ethiopia has diverse medicinal flora which are distributed in different vegetation types. Currently, about 1000 medicinal plants have been identified and documented (Zemede Asfaw and Tigist Wondimu, 2007).

2.4. Traditional Medicinal Plants and Indigenous Knowledge

2.4.1. Traditional medicine

According to the WHO (2001), traditional medicine is defined as the health practices, approaches, knowledge and beliefs incorporating plant, animal and mineral based medicines, spiritual therapies, manual techniques and exercises, applied singularly or in combination to treat, diagnose and prevent illnesses and maintain well-being. Since time immemorial human beings have found remedies within their habitat, and have different therapeutic strategies depending upon the climatic, physiographic, floral and faunal characteristics, as well as upon the peculiar cultural and socio-structural typologies. In doing so people have used traditional medicine to treat and prevent various disorders. It has incorporated plant, animal and mineral based medicines, spiritual therapies, include techniques and exercises, applied singularly or in combination (Adewumi, 1991). It depends exclusively on past practical experience and observations handed down from generation to generation, verbally or in writing in the

pharmacopeias. Traditional medicine comprises of therapeutic practices that have been in existence often for hundreds of years before the development of modern scientific medicine and are still in use today without documented evidence of either efficacy or adverse effects (Elujoba *et al*., 2005) except in few cases arising from impurities that are not easy to separate and problems related to imperfect measurement of dosages.

It is known that many countries in Africa, Asia and Latin America use traditional medicine (TM) to meet some of their primary health care needs. In Africa, up to 80% of the population uses traditional medicine for primary health care (WHO, 2003). Traditional medicine has maintained its popularity in all regions of the developing world and its use is rapidly spreading in industrialized countries. People in Ethiopia have been using traditional medicines for a long time. In particular in areas which are rural, traditional medicine is still widely practiced in places where modern public health and veterinary services are limited. Even in areas where modern medicine and veterinary services are available, they are often considered next to traditional treatments (Tafesse Mesfin and Mekonnen Lemma, 2001).

2.4.2. Indigenous knowledge

Indigenous knowledge (IK) is defined as the local knowledge that is unique to a given culture or society. It is the basis for the local level decision making in agriculture, health care, food preparation, education, natural resources, management and a host of other activities in rural communities (Warren, 1991). It is a result of many generations', long years experience, careful observations and trial and error experiments (Martin, 1995). Local knowledge of indigenous people includes information about the ecosystem in general, but also about specific plants used as medicine, food, building material, and similar uses (Leonti *et al.*, 2003).

IK develops and changes with time and space. Hence, such knowledge includes time-tested practice that developed in the process of interaction of humans with their environment. One of the widely used indigenous knowledge systems in many countries is the knowledge and application of traditional medicinal plants. Such knowledge known as ethnomedicinal knowledge involves traditional diagnosis, collection of raw materials and preparation. Preparation of the indigenous knowledge on plant remedies in many countries including Ethiopia, pass from one generation to the other generation verbally with great secrecy. Such secret and verbal transfer makes the indigenous knowledge or ethnomedicinal knowledge vulnerable to distortion and in most cases some of the lore is lost at each point of transfer (Amare Getahun, 1976). Hence, the need for systematic documentation of such a useful knowledge nowadays through ethnobotanical research. The quantity and quality of traditional knowledge differs among community members according to their gender, age, social-standing, profession and intellectual capabilities (Balick and Cox, 1996). Thus, systematic application of IK is important for sustainable use of resources and sustainable development (Thomas, 1995). Research shows that indigenous knowledge of medicinal plants by human beings is lost at an alarming rate. The main reasons that contribute to the loss of IK are rapid land degradation such as accelerated destruction of forests and adoption of modern culture (Kong *et al.*, 2003; Shrestha and Dhillion, 2003).

2.5. Status of Indigenous Knowledge of Medicinal Plants in Ethiopia

IK of medicinal plants in Ethiopia is unevenly distributed among community members (Zemede Asfaw, 2001). The distribution of knowledge and services are hierarchically placed and that such services are obtained from the family, the neighborhood, the village or beyond from specialized healers in what could be considered traditional referral system (Zemede Asfaw, 2001; Hareya Fassil, 2005). In Ethiopia, the loss of IK is not too far from what had happened in the developed

countries. The vast knowledge on traditional uses of plants is not fully documented and most of the knowledge is conveyed from generation to generation by word of mouth. This process together with the increasing acculturation, mobility and displacement of communities due to different factors (famine, water, etc..), secretive nature of traditional knowledge and skills and the negligence of the contemporary generation to acquire the knowledge on traditional medicine (TM) puts to question the future of the cultural heritage of the country which was known and practiced for centuries (Getachew Addis *et al*., 2001). Ethiopia's traditional medicine, as elsewhere in Africa, is faced with problems of continuity and sustainability primarily due to loss of taxa, habitats of medicinal plants and other category of plants (Ensermu Kelbessa *et al*., 1992). In the same work it has been pointed out that there is a real danger of genetic erosion, which in turn calls for the need of collection, investigation and conservation of these resources and the indigenous knowledge on them.

2.6. The Role of Medicinal Plants for Developing Modern Drugs

The term ‘medicinal plants’ include various types of plants used in herbalism and some of these plants have medicinal activities. These medicinal plants are considered rich resources of ingredients which can be used in drug development and synthesis. In addition, these plants play a critical role in the development of human cultures around the whole world (Rasool Hassan, 2012).

Worldwide, medicinal plants are important elements of medical systems. Ethno pharmacological surveys provide the rationale for selection and scientific investigation of medicinal plants, since some of these indigenous remedies have successfully been used by significant number of people (Geerling, 2001). Historically, plants have been our most fruitful area in the search for new medicine. Report has showed that, a success rate in the search of new drugs from randomly

synthesized chemicals is only one in 10,000; therefore, searching new drugs from traditionally used medicinal plants can be the shortest path to success (Chadwick, 1994) as the latter approach follows the ethnobotanical leads. Accordingly, the role of traditional medicinal plants in the development of new drugs could be either by serving as a natural blue print for the development of new drugs, or as phytomedicine to be used for the treatment of diseases (Andrew *et al*., 1996).

Knowledge of traditional herbal medicine has often evolved through many generations, a process that has led to many effective remedies, and filtered out many acutely toxic or non-active remedies. Traditional herbal medicine, in other words, should be the primary starting place for research on novel plant-based pharmaceuticals. It is important to note, however, that traditional herbal practice is unable to identify and select out remedies that have chronic carcinogenic or mutagenic side effects (De Boer, 2008).

2.7. Traditional veterinary medicine in Ethiopia

To treat both human and animal diseases, people in Ethiopia have been using traditional healing methods for a long time. Using of traditional medicine in connection with veterinary work has been termed as ethnoveterinary medicine. It is mainly concerned with folk beliefs, knowledge, skills, methods and practices which are used in the healthcare of animals (Fekadu Fullas, 2010). Ethiopia has large livestock population with estimates of farmer holdings in rural areas indicate that the country has about 50.9 million heads of cattle, 22 million goats, 26 million sheep and 2.3 million camels. These estimates exclude the livestock population in pastoral areas, as there are no official statistics for them (Azage Tegegne *et al*., 2013). However, animal disease remains one of the principal causes of poor livestock performance, leading to an ever increasing gap between the supply of, and the demand for, livestock products (Teshale Sori *et al*., 2004).

Pharmacotherapy is one of the most important means of controlling livestock diseases, but it is possible only if livestock owners can afford to cover the cost of treatments. Cost of treatment is therefore an important determinant of the usefulness of veterinary drugs (Ibrahim, 1986). Livestock owners cannot rely on veterinary services for control of various important livestock diseases; thus, people in Ethiopia used traditional veterinary methods to treat livestock diseases for generations as a practical solution for this problem, plants cover the largest component of the diverse therapeutic elements of traditional livestock healthcare practices (Endashaw Bekele, 2007).

2.8. Women's Health and Traditional Medicine

Women play an important role in the society as well as in the total life circumstances on earth. Despite obvious differences between women and men biologically, psychologically, and socially, the act of differentiating women's health from that of men came up in Western medicine only in the last two decades of the twentieth century. Only healthcare providers who are specialized in areas related to reproduction were expected to be knowledgeable about issues particular to women (Raja, 2015). In many of the developing countries, women serve as conservators and cultivators of medicinal plants. Through their household practices they use traditional approaches in caring for the health needs of the family. In Africa and Latin America, women constitute the majority of traditional medical practitioners, as well as the primary gatherers of medicinal plants (Lambert *et al*., 1997). "Women's health use plant" itself is defined as any plant reported to be used to increase fertility, induce menstruation, abortion, and fetal or placental expulsion, ease pregnancy and parturition, reduce menstrual bleeding, vaginal discharges, and postpartum hemorrhage, alleviate menstrual, parturition and postpartum pain,

increase or inhibit lactation, and treat mastitis, uterine prolapsed and sexually transmitted diseases (De Boer and Cotingting, 2014).

Women from rural sector or modern society rely on herbals for their healthcare and beauty care (Beal, 1998). Medicinal plants, because of their high values and little side effects, are used by women around the globe and the practice is growing quite encouragingly. Herbal remedies for women include medicinal herbs for problems like urinary tract infections, pubertal changes, post-menopausal syndrome, hot flushes, menopause, poly cystic ovarian syndrome, bacterial vaginosis, yeast infections, infertility, delayed labor, low breast milk production, abortion and other female disorders (Raja, 2015). Since women play multi roles and face a variety of problems, special healthcare is needed. Medical care is becoming costly and much painful; its affordability is not within the reach of the poor. There is, consequently, a great demand for usage of medicinal plants among women in both rural and urban sectors (Overk *et al*., 2008).

Ethiopian women had their own ways of dealing with health problems. The therapeutic methods and associated practices of the women are as diverse as their culture and the problem itself. However, the required positive effect on those ‘’women’s plants’’ is not always obvious and the effects of such practices on the users are not clearly studied. As a result, there is a lack of botanical data on the plants used. Additionally, women in Ethiopia have also indigenous knowledge on how to care for their beauty by using different plants either after childbirth or in their day-to-day life activities which is plant-based traditional cosmetics. In rural and semi-urban communities, women process and preserve cosmetics for the hair and the skin from various herbs, animal products and minerals. The preservation and processing of plant-based cosmetics over a long period of time has enabled women to accumulate vast knowledge and skills in the science. However, the knowledge of this important science has been relegated to a very low

status, that it is faced with extinction. It is well recognized that traditional cosmetic knowledge will be lost with its custodians unless efforts are made to record, research, and develop it to be used and passed on to future generations (Fetlework Ketsela, 1995).

2.9. Plants used for cosmetics

Herbal cosmetics are the products in which herbs are used in crude or extract form (Sahu *et al*., 2011). The demand of herbal medicines is rising fast due to their skin friendliness and lack of side effects. Hence, the World Health Organization currently recommends and encourages traditional herbal cures in natural healthcare programs as these drugs are easily available at low cost and are comparatively safe (Sharma *et al*., 2008). With these facts in Ethiopia, there are numerous herbs available naturally having different uses in cosmetic preparations naturally for skincare, hair care, as fragrant and other such uses. Women use these plants either after childbirth or in their day-to-day life activities (Fetlework Ketsela, 1995).

2.10. Threats to medicinal plants and associated knowledge

In Ethiopia traditional medicine 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 (Ensermu Kelbessa *et al*., 1992; Zemede Asfaw, 2001). Habitat and species are being lost quickly because of the combined effects of environmental degradation, agricultural expansion, deforestation and over harvesting of species. Due to this, loss of the biological diversity and indigenous knowledge which is also of global concern are happening in Ethiopia (Edwards, 2001; Ensermu *et al*., 1992). Hence, the diversity of plants in Ethiopia is on the process of erosion due to anthropogenic pressures (Abebe Demisse, 2001).

Some studies have shown that most of the medicinal plants utilized by Ethiopian people are harvested from wild habitats (Miruste Giday *et al.*, 2003; Mesfin Taddese *et al.*, 2005; Endalew Amenu, 2007; Fisseha Mesfin *et al*., 2009; Zewdie Kassa, 2009; Mohammed Adefa and Berhanu Abraha, 2011; Abreha Teklay *et al.*, 2013; Kalayu Mesfin *et al.*, 2013; Moa Megersa *et al.*, 2013; Mathewos Agize *et al.*, 2013). Hence, this aggravates the rate of loss of taxa with related indigenous knowledge and loss widely occurring medicinal plant species. Acculturation, deteriorated interest among younger generation in practice of traditional medicinal plants are also the other main causes to loss ethnomedicinal knowledge (Abbink, 1993 and1995; Miruste Giday *et al*., 2003). Another threat to the effective use of traditional medicinal plants and plants used for body care is related to getting pure products without adultration by other plant material. Thus, there is a need to put in place a method for authenticating purity of products particularly for marketed products to complement voucher specimen identification.

2.11. Conservation of medicinal plants

Conservation is defined as the sustainable use of biological resources. The concept of sustainability is now seen as the guiding principle for economic and social development, particularly with reference to biological resources. Conservation is achieved through in-situ and ex-situ means. In-situ conservation is conservation of species in their natural habitat. Some traditional plants have to be conserved in-situ due to difficulty for domestication and management. Moreover, some plants fail to produce the desired amount and quantity of the active principles under cultivation out of their natural habitats. Medicinal plants can also be conserved by ensuring and encouraging their growth in special places, as they have been traditionally (Zemede Asfaw, 2001).

Sustainable management of traditional medicinal plant resources is important, not only because of their value as a potential source of new drugs, but due to reliance on traditional medicine for health (Cunningham, 1993). Medicinal plants are considered to be at conservation risk due to over use and destructive harvesting (Roots and bark collection). Hence, medicinal plants can be conserved using appropriate conservational method in gene banks and botanical gardens (Zemede Asfaw, 2001).

The diversity of plants in Ethiopia is on the process of erosion due to anthropogenic pressure like habitat destruction and deforestation by commercial timber production and for agriculture which harbor useful medicinal plants over the past several decades (Abebe Demisse, 2001). Conservation of medicinal plant resource is a critical ecological, cultural and economic issue (Vanon *et al*., 2001). In order to achieve this, Ethiopia has polices and strategies that support the development and utilization of plant resources in a sustainable manner. The policies are reflected under various sectors including environmental protection, development of the natural resources and diversification of the domestic and export commodities. The country also has developed policy and a guide line for intellectual property rights protection of traditional medicine (Endashaw Bekele, 2007). The policies are in line with the convention on biological diversity (CBD) which was adopted at the earth summit in Rio de Janeiro, Brazil in June 1992, and entered in to force on December 1993. The CBD provides the legal framework for biodiversity conservation.

Moreover, documenting the indigenous knowledge through ethnobotanical studies is important for the conservation and utilization of biological resources particularly traditional medicinal plants (Sirvastava, 2000). These plants play an important role in the biodiversity of the region and have great conservation value for global biodiversity. Meanwhile, the planning for natural

resources development should continue by establishing close dialogue and communication with indigenous peoples using ethnobotanical approaches. This will also ensure local peoples participation in future management, and avoid the adverse impact on the local people and the environment that might be caused otherwise (Pei, 1991).

2.12. DNA Barcoding

DNA barcoding is a relatively new method which has been developed to provide rapid, accurate and automatable species identification using standardized DNA sequences as tags (Hebert *et al*., 2003; Taberlet *et al*., 2007), and recent papers have been written about DNA barcoding in plants (Schori and Showalter, 2011; Kool *et al*., 2012).

Barcoding has multiple applications and has been used for ecological surveys (Dick and Kress, 2009), cryptic taxon identification (Lahaye *et al.,* 2008) and confirmation of medicinal plant samples (Xue and Li, 2011). Barcoding works by matching sequence data from a query sample (an unknown specimen) to a reference sequence (from a voucher specimen) (Schori and Showalter, 2011). DNA barcoding can detect contamination and substitution of herbal products and help to protect consumers from health risks associated with product substitution and contamination. There are currently no best practices in place for identifying the species of the various ingredients used in herbal products. This is because the diagnostic morphological features of the plants on which the current Linnaean taxonomic system is based cannot typically be assessed from powdered or otherwise processed biomaterials. As a result, the marketplace is prone to contamination and possible product substitution, which dilute the effectiveness of remedies, lowering the perceived value of all related products because of a lack of consumer confidence in them (Newmaster *et al*. 2013). For example, in the work of Newmaster *et al.,*

(2013), DNA barcoding was effective to detect contamination and substitution in North American herbal products.

Generally, use of molecular markers and molecular diagnostic tools to give valuable support for the rapid and accurate identification of plant species through DNA barcoding is aimed at finding one or a few regions of DNA that will distinguish among the majority of the world's species, and sequence these from diverse sample sets to produce a large-scale reference library of life on earth (Hebert *et al*., 2003). This approach can then be used as a tool for species identification and to help in the discovery of new species (Hebert *et al*., 2004). Since there are currently no best practice in place for identifying the species of the various ingredients in herbal products to detect contamination and substitution of herbal products, this finding or identifying the species by barcoding is important to avoid health risk and protecting the herbal medicine consumers by authenticate the herbal medicine for the future in our context.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in South Wollo Zone of Amhara National Regional State specifically in Kalu and Bati districts (Figure 1).

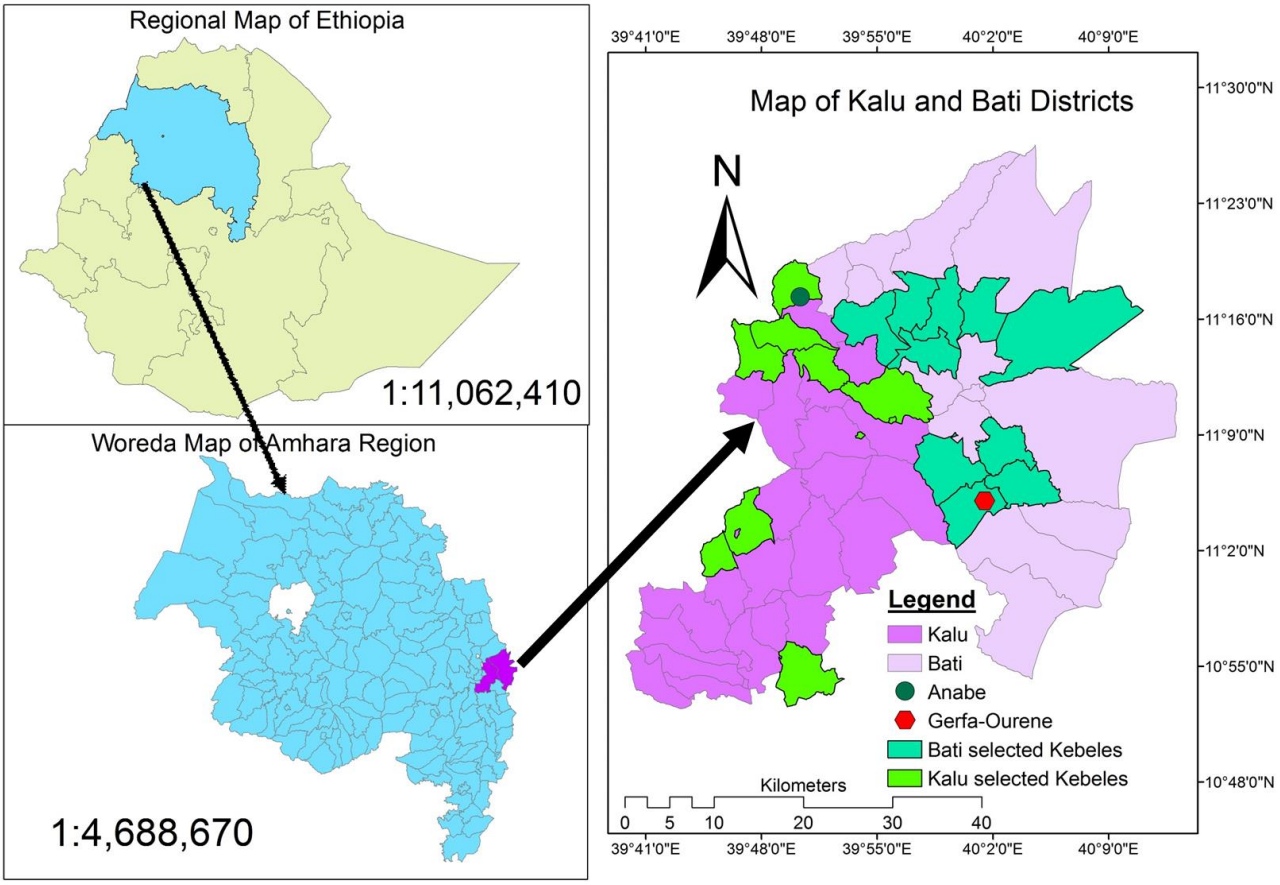

Figure 1. Map of Ethiopia showing Amhara region and the location of the study districts

3.1.1. Kalu District

3.1.1.1. Location

Kalu District is located at 10^0 48’ 0’’ and 11^0 11’ 0’’ N latitude and 39^0 41’ 00’’ and 39^0 55’ 0’’E longitude. Kombolicha is the capital of the District and is situated at 376 km north of Addis Ababa on Dessie road. Dessie Zuria and Albiko in the West, Dessie Zuria and Tehulederie in the North, Bati and Argoba in the East and Dawa chafa (Oromia Zone) in the south are boundaries of the District. It has 34 local administrative communities. Of these, 30 are rural and four are urban communities (KWARDO, 2009).

3.1.1.2. Topography

The altitude of the District ranges from 1400 to 1850 m.a.s.l. The District’s ecology is classified as mid altitude/ “weina-dega” (64%), high altitude/ “dega” (19%) and lowland/ “kola (17%) (KWARDO, 2009).

3.1.1.3. Climate

According to the monthly dataset collected from 1998 – 2016 from National Meteorology Services Agency of Ethiopia for the Kombolcha station the average mean rainfall record for 19 years was 1007 mm. The District has a bimodal rainfall with a long rainy season from July to September. Mean annual temperature of Kalu is 19.9^0C (Figure 2). The mean minimum and maximum temperatures in the District are 8.9^0C and 30.8^0C respectively (Figure 2).

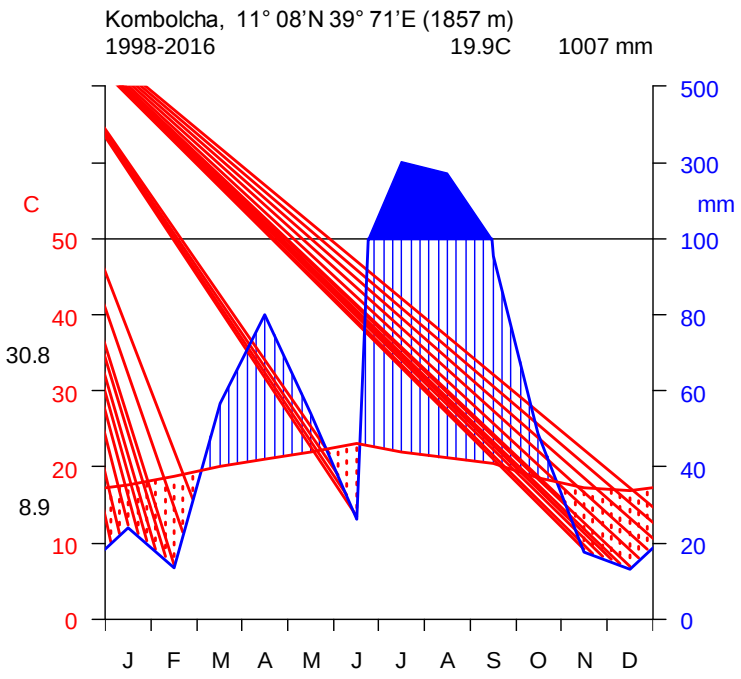

Figure 2. Climate diagram of Kalu District

3.1.1.4. Demographics

The total human population of the District is 203,768; the number of households in the District is 39,187, where 7,838 (20%) are female headed (CSA, 2007). Out of the total inhabitants 99% are followers of Islamic religion and the rest 1% are followers of different sects of Christianity. The largest ethnic group reported in Kalu District is the Amhara (99.24%) and Amharic is spoken as a first language by 99.27% (KWARDO, 2009).

3.1.1.5. Socio economic information, and land use in Kalu District

Kalu District is endowed with diverse natural resource, with capacity to grow diverse annual and perennial crops. Kalu is classified as one of the drought prone Districts in the Region. The dominant crops grown in the District are sorghum (*Sorghum bicolor*), "teff" (*Eragrostis tef*), haricot bean (*Phaseolus vulgaris*), chickpea (*Cicer arietinum*), and maize (*Zea mays*) during the

long rain season and "belg" seasons. The total land area of the District is 87,523 hectare. The land use pattern of the District is known to be cultivated land (27,454 ha), grazing land (937 ha), forest and bushland (51,614 ha), and building and settlement (3,786 ha) (KWARDO, 2009).

3.1.2. Bati District

3.1.2.1. Location

Bati District is one of the seven districts of Oromia Zone of the Amhara National Regional State (ANRS). The geographical location of Bati District is 10^0 05' 5" and 11^0 03' 0" N latitudes and 39^0 05' 0" and 40^0 01' 5" E longitude (BWARDO, 2007). It is situated 420 km in the north east direction from the capital city of Ethiopia, Addis Ababa. The capital of Bati District is Bati Town which is found 42 km east of Kombolcha town. The District has 32 peasant associations out of which 23 are rural peasant associations and nine are urban peasant associations.

The total area of the District is 124,696 ha; which is 34.6% in Oromia Zone. It has an altitudinal range between 1000-2500 m.a.s.l. The District shares boundaries with Afar National Regional State in the east, Kalu District (South Wollo Zone) in the west, Werebabu (South Wollo Zone) and Dawa Chefa District (Oromia Zone) in the south. The study area is agroecologically classified as mid altitude ("weyna dega") 19% and lowland ("Kola") 81% (BWARDO, 2007).

3.1.2.2. Topography and soil type

The landscape of Bati District is classified as rugged terrain (42%), mountainous (20%), gorge (28%) and plane (10%). Even though a large part of the land is covered with scattered bushes or shrubs, the soil is very shallow and consists of highly weathered and fractured volcanic rocks. Most of the farm plots are found in the hillsides and at bottom of mountains, following the valley, where the degree of vulnerability to erosion is very high. Type of soil found in the study District are black, red, sandy and gray soils (BWARDO, 2007).

3.1.2.3. Climate

From the nearby Bati principal weather station, the data collected from 1998–2016 indicated similar climatic characteristics like the Kombolcha Synoptic weather station (Figure 3). The annual average mean rainfall in this station is recorded to be about 899 mm/annum and the District has a bimodal rainfall with a long rainy season from July to September. Mean annual temperature of Bati is 21 ^{0}C while the mean minimum and maximum temperatures in the District are 9.7 ^{0}C and 33.1^{0}C respectively (Figure 3).

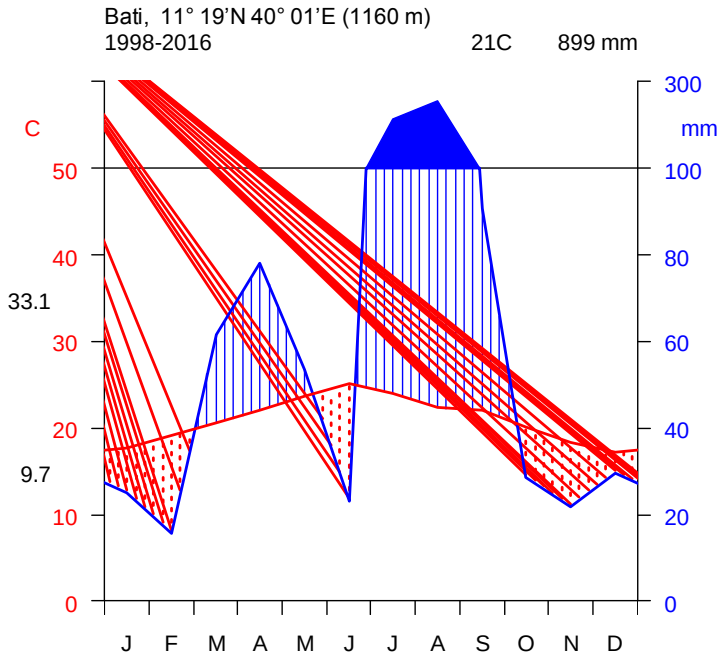

Figure 3. Climate diagram of Bati District

3.1.2.4. Demographics

The total population of the District is estimated to be 107,343. The rural population comprises 90,642 out of which 45,968 are male and 44,674 are female. The other 16,701 are urban dwellers

(CSA, 2007). The average family size is five and the population density is 92 persons per sq. km. This coupled with the rugged and mountainous landscape created the problem of deforestation and intensive cultivation including on steep lands which aggravated the rate of soil erosion. The main ethnic groups in the District are Oromo (92%), Amhara (7%) and Afar (1%). The most commonly spoken languages are Afan Oromo (88%) and Amharic (11.4%), while the main religions are Muslim (97.3%) and Orthodox Christian (2.4%) in the District (CHF, 2004).

3.1.2.5. Scio economic information and land use in Bati District

The socio economy of the people in Bati District is based on crop production and livestock rearing. All of the farmers are dependent on the main rainy season/"meher", which is erratic and inconsistent in frequency and distribution. Among the crop varieties that grow in the District Sorghum (*Sorghum bicolor*), "teff" (*Eragrostis tef*), and maize (*Zea mays*) are leading cereals (BWARDO, 2007). According to BWARDO (2007), the District has a total area of 124,696 ha; of this total 8.96% is cultivated, 15.16% is grazing land, 0.5% is forest, 49.38% is bush land, 6.8% is used for settlement, and over 19% is marginal land or waste land.

3.2. Research methods

3.2.1. Data collection

3.2.1.1. Vegetation data collection

A reconnaissance survey was made in September 2014 to get a general impression of the physiognomy of the two forest patches. Following that, detailed data collection was conducted in dry and wet seasons from December 2015 to May 2017. Four transects, 450 meters apart from each other for Anabe Forest patch; eight transects, 100 meters apart from each other for Gerfa-ourene Forest patch were established along an altitudinal gradient, from the top elevation of the mountain (2086 m.a.s.l.) to the bottom (2007 m.a.s.l.) for Anabe Forest patch and from the top (2162 m.a.s.l.) to the bottom (1935 m.a.s.l.) for Gerfa-ourene Forest patch where human interference is relatively low. A total of 50 and 30, 20 x 20 m2 quadrats were established for trees respectively for Anabe and Gerfa-ourene Forest patches. For shrubs 5 m x 5 m and herbs 1 m x1 m subplots were laid, within each quadrat respectively for Anabe and Gerfa-ourene Forest patches at every 60 m altitudinal drop.

A complete list of trees, shrubs and herbs including vascular epiphytes was made from the selected plots. Species occurring within 10 m distance from the plot boundaries were also recorded as present for floristic composition although not used for the analysis. Plants were identified during the fieldwork and that included recording of scientific names by the researcher and the vernacular names by informants. The cover abundance data (defined here as the proportion of area in a quadrat covered by every species recorded and gathered from each quadrat) was converted to cover abundance values using the modified 1-9 Braun-Blanquet scale (van der Maarel, 1979). In each plot, 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 were collected with the help of local field assistants.

3.2.1.2. Ethnobotanical data collection

Informant selection

General informants and key informants of the two Districts were selected using systematic random and purposive sampling approaches, respectively, following Martin (1995) and Alexiades (1996). The total number of informants involved in Kalu and Bati Districts in the ethnomedicinal study were 300 (150 from each district) constituting 180 males and 120 females. The ages of informants ranged from 18-85 years old. To select the key informants from each Kebele (sub-district), recommendations from elderly people and other community members were considered. Accordingly, 20 key informants from both districts taking 10 from each (18 males and 2 females) participated in the study, whereas general informants were selected using systematic random approach during formal visit of households in the study Kebeles. Authorized consent to do the research was obtained from the applicable administrative unit.

Semi-structured interview

A semi-structured list consisting of 26 questions was prepared which was covered in discussion with the informants in a particular order (Appendix 1). The interviews were done in their local language which is used most frequently with the informants, Amharic (Kalu District) and Afan Oromo (with the help of translators) and Amharic in Bati District while all responses were recorded in English. The interview was held independently with each informant. It was done with those born or having lived most of their lives in the districts. During the interview, information regarding local name of medicinal plant, the health problems treated, parts used, methods of preparation, mode of application, ingredients used in combination, threats and management and other relevant ones were recorded.

Guided field walk

Field walk together with guides and traditional healer(s) was made during the research as recommended by Cotton (1996) and Alexiades (1996). During that time, all relevant data including the vernacular name and scientific name of plants, the parts used, the preparation methods and modes of administration, and disease to be treated as well as their cultural knowledge for the conservation and preservation of medicinal plants was gathered. In some study sites, only the researcher and an informant made the field observation without the guide, as they were not willing to go with the guide to keep the indigenous knowledge secretly.

Informant consensus

The relative popularity of each medicinal plant species was evaluated based on the proportion of informants who independently report its medicinal use (informant consensus) in the area. During data collection, each informant was visited two times in order to confirm and exhaust the reliability of ethnobotanical information. The response of each informant, which was not in agreement with each other, was rejected and the informant replaced by another person. This is because such response is considered unreliable. As a result, only the relevant ones were taken into account and statistically analyzed (Heinrich *et al*., 1998).

Group discussion

Focus group discussions were conducted to verify the reliability of the data that had been collected through semi-structured interviews and to gain additional information on medicinal plant knowledge at the community level (Martin, 1995). Twenty focus group discussions in which (one-group discussion per kebele) in both districts were conducted. The discussions were undertaken with five informants at each kebele and while the group discussion, traditional

healers also participated sometimes in the discussion to share some common traditional knowledge with the selected informants for the discussion.

Plant specimen collection and identification

Voucher specimens were collected for each plant species. The local names, scientific names, habits and associated plant knowledge were recorded. The collected voucher specimens were taken to the National Herbarium (ETH), Addis Ababa University. The identification was done by using taxonomic keys in the various volumes of the Flora of Ethiopia and Eritrea; whereas, the molecular identification was done in the laboratory of Natural History Museum, University Of Oslo, Norway.

Market survey

According to Martin (1995), conducting a survey of useful plants in a market place is similar to carrying out an ethnobotanical inventory in a community. A market survey was conducted at eight markets of both districts. Among these, seven of them were weekly markets, i.e. Adame, Bati, Degan, Gedero, Gerba, Harbu and Kombolcha whereas, Borchelle was a daily market. From the listed local markets in the two districts, only Bati weekly market was found in Bati district, where as others were belongs to Kalu district. Each marketable medicinal plants were documented and voucher specimens of medicinal plants were collected.

3.2.1.3. Methods to identify and classify plants using DNA barcodes

Sample collection

A total of 145 medicinal plant species which belong to 116 genera and 62 families were collected from Kalu and Bati districts. Of these, 87 medicinal plant species were gathered in voucher form, 49 of them both in silica gel and voucher form whereas 9 medicinal plant species were collected

only by silica gel. Additional 9 powder form of three medicinal plant species from the market in the study districts were also gathered. Hence, 203 samples were extracted and 154 samples were amplified, which are the 145 collected traditional medicinal plants and 9 additional powder form for three medicinal plant species (Appendix 10). The plant parts of the collected medicinal plant species were 136 were leaf samples, 4 each of roots and stems and 1 seed. From the collected 145 medicinal plant species 140 of them were identified morphologically at National Herbarium (ETH), Addis Ababa University, whereas 5 of them were not identified morphologically.

DNA extraction, amplification and sequencing

DNA extraction

Genomic DNA was extracted from the silica-gel-dried leaves, voucher specimens and the powder medicinal plant samples using a modified CTAB (cetyl trimethyl ammonium bromide) procedure (Cota-sánchez *et al.*, 2006) in the step-wise protocol.

PCR amplification and sequencing

The ITS region (ITS4 and ITS5) was amplified using the universal primers ITS4 (5'-TCCTCCGCTTATTGATATGC-3') and ITS5 (5'-GGAAGTAAAAGTCGTAACAAGG-3') (White *et al*., 1990); rbcL region, rbcLa-F (5'-ATGTCACCACAAACAGAGACTAAAGC-3') (Fazekas A *et al*., 2008) and rbcLr590 (5'-AGTCCACCGCGTAGACATTCAT-3') De Vere *et al*., (2012); matK, matK_3F-Kim *(5'-CGTACAGTACTTTTGTGTTTACGAG-3')* and matK_1R-Kim(5'-ACCCAGTCCATCTGGAAATCTTGGTTC-3') Jeanson ML *et al*., (2011); matK390F (5'-CGATCTATTCATTCAATATTTC-3') and matK1326R(5'-TCTAGCACACGAAAGTCGAAGT-3') Cuénoud *et al*., (2002). PCR amplification was carried out under the following conditions: initial denaturation at 94ºC (5 min) followed by 35 cycles of 94ºC denaturation (30sec), 50ºC annealing (30 sec), and 72ºC extension (50 sec) a final

extension at 72ºC for 7 min for ITS; for rbcL: initial denaturation at 94ºC (5 min) followed by 35 cycles of 94ºC denaturation (30sec), 50ºC annealing (30 sec), and 72ºC extension (50 sec), a final extension at 72ºC for 7 min; for matK (matK_3F-Kim/ matK_1R-Kim): initial denaturation at 94ºC (2min 30 sec), followed by 30 cycles of 94ºC denaturation (30sec), 54ºC annealing (30 sec), and 72ºC extension (10 min) a final extension at 72ºC for 10 min and for matK390F /matK1326R: initial denaturation at 94ºC (2min 30 sec), followed by 30 cycles of 94ºC denaturation (30sec), 50ºC annealing (30 sec), and 72ºC extension (30sec); a final extension at 72ºC for 10 min. The final PCR products were sequenced by Sanger sequence.

3.2.2. Data Analysis

3.2.2.1. Vegetation data analysis

Multivariate analysis of vegetation data

The cover/abundance data of all plant species in all plots was analyzed and classified by applying R-computer program for Agglomerative Hierarchical Cluster Analysis using R Version 3.0.2, 2013 with the help of libraries (Cluster and Vegan). The resulting groups were recognized as community types. Each community was named by two dominant species manifesting high cover-abundance value.

Plant diversity analysis

The Shannon-Wiener (1949) diversity index was applied to quantify species diversity by running R Version 3.0.2, 2013 using library Vegan as used in Zerihun Woldu (2012). This method is one of the most widely used approaches in measuring the diversity of species in community ecology (Kent and Coker, 1992) and calculated as:

H' $= -\sum_{i=1}^{s} pilnpi$ Where,

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=natural logarithm,

Species evenness or equitability is used to quantify the unique representation of a given species against a hypothetical community in which all species are equally common. One of the simplest means of analyzing floristic vegetation data is to look at the degree of association between species and level of similarity between plots or samples (Kent and Kocker, 1992). Evenness was calculated using R-software with the formula:

J=H'/lns Where, J=evenness or equability

H'= Shannon-Wiener Diversity Index,

S=total number of species in the sample, and

ln=natural logarithm

The value of evenness index falls between 0 and 1. The higher the value of evenness index (J), the more even the species in its distribution within the given area. (i.e., community or quadrat) (Kent and Kocker, 1992). Species richness of the two forest patches in various quadrats was also compared using R-software.

The frequency of the vascular plant species in all the plots was computed. It shows the level of distribution of individual species in an area and commonly expressed in terms of percentage occurrence, which is the number of times a species occurs in a given number of frequently

placed sample plots. The higher the frequency, the more important the plant is in the community (Kent and Kocker, 1992). The importance of a species with the frequency can be obtained by comparing the frequency of occurrences of all of the plant species present. The result is called the relative frequency and is given by the formula:

$$RF = \frac{Frequency\ of\ a\ species}{Total\ frequency\ of\ all\ species} * 100, \quad Where\ RF = Relative\ frequency$$

$$\text{Frequency (\%)} = \frac{\text{Number of plots in which the species occured}}{\text{Total nunber of plots studied}} * 100$$

3.2.2.2. Structural Analysis of Anabe and Gerfa-ourene Forest patches

The structure of the forest patches were analyzed in terms of Density, DBH and basal area (BA) per hectare in both Anabe and Gerfa-ourene. Frequency of a species which is the probability of finding a species in a given plot was calculated as the percentage of samples within which a species is found. Density and basal area were computed from all plots in a hectare basis following Kent & Coker (1992). The DBH was classified into seven DBH classes in Anabe Forest patch following Tamrat Bekele (1993), and five DBH classes in Gerfa-ourene Forest patch then percentage distribution of woody species in each class was computed per DBH class (Kent and Coker, 1992). Basal area of trees which is the cross-sectional area of tree stems at breast height was calculated as, BA=$\pi d2/4$, Where: BA= Basal Area in m2 per hectare; d = diameter of tree stem at breast height. This measures the dominance, which is the degree of coverage of species as an expression of the space it occupies (Barbour *et al*., 1987). To determine the overall importance of each species in the forest patches, Importance value indices

of woody species were computed by adding relative density, relative frequency and relative dominance of the individual species (Mueller-Dombois and Ellenberg, 1974).

3.2.2.3. Floristic similarity analysis

Sorensen's similarity (Ss) coefficient was computed using qualitative data and is widely used because it gives more weight to the species that are common to the samples rather than to those that only occur in either sample (Kent and Kocker, 1992). It ranges from 0 (complete dissimilarity) to 1(total similarity) and is described using the following formula (Kent and Kocker, 1992).

$Ss = \frac{2a}{(2a+b+c)}$, Where Ss= Sorenson's Similarity Coefficient

a=the number of species common to both samples,

b=the number of species in sample 1(community1) and

c= the number of species in sample 2(community2)

The floristic similarity of community types was assessed using Sorenson's coefficient of similarity (Ss) directly by applying R-computer program (R Version 3.0.2, 2013) as used in Zerihun Woldu (2012).

3.2.2.4. Ethnobotanical data analysis

Preference ranking

Preference ranking was made following Martin (1995) and accordingly, doing preference ranking involves asking each selected key informant to arrange some items in accordance to their perceived degree of importance in their community. The 10 key informants in each district were chosen from the list of people who already participated in the interview to rank those selected

medicinal plants individually according to their preferences. Each rank was stated by integer values 1, 2, 3, 4, and 5. The most preferred plant was given the highest value 5 while the least important was given a value of 1. Overall scores for the species were given by adding up these values for all respondents and giving the first rank to the highest total score.

Direct matrix ranking

Direct matrix ranking was conducted following Cotton (1996) for multipurpose medicinal plants. Based on the relative benefits obtained from each plant, informants were asked to order the items by considering several attributes one at a time. Ten key informants were selected and asked to assign numerical scale individually in which the highest number is equal to the most preferred benefit/attribute of a multipurpose species being compared whereas, the lowest is given to the least benefit. Then, the informants were asked to rate their preferences. Informants were asked to give values to different usages of a medicinal plant species as agricultural tool, construction, firewood, charcoal, fodder, fence and medicine based on the degree of importance (with 5= best; 4= very good; 3=good; 2= less used and 1=least used. Direct matrix ranking exercise was conducted for multipurpose medicinal plants to determine the main cause for over harvesting of the respective plants (Cotton, 1996).

Informant consensus factor (ICF)

Informant Consensus Factor was calculated to determine the most important human ailment types in the study districts, and categorize potentially effective medicinal plant species in the corresponding disease types. Consequently, the reported traditional remedies and equivalent diseases were grouped into 11 categories for humans in each districts and ICF was then calculated by computing number of use citations in each disease category (nur) minus the

number of times a species used (nt), divided by the number of use citations in each category minus one (Heinrich *et al*., 1998).

ICF=$\frac{nur-nt}{nur-1}$ Where;

ICF= is informant Consensus Factor

nur= is number of use citation

nt= is number of species used

Fidelity level index

Fidelity level index is used to quantify the importance of a given species for a particular purpose in a given cultural group (Friedman *et al*., 1986; cited in Cotton, 1996). The relative healing potential of individual medicinal plants used against human or livestock ailments using an index called Fidelity Level Index (FL) based on the proportion of informants who agreed on the use of a given medicinal plant against a given disease. The formula for FL is given as FL percentage = Ip/Iu X 100, where Ip, is the number of informants who independently indicated the use of a species for the same major ailments and Iu, the total number of informants who mentioned the plant for any major ailment.

3.2.2.5. Sequence analysis for DNA barcoding

From the Macrogen results 154 samples yielded sequences. New Fasta files were generated for ITS, rbcL and matK from the received trace files. Hence, results were aligned by SeqTrace (0.9.0) version 3 free software. Each of the sequences in the three FASTA files were then queried using NCBI BLAST, https://blast.ncbi.nlm.nih.gov/Blast.cgi# to the online database. The highest-scoring hit from each query is taken as the barcoding identification.

CHAPTER FOUR

4. RESULTS

The study presented the floristic diversity of the selected two forest patches, Anabe and Gerfa-ourene forest patches, the ethnomedicinal and cosmetic plants that people cared about in the two districts, and the DNA barcoding sequences of the medicinal and cosmetic plant species. From the selected forest patches, totally 128 plant species which belong to 114 genera and 60 families were recorded. Among them 68 of the total were common for both of the two forest patches (Appendix 2). The plant diversity of each forest patch is described in the following sections.

4.1. Plant diversity in Anabe Forest patch

4.1.1. Floristic composition

A total of 108 plant species representing 97 genera and 52 families were identified in Anabe forest patch (Appendix 2). Fifty percent of the families were represented by more than one species. The highest number of species was recorded for families Lamiaceae (9 species, 17%) and Fabaceae (7 species, 13%) followed by Asteraceae, Poaceae (six species each, 12%), Rubiaceae (5 species, 10%), Pteridaceae, Flacourtiaceae (four species, 8% each), Acanthaceae, Boraginaceae and Euphorbiaceae (three species each, 6%). Sixteen of the families, i.e. Apocynaceae, Cucurbitaceae, Cupressaceae, Myrtaceae, Oleaceae, Polygonaceae, Rosaceae, Rutaceae, Sapindaceae, Anacardiaceae, Asparagaceae, Aspleniaceae, Commelinaceae, Crassulaceae, Malvaceae and Tiliaceae were represented by two species (31%) each, whereas the remaining 26 (50%) families only had single-species representation. Three species (1.85%), which are *Acalypha Marissima, Lippia adoensis and Millettia ferruginea* in Anabe forest patch are endemic to Ethiopia (Appendix 2). Herbs were found to occur more abundantly (39 species, 36.11%) followed by trees (32, 29.63%), shrubs (27, 25%) and climbers (both liana and herbaceous forms) (10, 9.26%).

4.1.2. Plant community types in Anabe Forest patch

Three plant community types were identified from the hierarchical cluster analysis of Anabe Forest patch (Figure 4). Species with the highest synoptic values in the group were used to name the corresponding communities (Table 1).

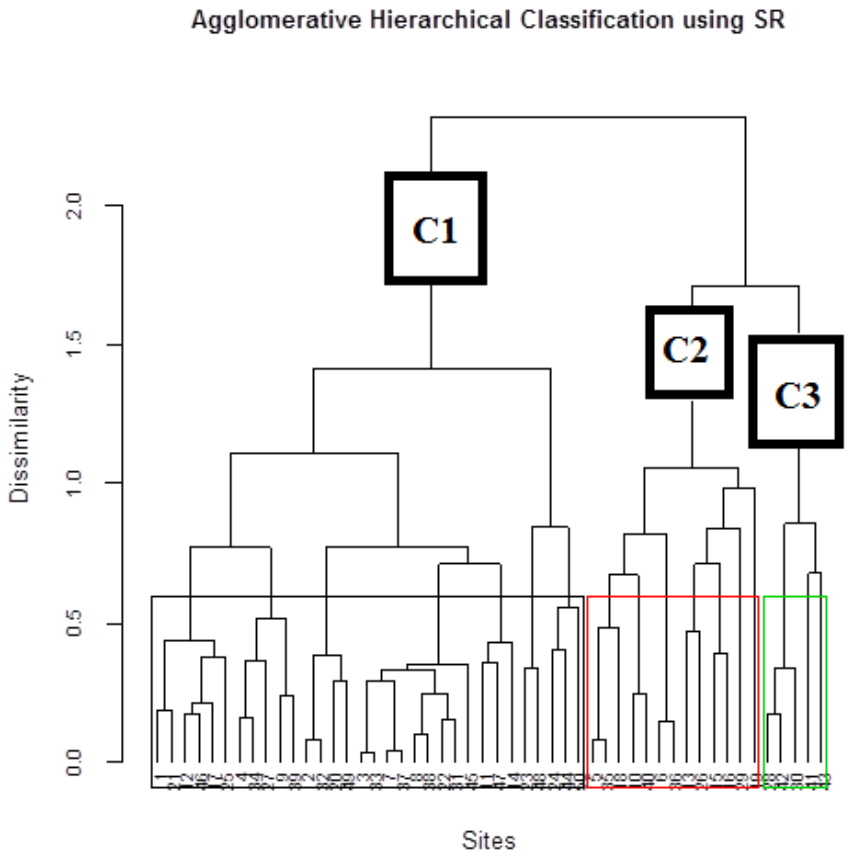

Figure 4. Dendrogram obtained from hierarchical cluster analysis of vegetation data of Anabe Forest patch

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

Community	**1**	**2**	**3**
Cupressus lusitanica	**7.28**	0.31	0
Juniperus procera	**6.31**	5.15	0
Podocarpus falcatus	3.47	**4.54**	2.6
Pittosporum viridiflorum	0	**2.08**	0.6
Olea europaea subsp.*cuspidata*	1.53	1.85	**8.2**
Acacia abyssinica	1.34	0.85	**5.2**
Myrsine africana	1.16	1.54	0.4
Ficus sur	1.00	0.54	1.0
Carissa spinarum	0.81	0.92	0.4
Achyranthes aspera	0.78	0.46	0.4
Oplismenus hirtellus	0.56	0.62	0
Dovyalis verrucossa	0.56	0.31	0
Maytenus arbutifolia	0.53	0.54	0.4
Phaulopsis imbricata	0.50	0.23	0
Calpurnia aurea	0.47	0.46	1.2
Euclea racemosa	0.47	1.15	0
Caesalpinia decapetala	0.44	0.62	0.8
Croton macrostachyus	0.44	0.62	0
Rosa abyssinica	0.28	1.0	0
Bersama abyssinica	0.25	0.46	0.6
Psidium guajava	0.19	0	0.8
Prunus africana	0.19	0.77	0
Grewia ferruginea	0.09	0	1.4
Psydrax schimperiana	0.09	0.69	1.0
Ehretia cymosa	0.06	0.54	0.4
Premna schimperi	0	0.62	0.6

A description of the community types identified in Anabe forest patch is given below:

Community 1: *Cupressus lusitanica-Juniperus procera* Community Type

The *Cupressus lusitanica-Juniperus procera* community type was distributed between 2063 and 2286 m.a.s.l. It consisted of 75 species distributed in 32 quadrats; the upper canopy of the community type was dominated by *Cupressus lusitanica* and *Juniperus procera*. The understory was occupied by herbaceous plants such as *Bidens pilosa*, *Bothriochloa insculpta*, *Hyparrhenia*

collina, *Hypoestes forskaolii*, *Phaulopsis imbricata* and *Salvia tiliifolia*. Species such as *Achyranthes aspera*, *Asplenium monanthes*, *Galinsoga Parviflora*, *Oplismenus hirtellus* and *Pennisetum thunbergii* were also frequently occur in this community.

Community 2: *Podocarpus falcatus-Pittosporum viridiflorum* Community Type

Altitudinal distribution of this community type ranges from 2055 to 2240 m.a.s.l. *Podocarpus falcatus* and *Pittosporum viridiflorum* were the dominant species forming the upper canopy. The community comprised of 56 species distributed in 13 quadrats. Species such as *Allophylus abyssinicus*, *Cassipourea malosana*, *Cordia africana*, *Croton macrostachyus*, *Dodonea angustifolia*, *Ehretia cymosa*, *Premna schimperi* and *Prunus africana* were also found in a few numbers in this community type. On the herbaceous layer of this community *Achyranthes aspera*, *Commelina benghalensis*, *Hyparrhenia collina*, *Hypoestes forskaolii*, *Kalanchoe densiflora*, *Salvia tiliifolia*, *Satureja punctate*, *Setaria megaphylla* and *Themeda triandra* were common.

Community 3: *Olea europaea* subsp. *cuspidata-Acacia abyssinica* Community Type

This community occurred in 5 quadrats extending from 2007 to 2074 m.a.s.l. and had 36 species. *Olea europaea* subsp. *cuspidata* and *Acacia abyssinica* trees were the dominant species in the upper layer. It also contained some other important species including *Acacia decurrens*, *Celtis africana*, *Ficus sur*, *Grewia ferruginea*, *Grewia trichocarpa*, *Olinia rochetiana* and *Teclea simplicifolia*. The herbaceous layer of this community included species such as *Actiniopleris semioabellata*, *Cynoglossum lanceolatum*, *Hyparrhenia collina*, *Hypoestes forskaolii* and *Salvia tiliifolia*.

4.1.3. Species richness, Diversity and Evenness in Anabe Forest patch

The identified plant communities of Anabe Forest patch showed the highest value of overall species richness (86) for community 1, species diversity (Shannon's diversity) (3.45) and species evenness (0.83) for community 2 (Table 2).

Table 2. Overall species richness, diversity and evenness values of the three plant communities identified in Anabe Forest patch

Community types	**Altitudinal range**	**Species Richness (S)**	**Shannon-Wiener Diversity Index (H')**	**Shannon's evenness index (J)**
1: *Cupressus lusitanica - Juniperus procera*	2063-2286	86	3.14	0.70
2: *Podocarpus falcatus - Pittosporum viridiflorum*	2055-2240	63	3.45	0.83
3: *Olea europaea* subsp. *Cuspidata - Acacia abyssinica*	2007-2074	36	2.88	0.80

4.1.4. Sorensen's similarity index in the three plant communities identified in Anabe Forest patch

Analysis of the similarity between the three plant communities showed that there was more floristic similarity (0.65) between communities one and two, than between any of the others (Table 3). The least similarity with any of the other communities was recorded for community three.

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

Community types	**C1**	**C2**	**C3**
1: *Cupressus lusitanica - Juniperus procera*		0.65	0.48
2: *Podocarpus falcatus - Pittosporum viridiflorum*			0.5
3:*Olea europaea* subsp. *Cuspidata - Acacia abyssinica*			

4.1.5. Vegetation structure of the Anabe Forest patch

4.1.5.1. Density of trees and shrubs

The overall tree and shrub species density in Anabe Forest patch was 2246.13 individuals ha-1. The density of trees and shrubs with DBH > 2 cm was 1490.72 individuals ha-1. The density of those species with DBH > 10 cm was 513.62 individuals ha-1 whereas that of species with DBH > 20 cm was 241.78 individuals ha-1. Thus, the ratio of density of trees with DBH greater than 10 cm to DBH greater than 20 cm in Anabe Forest patch was 2.12. About 66.37% of overall tree density came from species with DBH > 2 cm, whereas those with DBH > 10 cm and 20 cm contributed, respectively, 22.87% and 10.76% to overall tree density.

4.1.5.2. Diameter at Breast Height (DBH)

The percentage distribution of trees and shrubs in Anabe Forest patch across seven DBH classes indicated a relatively high proportion of individuals in DBH class 2-10 cm (46.10%) and DBH class 10-20 cm (38.62%). The lowest proportion of individuals was recorded for DBH class 50-80 cm (Figure 5). *Cupressus lusitanica*, *Juniperus procera* and *Podocarpus falcatus* were found to be the dominant large-sized trees in Anabe Forest patch, with DBH 80-110, DBH 110-140 cm and DBH >140 cm (Figure 5).

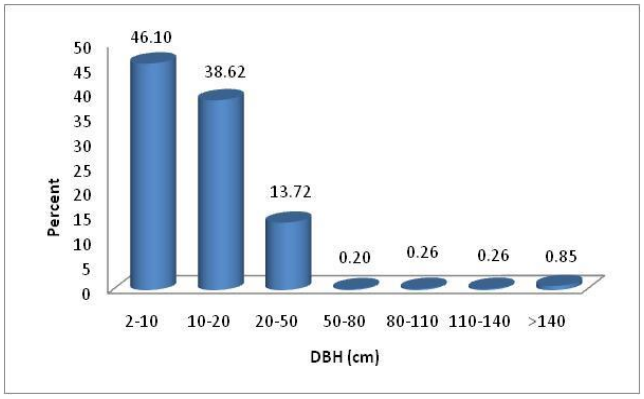

Figure 5. Proportion of DBH class distributions of trees and shrubs in Anabe Forest patch

4.1.5.3. Basal area (BA)

Total basal area of trees in Anabe Forest patch was 29.09 m2/ha (Appendix 3). About 85.40% of the total basal area was contributed by eight large-sized tree species, i.e. *Podocarpus falcatus*, *Ficus sur*, *Juniperus procera*, *Cupressus lusitanica*, *Olea europaea* subsp *cuspidata*, *Acacia abyssinica*, *Croton macrostachyus* and *Ekebergia capensis* (Table 4).

Table 4. Basal area (BA) (m2 ha -1) and percentage contribution of eight most dominant trees and shrubs in Anabe Forest patch

Scientific name	**BA (m2/ha)**	**Percent contribution**
Podocarpus falcatus	291.57	32.33
Ficus sur	127.02	14.08
Juniperus procera	102.40	11.35
Cupressus lusitanica	83.64	9.27
Olea europaea subsp. *cuspidata*	56.86	6.30
Acacia abyssinica	40.85	4.53
Croton macrostachyus	37.75	4.19
Ekebergia capensis	30.09	3.34
Total	**770.19**	**85.40**

4.1.5.4. Frequency

Juniperus procera was found to be the most frequent species in Anabe Forest patch occurring in 80% of all quadrats sampled. Species such as *Podocarpus falcatus* (68%) and *Cupressus lusitanica* (66%) were also common across quadrats. A list of most frequent trees occurring above 20% of quadrats sampled is given in Table 5, and frequency of all species documented from Anabe Forest patch with DBH > 2 cm is given in Appendix 4.

Table 5. Most-frequent trees and shrubs in Anabe Forest patch

Scientific Name	**Frequency (%)**
Juniperus procera	80
Podocarpus falcatus	68
Cupressus lusitanica	66
Myrsine africana	58
Olea europaea subsp *cuspidata*	40
Maytenus arbutifolia	38
Acacia abyssinica	26
Calpurnia aurea	26
Bersama abyssinica	22
Pittosporum viridiflorum	22

4.1.5.5. Importance Value Index (IVI)

The highest IVI values were recorded for ten of the most frequent trees and shrubs in Anabe Forest patch. The highest IVI value was recorded for *Podocarpus falcatus* (75.24) followed by *Juniperus procera* (56.69) (Table 6).

Table 6. IVI values of ten most-frequent trees and shrubs in Anabe Forest patch

Scientific name	**Rel.Den**	**RF**	**Rela. Dom**	**IVI**
Podocarpus falcatus	7.89	11.56	55.79	75.24
Juniperus procera	40.72	13.61	2.37	56.69
Cupressus lusitanica	21.75	11.22	3.78	36.76
Olea europaea subsp. *cuspidata*	8.35	6.80	2.34	17.50
Myrsine africana	5.86	9.86	0.05	15.78
Acacia abyssinica	3.19	4.42	3.91	11.52
Ficus sur	0.58	2.72	6.04	9.34
Maytenus arbutifolia	1.57	6.46	0.27	8.30
Calpurnia aurea	1.57	4.42	0.35	6.33
Croton macrostachyus	0.75	2.04	3.23	6.03

4.1.5.6. Population structure

The population structures of the 13 most-common tree species in the Anabe Forest patch was analyzed and four representative patterns were identified (Figure 6 a-d).

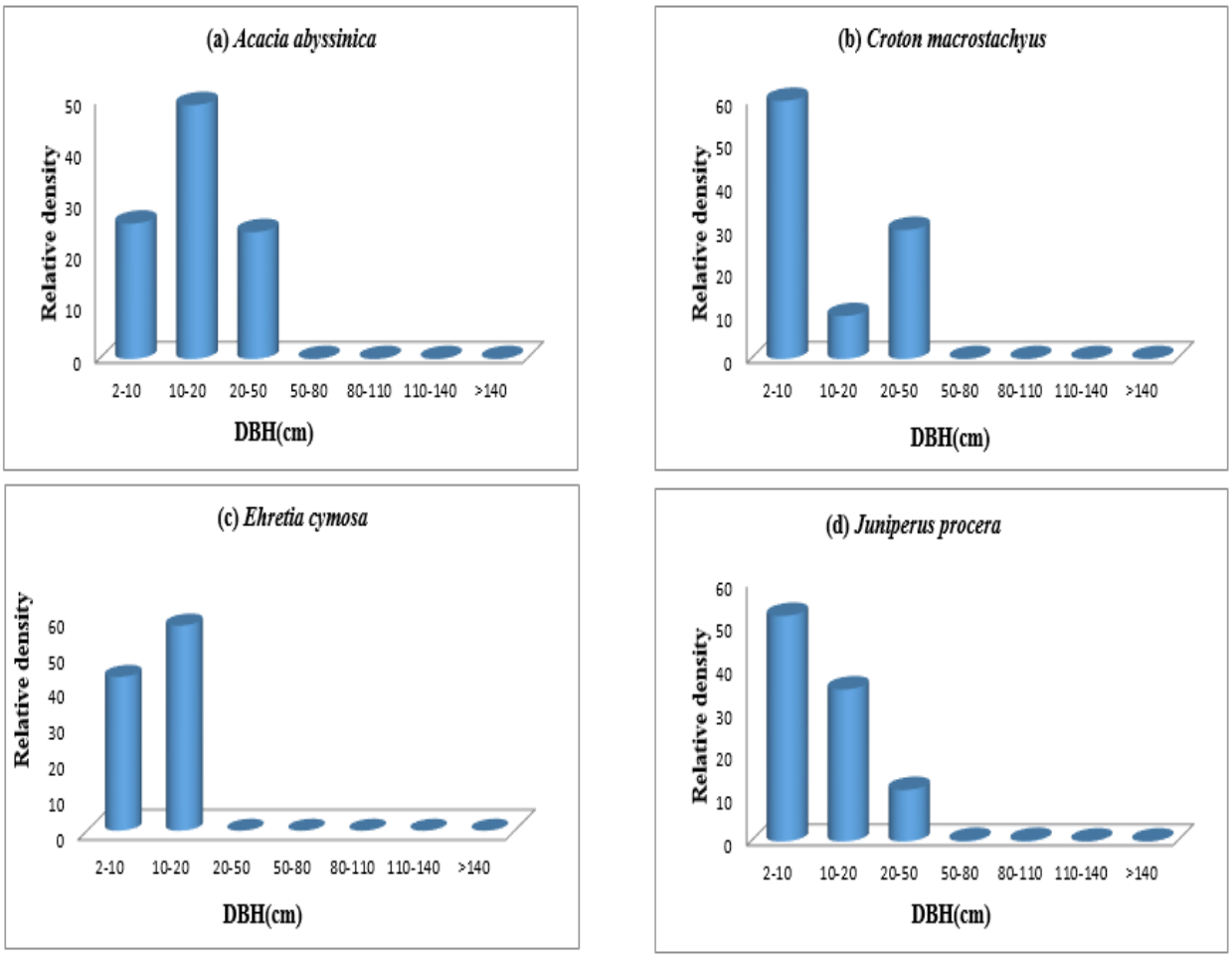

Figure 6. Representative patterns of species population structures in Anabe Forest patch (a-d)

4.2. Plant diversity in Gerfa-ourene Forest patch

4.2.1. Floristic composition

A total of 84 plant species representing 75 genera in 46 families was identified in Gerfa-ourene Forest patch (Appendix 2). Thirty five percent of the families were represented by more than one species. The highest number of species was recorded for families Lamiaceae (9 species, 20%) and Poaceae (7 species, 15%) followed by Fabaceae (five species, 11%), Anacardiaceae, Euphorbiaceae (four species, 9% each) Asteraceae, Pteridaceae and Tiliaceae were represented by three species (7%) each. Eight of the families, i.e. Acanthaceae, Apocynaceae, Asparagaceae, Aspleniaceae, Commelinaceae, Oleaceae, Rosaceae, and Rubiaceae were represented by two species, whereas the remaining 30 (65%) families only had single-species representation. One species (1.19%) in Gerfa-ourene Forest patch is endemic to Ethiopia (Appendix 2). Herbs were found to occur more abundantly (31 species, 37%) than shrubs (27, 32%), trees (18, 21%) and climbers (both liana and herbaceous forms) (8, 10%).

4.2.2. Plant community types in Gerfa-ourene Forest patch

Three plant community types were identified after the hierarchical cluster analysis of Gerfa-ourene Forest patch (Figure 7). Naming of the communities were done by the parallel species with the highest synoptic values in the group (Table 7).

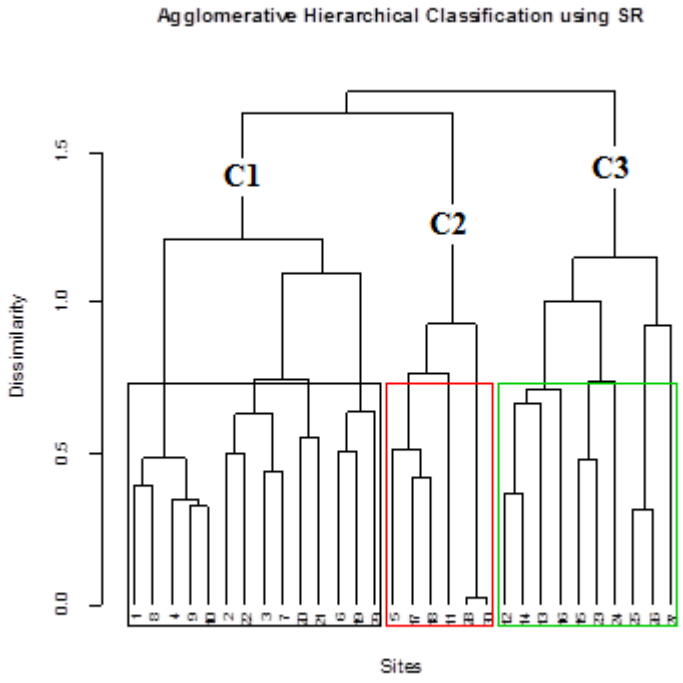

Figure 7. Dendrogram from the hierarchical cluster analysis of vegetation data of Gerfa-ourene Forest patch

Table 7. Synoptic cover abundance values of species reaching a value of > 0.5 in at least one community type in Gerfa-ourene Forest patch. Values in bold refer to species used to name community types

Community	**1**	**2**	**3**
Psydrax schimperiana	**4.50**	1.67	0.3
Juniperus procera	**4.29**	0.67	0.3
Prunus africana	2.00	**5.50**	1.0
Acokanthera schimperi	1.07	**4.50**	0
Acacia abyssinica	0.57	0	**4.3**
Pittosporum viridiflorum	2.07	0.50	**2.5**
Olea europaea subsp.*cuspidata*	4.07	0	0.7
Rhus glutinosa	3.21	2.50	3.2
Cadia purpurea	3.07	1.83	0.4
Dodonea angustifolia	2.86	0	2.8
Euclea racemosa	2.57	2.50	2.3
Calpurnia aurea	1.50	1.00	2.1
Myrsine africana	1.07	0	1.6
Maytenus arbutifolia	0.86	0.33	1.5
Olinia rochetiana	0.64	0	2.1
Ehretia cymosa	0.50	1.50	0.5
Rhus retinorrhoea	0.36	0	1.0
Premna schimperi	0.29	1.33	0.6
Celtis africana	0.21	3.50	1.4
Flacourtia indica	0	1.17	0

The details of the identified community types in Gerfa-ourene Forest patch is given below:

Community 1: *Psydrax schimperiana* - *Juniperus procera* Community Type

The *Psydrax schimperiana* - *Juniperus procera* community type was found between 1998 and 2162 m.a.s.l. This community type contained 61 species distributed in 14 plots, *Psydrax schimperiana* and *Juniperus procera* were dominant in the upper canopy of the community. The herbaceous species including *Salvia tiliifolia*, *Hyparrhenia collina*, *Achyranthes aspera* and *Phaulopsis imbricata* were found abundantly in the understory. *Asplenium aethiopicum*, *Cheilanthes farinosa*, *Hypoestes forskaolii*, *Plectranthus punctatus*, *Polygala abyssinica* and *Setaria megaphylla* were also frequently recorded in this community type.

Community 2: *Prunus africana - Acokanthera schimperi* Community Type

This community type was found between 1935 to 2059 m.a.s.l. altitudinal ranges. *Prunus africana* and *Acokanthera schimperi* were the dominant species forming the upper canopy. The community encompassed 37 species which were distributed in six plots. In this community type species like *Ehretia cymosa, Flacourtia indica, Grewia trichocarpa* and *Nuxia congesta* were also found in a few numbers. The herbaceous layer of the community contained *Hypoestes forskaolii, Oplismenus hirtellus, Phaulopsis imbricata* and *Salvia tiliifolia*.

Community 3: *Acacia abyssinica - Pittosporum viridiflorum* Community Type

The altitudinal range of this community type is stretching from 2031 to 2118 m.a.s.l. and this community was found in 10 quadrats. It had 52 species in 10 plots, the upper layer dominated by *Acacia abyssinica* and *Pittosporum viridiflorum.* This community in the lower layers includes species like *Croton macrostachyus, Dodonaea angustifolia, Ekebergia capensis, Heteromorpha arborescens, Olea europaea* subsp. *cuspidata* and *Olinia rochetiana*. *Bidens pilosa, Galinsoga Parviflora, Hetropogon contortus, Satureja punctata, Setaria megaphylla, Themeda triandra* and *Thymus schimperi* were also included in the herbacious layer of this community.

4.2.3. Species richness, Diversity and Evenness in Gerfa-ourene Forest patch

The identified plant communities of Gerfa-ourene Forest patch showed that the highest value of overall species richness (62) for community 1, species diversity (Shannon's diversity) (3.38) for community 3, and species evenness (0.85) for community 2 (Table 8).

Table 8. Overall species richness, diversity and evenness values of the three plant communities identified in Gerfa-ourene Forest patch

Community types	Altitudinal range	Species Richness (S)	Shannon-Wiener Diversity Index (H')	Shannon's evenness index (J)
1:*Psydrax schimperiana - Juniperus procera*	1998-2162	62	3.33	0.8
2:*Prunus Africana - Acokanthera schimperi*	1935-2059	36	3.07	0.85
3:*Acacia abyssinica - Pittosporum viridiflorum*	2031-2118	54	3.38	0.84

4.2.4. Sorensen's similarity index in the three plant communities identified in Gerfa-ourene Forest patch

The analysis of similarity in species between the three plant communities showed a high floristic similarity between communities one and three, than between any of the others (Table 9). The least similarity with every other community was recorded for community three.

Table 9. Sorensen's similarity analysis of floristic composition of plant communities in Gerfa-ourene Forest patch

Community types	1	2	3
1: *Psydrax schimperiana - Juniperus procera*		0.59	0.64
2: *Prunus Africana - Acokanthera schimperi*			0.42
3: *Acacia abyssinica - Pittosporum viridiflorum*			

4.2.5. Vegetation structure of Gerfa-ourene Forest patch

4.2.5.1. Density of trees and shrubs

The density of tree and shrub species in Gerfa-ourene Forest patch was 1843.91 individuals ha^{-1}. The density of trees and shrubs with DBH > 2 cm was 703.82 individuals ha^{-1}. The density of those species with DBH > 10 cm was 596.67 individuals ha^{-1}, whereas that of species with DBH > 20 cm was 543.42 individuals ha^{-1}. Thus, the ratio of density of trees with DBH greater than 10 cm to DBH greater than 20 cm in Gerfa-ourene Forest patch was 1.09. About 38.17% of overall

tree density came from species with DBH > 2 cm, whereas those with DBH > 10 cm and 20 cm contributed 32.36% and 29.47% respectively to overall tree density.

4.2.5.2. Diameter at Breast Height (DBH)

The percentage distribution of trees and shrubs across five DBH classes in the Gerfa-ourene Forest patch indicated, a relatively high proportion of individuals in the DBH class 2-10 cm (44%) and DBH class 10.1-20 cm (37%). The lowest proportion of individuals were recorded for DBH class 30.1-40 (5%) and >40 (2%) (Figure 8). *Olea europaea* subsp. *cuspidata*, with DBH >40, *Rhus retinorrhoea*, *Croton macrostachyus* and *Psydrax schimperiana* with DBH 30.1-40 cm were found to be the dominant large-sized trees in Gerfa-ourene Forest patch.

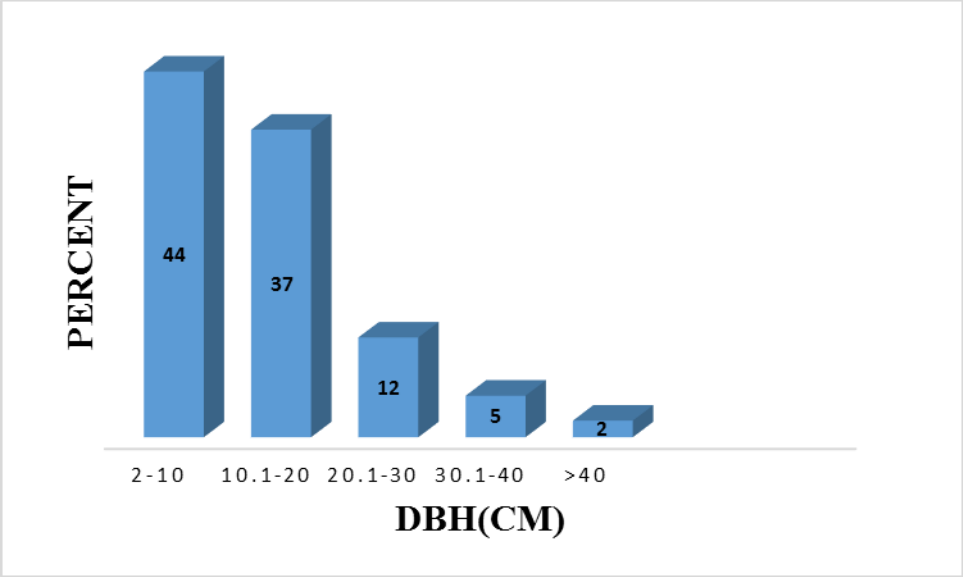

Figure 8. DBH class distribution of trees and shrubs in Gerfa-ourene Forest patch

4.2.5.3. Basal area (BA)

The total basal area of trees in Gerfa-ourene Forest patch was 30.65 m2/ha (Appendix 5). About 61.67% of the total basal area was based on ten large-sized tree species, i.e. *Acacia abyssinica*, *Rhus retinorrhoea*, *Rhus glutinosa*, *Olea europaea* subsp. *cuspidata*, *Nuxia congesta*,

Acokanthera schimperi, Juniperus procera, Cadia purpurea, Psydrax schimperiana and *Ekebergia capensis* (Table 10).

Table 10. Basal area (m2 ha^{-1}) of the ten most dominant trees and shrubs in the Gerfa-ourene Forest patch and their percentage contribution to the total basal area in the forest

Scientific name	**BA/ha**	**Percent Contribution**
Acacia abyssinica	65.26	7.10
Rhus retinorrhoea	64.06	6.97
Rhus glutinosa	63.14	6.87
Olea europaea subsp. *cuspidata*	59.23	6.44
Nuxia congesta	56.46	6.14
Acokanthera schimperi	56.06	6.10
Juniperus procera	54.78	5.96
Cadia purpurea	52.76	5.74
Psydrax schimperiana	48.21	5.24
Ekebergia capensis	47.02	5.11
Total	566.98	61.67

4.2.5.4. Frequency

The most frequent species in Gerfa-ourene Forest patch was *Euclea racemosa*, occurring in 73.33% of all the sampled. Species such as *Rhus glutinosa* (70%), *Dodonaea angustifolia* (53%) and *Prunus africana* (50%) were also common across the sampled quadrats. A list of most frequent trees occurring at least in 30% of quadrats sampled is given in Table 11, and frequency of all species documented from Gerfa-ourene Forest patch with DBH > 2 cm is given in Appendix 6.

Table 11. Most-frequent trees and shrubs in Gerfa-ourene Forest patch

Scientific name	Frequency (%)
Euclea racemosa	73.33
Rhus glutinosa	70.00
Dodonaea angustifolia	53.33
Prunus africana	50.00
Calpurnia aurea	43.33
Pittosporum viridiflorum	43.33
Cadia purpurea	40.00
Juniperus procera	40.00
Olea europaea subsp. *cuspidata*	40.00
Psydrax schimperiana	40.00
Maytenus arbutifolia	33.33
Acokanthera schimperi	30.00

4.2.5.5. Importance Value Index (IVI)

The highest IVI values were recorded for eight of the most frequent trees in Gerfa-ourene Forest patch. The highest IVI value was recorded for *Juniperus procera* (29.20) followed by *Psydrax schimperiana* (24.04) (Table 12).

Table 12. IVI values of eight most-frequent trees and shrubs in Gerfa-ourene Forest patch

Scientific name	RD	RF	RDOM	IVI
Juniperus procera	10.03	5.19	13.97	29.20
Psydrax schimperiana	14.58	5.19	4.26	24.04
Olea europaea subsp. *cuspidata*	6.43	5.19	12.09	23.71
Rhus glutinosa	6.11	9.09	4.29	19.50
Euclea racemosa	7.21	9.52	1.60	18.33
Acacia abyssinica	7.05	4.33	6.25	17.64
Prunus africana	7.84	6.49	2.88	17.21
Pittosporum viridiflorum	4.86	5.63	3.79	14.28

4.2.5.6. Population structure

The population structures of 9 most-common tree species in Gerfa-ourene Forest patch were analyzed and 3 representative patterns were identified (Figure 9a-c).

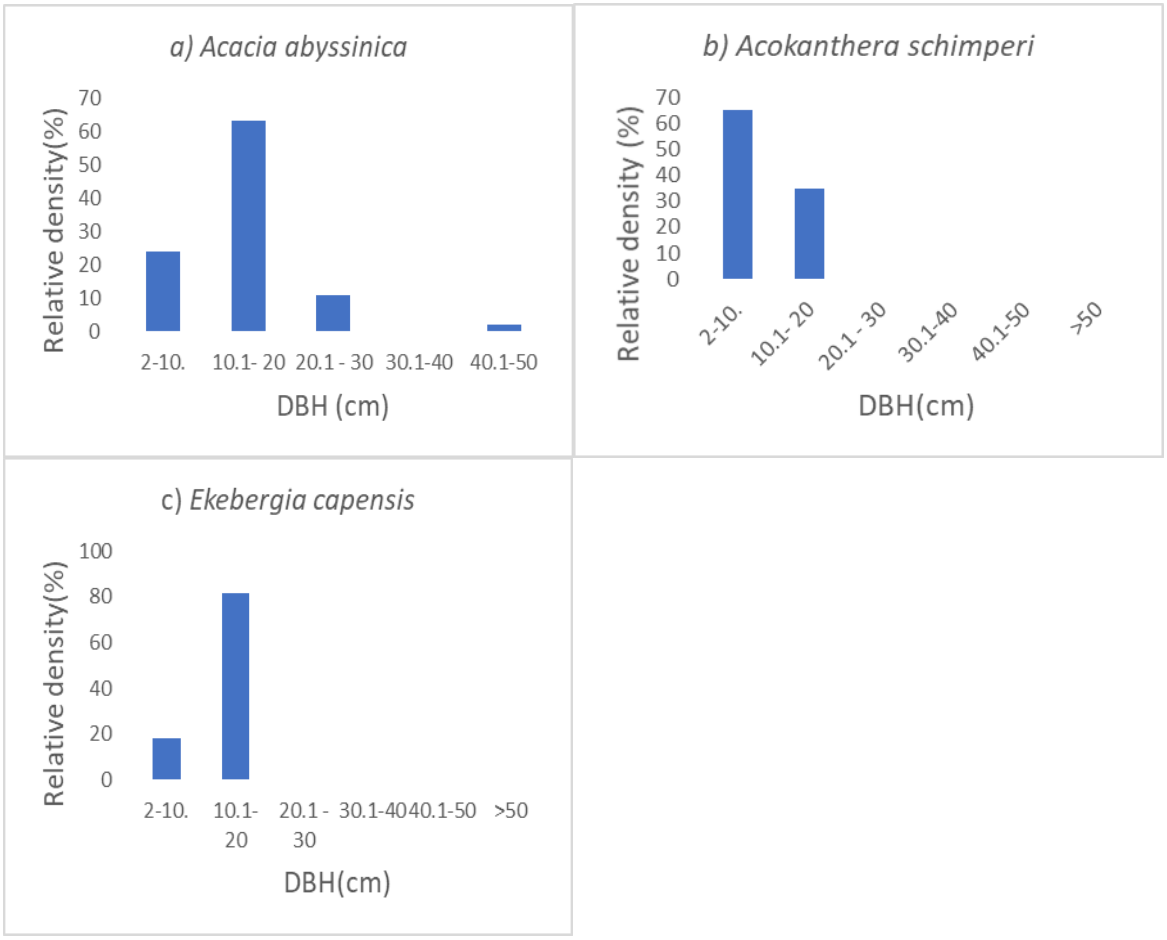

Figure 9. Representative patterns of species population structures in Gerfa-ourene Forest Patch (a-c)

4.3. Ethnobotany of medicinal plants in Kalu District

A total of 129 medicinal plant species (five of them were not identified morphologically) belonging to 108 genera and 59 families were documented in the District. Out of these, 111 species (88%) were cited for their use in the treatment of human ailments and 8 (6%) for the treatment of livestock diseases. Seven species (5.6%) were mentioned for their use against various ailments affecting both humans and livestock ailments (Figure 10).

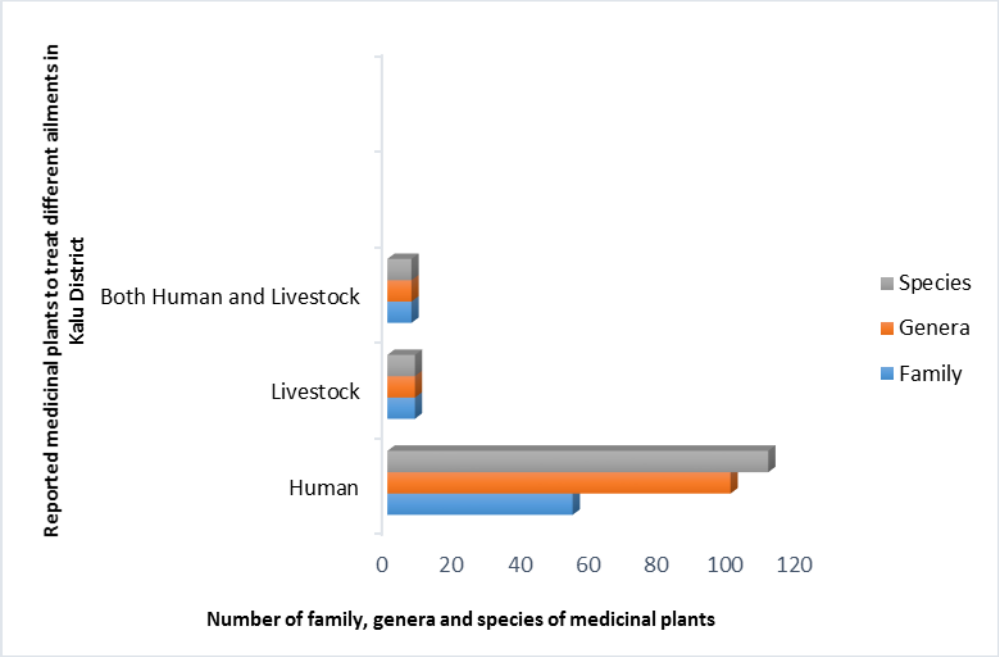

Figure 10. Number of families, genera and species of medicinal plants used to treat human, livestock or both human and livestock ailments in Kalu District

Four species (3%) of the total medicinal plants in the District were found to be endemic to Ethiopia (Appendix 7). The families with the highest number of medicinal plant species representation were Lamiaceae (10, 8%), Asteraceae, Fabaceae, Euphorbiaceae (8 species each, 6%) and Solanaceae (6, 4.76%). About 71% of the families were represented by more than one medicinal plant species (Figure 11).

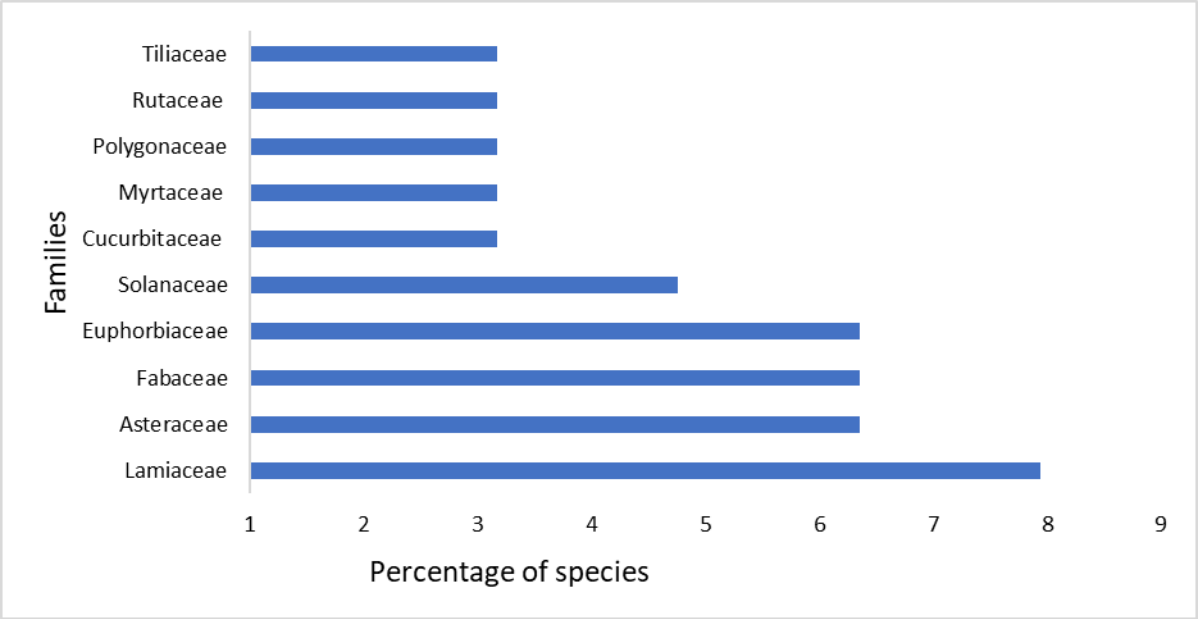

Figure 11. The families with the highest percentage of medicinal plant species in Kalu District

4.3.1. Ethnomedicinal plants used to treat human ailments

4.3.1.1. Diversity of reported medicinal plants

A total of 118 medicinal plant species belonging to 100 genera and 54 families (all are angiosperms) were reported to be used for treating human ailments in Kalu District (Appendix 7). Family Lamiaceae was represented by the highest number of species (nine, 7.63%), Asteraceae and Euphorbiaceae (8 species each, 6.78%), followed by Fabaceae (seven, 5.93%), Solanaceae (six species, 5.08%), Cucurbitaceae, Myrtaceae, Polygonaceae, Rutaceae and Tiliaceae (four species each, 3.39%) and Apiaceae, Brassicaceae, Rhamnaceae (three species each, 2.54%). Ten families were represented by two species each, whereas each of the remaining 31 families had single-species representation. Thus, 73.73% of the families were represented by more than one medicinal plant species. Identified growth forms of medicinal plants indicated that herbs (55 species; 46.61%) were more dominant than shrubs (34; 28.81%) or trees (25; 21.19%) and climber (four species, 3.39%).

4.3.1.2. Types of ailments and treatment methods

In Kalu District about 49 types of ailments affecting humans were identified to be treated by traditional medicinal plants (Appendix 7). Fever/"Mich", Evil eye/Evil spirit, Abdominal problems, Tooth ache, Arthritis, Wound/infection and Back pain were the most common and frequently reported ailment among them.

4.3.1.3. Plant parts used for preparing herbal remedies

Several plant parts were being used for remedy preparation, however the majority of preparations for treating human ailments were just based on leaves (43%), followed by roots (11%) alone, and seed (10%) (Figure 12). Freshly harvested plant parts were the dominant ones (74%) used in remedy preparation, whereas dried parts were used (20%); the remaining 6% of remedies were reported to be prepared both from dried or fresh parts of medicinal plant species.

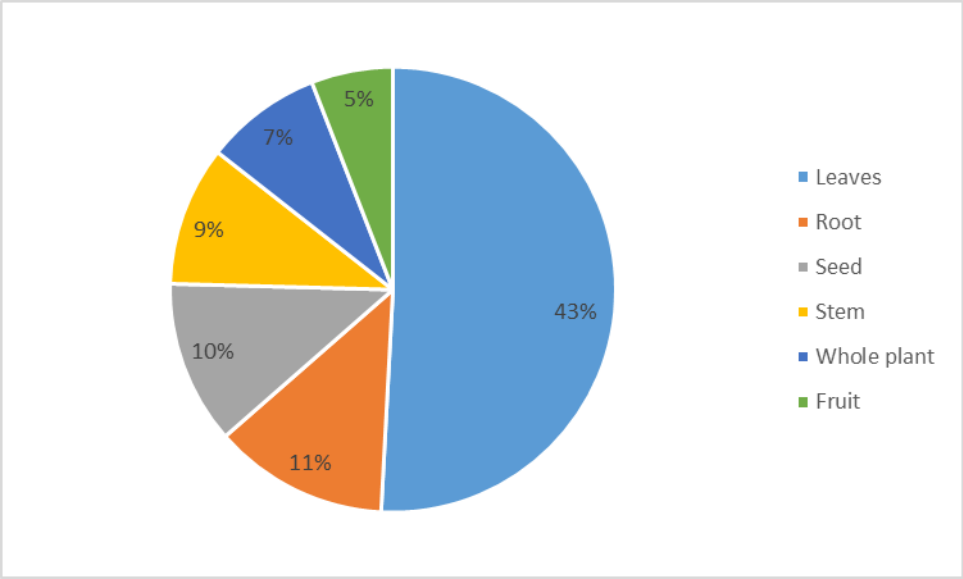

Figure 12. Plant parts used for preparing herbal remedies to treat human ailments in Kalu District

4.3.1.4. Methods of remedy preparation

The major modes of remedy preparation for various human ailments were crush and paste (28.10%); fumigating the smoke (17.65%); crush and homogenize with water (13.73%) (Figure 13).

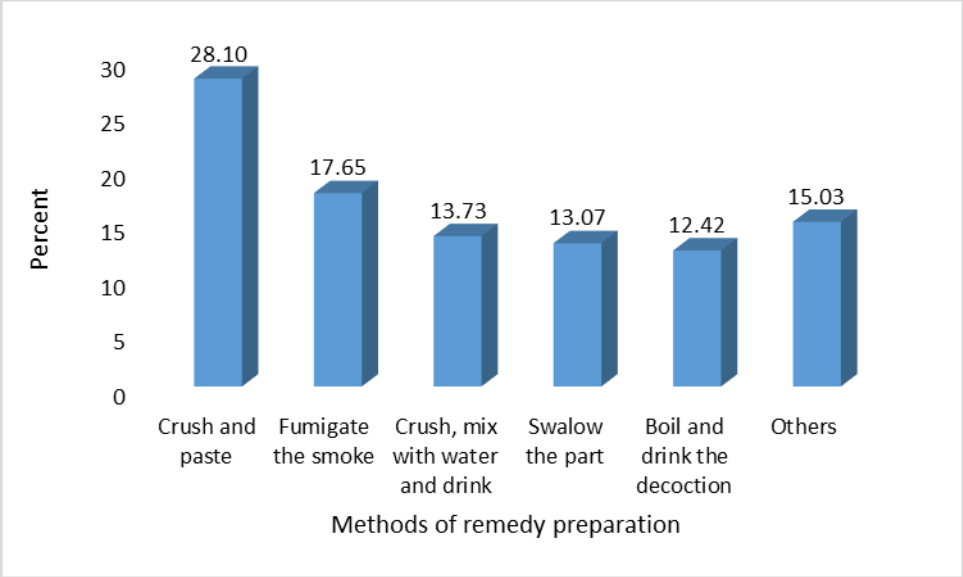

Figure 13. Methods of remedy preparation to treat human ailments in Kalu District

4.3.1.5. Routes of administration

For the clamed various human ailments, different routes of administration of medicinal plant preparations were documented. Oral application (59 preparations, 39.60%) was the most commonly used route of administration, followed by external application (48 preparations, 32.21%). The remaining remedies were administered through fumigation, optical, nasal, dermal, vaginal and auricular routes.

4.3.1.6. Dosages used for remedies and antidotes

People in the study district were using traditional medicinal plants without any clearly standardized doses. However, estimated dosages were reported considering age, gender, pregnancy and the condition of patients. Local people reported to measure their medicinal plant preparations in different

ways. For example size of a finger, small coffee cups, different glasses and plastic jugs were mentioned as commen measurement things to quantify medicinal plants while preparation. They also reported to measure remedies using handful and spoonful. Coffee, honey and butter were the commonly reported antidotes for herbal preparations with adverse side effects.

4.3.1.7. Marketability of medicinal plants

Out of the whole reported traditional medicinal plants which were used to treat human ailments 49 (41.5%) species of medicinal plants were available in the market places, but among these only seven species, i.e. *Clerodendrum myricoides*, *Echinops kebericho*, *Indigofera suaveolens*, *Lepidium sativum*, *Nicotiana tabacum* and *Otostegia integrifolia* were actually found on markets being sold and acquired for the importance of their medicinal purposes. The remaining listed medicinal plants were mainly sold for their non-medicinal importance but are occasionally also applied as medicine when the need arises.

4.3.1.8. Consensus on medicinal plants

From the reported totally 49 human ailments in the District, eleven disease were identified. Among these, Back pain was found with the highest ICF value (0.94) followed by Arthritis (0.93), and Evil eye/Evil spirit (0.76) (Table 13).

Table 13. ICF values of traditional medicinal plants used for treating human ailments in Kalu District

No	Disease category	No of Species	% all species	Use citations	% all use citations	ICF
1	Back pain	5	4.24	71	20.40	0.94
2	Arthritis	6	5.08	75	21.55	0.93
3	Evil eye/Evil spirit	12	10.17	50	14.37	0.76
4	Fever/"Mich"	22	18.64	70	20.11	0.70
5	Tooth ache	7	5.93	18	5.17	0.65
6	Wound/Wound infection	6	5.08	15	4.31	0.64
7	Minor bleeding/Bleeding during cutting	5	4.24	12	3.45	0.63
8	Eye diseases	4	3.39	7	2.01	0.50
9	Abdominal pain/Abdominal problem/diarrhea/vomiting	11	9.32	20	5.75	0.47
10	Hemorrhoid	4	3.39	5	1.44	0.25
11	Preventing snake/Snake bite/Snake/scorpion poison	4	3.39	5	1.44	0.25

4.3.1.9. Fidelity level of medicinal plants used for treating human ailments

Among the clamed traditional medicinal plants the fidelity level value of *Withania somnifera* (93.5%) was recorded as a highest followed by *Olea europaea* subsp. *cuspidata* (92.6%), *Carissa spinarum* (90.5%) and *Ehertia cymosa* (76%) (Table 14). The recorded highest fidelity level values for *Withania somnifera* was found under the Fever/"Mich" ailment disease category. But, the highest fidelity level values of *Olea europaea* subsp. *cuspidata* was obtained in the category of the Back pain diseases. Whereas, the highest fidelity level values of *Carissa spinarum* was reported for the category of Evil spirit disease category.

Table 14. Fidelity level values of medicinal plants commonly reported against a given human ailments in Kalu District

No	Scientific name	Therapeutic category	Ip*	Iu*	FL (%)*
1	*Withania somnifera*	Fever/"Mich"	29	31	93.5
2	*Olea europaea* subsp. *cuspidata*	Back pain	75	81	92.6
3	*Carissa spinarum*	Evil sprit	19	21	90.5
4	*Ehertia cymosa*	Fever/"Mich"	19	25	76
5	*Nigella sativa*	Abdominal pain	35	51	68.6
6	*Clerodendrum myricoides*	Arthritis	31	49	63.3
7	*Clematis hirsute*	Hemorrhoid	5	11	45.5
8	*Croton macrostachyus*	Bleeding during cut	7	19	36.8

*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

4.3.1.10. Direct matrix ranking on multipurpose medicinal plants

Nine commonly reported multipurpose medicinal plant species were considered in the direct matrix ranking (DMR) exercise to assess their degree of threat based on their multiple use reports. Accordingly, *Olea europaea* subsp. *cuspidata* was ranked first (most-threatened) followed by *Ehretia cymosa* and *Grewia trichocarpa* (Table 15).

Table 15. Average DMR score for nine medicinal plant species with additional uses in Kalu District

Use diversity	Agricultural tool	Construction	Fire wood	Char coal	Fodder	Fence	Medicine	Total	Rank
Olea europaea subsp. *cuspidata*	4	4	5	5	2	2	4	26	1
Ehretia cymosa	3	4	5	4	3	3	3	25	2
Grewia trichocarpa	3	4	5	4	1	3	3	23	3
Croton macrostachyus	3	4	5	2	1	2	5	22	4
Eucalyptus globulus	2	5	5	0	0	5	4	21	5
Eucalyptus camaldulensis	3	5	5	0	0	4	3	20	6
Grewia similis	2	3	4	3	1	3	3	19	7
Pittosporum viridiflorum	2	3	4	2	1	2	3	17	8
Bersama abyssinica	3	2	4	2	0	1	4	16	9

4.3.1.11. Preference ranking of medicinal plants used for treating human ailments

The preference ranking exercise of five medicinal plants that were reported to be used against minor bleeding/bleeding during cutting in Kalu district indicated *Achyranthes aspera* was the most-preferred species to treat the reported ailment. *Croton macrostachyus* and *Solanum incanum* were ranked 2nd and 3rd, respectively, to treat bleeding/bleeding during cutting (Table 16).

Table 16. Results of preference ranking of five medicinal plants reported for treating minor bleeding/bleeding during cutting in Kalu District

Medicinal plants for Minor bleeding/Bleeding during cutting	**Informants labelled A to J**											
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**Total score**	**Rank**
Achyranthes aspera	5	4	5	4	5	4	5	5	4	4	45	1
Croton macrostachyus	3	5	3	5	3	5	3	3	3	5	38	2
Solanum incanum	4	3	4	3	4	3	4	4	5	3	37	3
Olea europaea subsp. *cuspidata*	2	1	2	1	2	1	2	1	2	2	16	4
Jatropha curcas	1	2	1	2	1	2	1	2	1	1	14	5

4.3.2. Medicinal plants used traditionally in ethnoveterinary practice

4.3.2.1. Medicinal plant diversity for ethnoveterinary practice in Kalu District

In Kalu District, 15 medicinal plant species which were important for ethnoveterinary medicine (representing 15 genera and 14 families) were identified (Appendix 7). Only the family Fabaceae contributing 13.33% of the families was represented by two species. However, the remaining 13 (86.7%) families, i.e. Aizoaceae, Alliaceae, Amaranthaceae, Brassicaceae, Rubiaceae, Scrophulariaceae, Vitaceae, Santalaceae, Sapindaceae, Boraginaceae, Lamiaceae, Rhamnaceae and Ulmaceae had single-species representation. The growth forms of medicinal plant species for veterinary medicine constituted more herbs (7 species, 46.7%), followed by trees (5, 33.3%) and shrubs (three, 20%).

4.3.2.2. Livestock ailments and traditional methods for their diagnosis

Nine types of ailments which were reported to affect livestock health were identified in the district. For the claimed various livestock ailments, informants reported different medicinal plant species (Appendix 7). Abdominal dryness and bloating were found to be the most commonly reported forms of veterinary ailments in the study area. Oral administration of homogenized remedial preparations were the commonly reported treatment methods for treating various internal livestock ailments.

4.3.2.3. Applications of ethnoveterinary remedies

Ethnoveterinary medicinal plants were applied for various livestock ailments. Ailments which were reported to affect cattle, sheep, goats and camels were more treated by the claimed traditional medicinal plants in the District. From the reported medicinal plants applied for various ailments the majority of the claimed medicinal plant species (55.6%, 5 species) was applied to treat various cattle ailments (Appendix 7). But only a single species was reported against camel ailment.

4.3.2.4. Plant parts used to prepare ethnoveterinary remedies

Various plant parts were reported for preparation of different remedies. The majority (53.33%) of the preparations were from leaves alone, followed by the whole plant (20%) and roots alone (13.33%) (Figure 14). Ethnoveterinary remedy preparation were dominantly from freshly harvested plant parts (93.33%) whereas the remaining 6.7% of remedies were prepared from dried plant species.

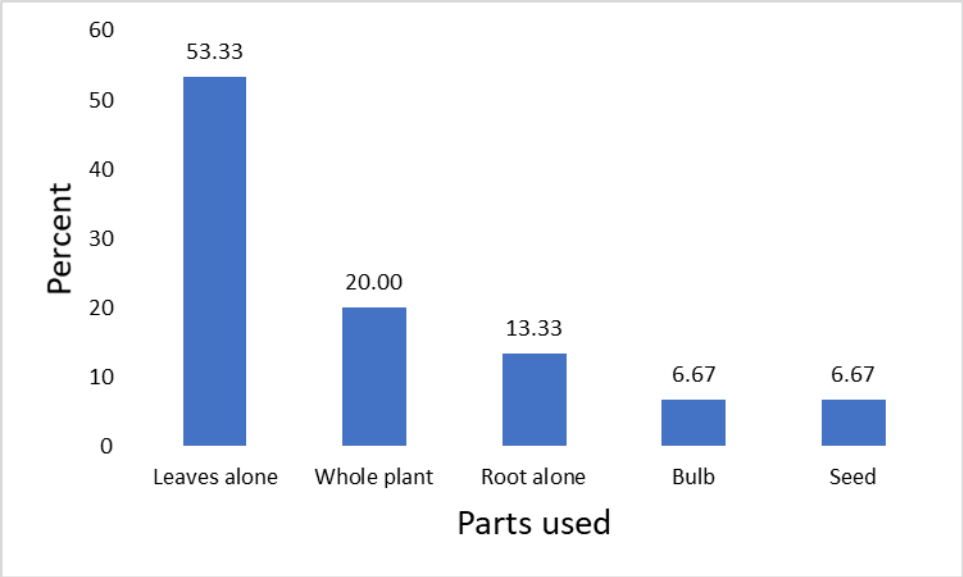

Figure 14. Plant parts used for ethnoveterinary remedy preparation in Kalu District

4.3.2.5. Methods for preparing the remedies, how they are administered and dosages used

In the study district, several modes of ethnoveterinary remedy preparations were reported. Crushing the part and homogenizing it with cold water was claimed as the major mode of remedy preparation (53%), followed by paste and tie the crushed part on the affected part of the body, eat as a forage (13%) each (Figure 15). Traditional plant medicines were administered through oral, external and optical routes. Oral application was the mostly frequently used route of administration (10 preparations, 66.67 %), followed by external (3, 20%) and optical (2, 13.33%) routes. There were no standard doses on preparation of traditional medicinal plants in the district to treat the claimed livestock ailments. However, traditional healers use their finger to measure the size, plastic jugs and a handful to determine dosage for remedial preparations.

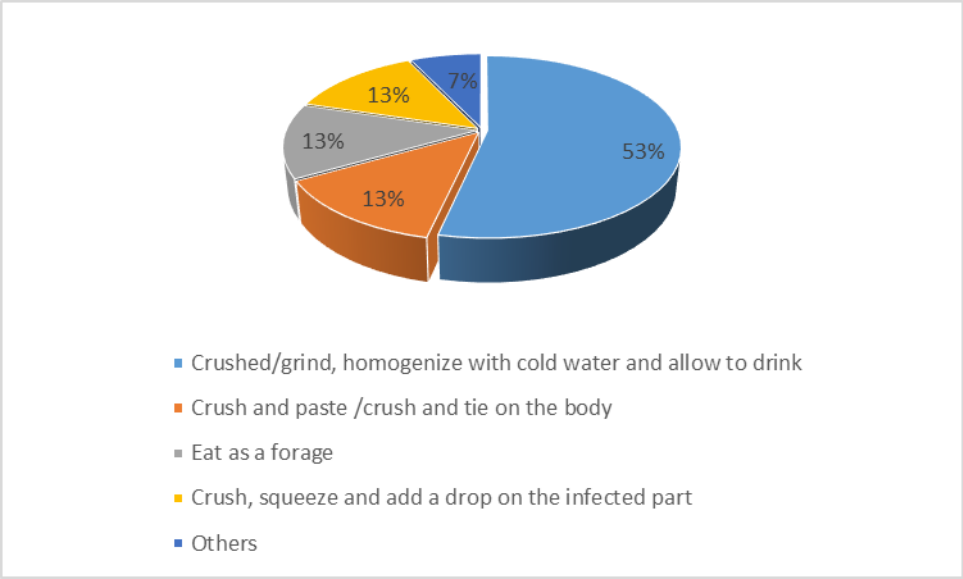

Figure 15. Methods of remedy preparation and administration for treating livestock ailments in Kalu District

4.3.2.6. Marketability of medicinal plants used in ethnoveterinary practice

Only two medicinal plant species (13.33%) that are important for ethnoveterinary medicine were reported from the market place of the study district (Appendix 7). However, both of them *Allium sativum* and *Brassica carinata* were mainly sold for their non-medicinal uses, but also rarely used as medicine.

4.4. Medicinal plants and their distribution in Anabe Forest patch

4.4.1. Medicinal plants in Anabe Forest patch

In Anabe Forest patch about 37 plant species which belong to 34 genera and 25 families were reported for treating various ailments in the district (Appendix 2). The family Lamiaceae (4 species, 10.81%) was dominant family of Anabe Forest patch, the other families such as Boraginaceae, Crassulaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Myrtaceae, Oleaceae, Polygonaceae, and Tiliaceae were represented with two species each (5.41%). In Anabe Forest patch 26 plant families (59.46%) were represented with more than one medicinal species. With

regard to the growth forms of the medicinal plants in Anabe Forest patch, shrubs species were represented with 14 species (37.84%) followed by tree species 9 (24.32%), herbaceous species 8 (21.62%) and climbers 6 (16.22%).

4.4.2. Distribution of medicinal plants across plant communities in Anabe Forest patch

In Anabe Forest patch in each of the identified plant community types, the reported traditional medicinal plants which are used for different ailments in Kalu District were distributed. In Community 1 (*Cupressus lusitanica* - *Juniperus procera* community type) there were 30 (39.47%) different traditional medicinal plant species and this community was relatively the richest in its medicinal plant composition. *Achyranthes aspera*, *Olea europaea* subsp. *cuspidata*, *Ocimum gratissimum* and *Ocimum lamiifolium* were among the most mentioned species which occurred in this community type. In community 2 (*Podocarpus falcatus* - *Pittosporum viridiflorum* community type), a total 19 (33.92%) medicinal plant species were recorded. This community type was the second richest in its medicinal plant species composition. *Achyranthes aspera*, *Carissa spinarum*, *Croton macrostachyus*, *Ehretia cymosa*, *Jasminium grandiflorum*, *Kalanchoe densiflora*, *Olea europaea* subsp. *cuspidata*, *Rosa abyssinica* and *Zehneria scabra* were the major medicinal plant species in this community type. Community type 3 (*Olea europaea* subsp. *Cuspidata* - *Acacia abyssinica* community type) contains 14 (38.88%) medicinal plant species. *Achyranthes aspera*, *Caesalpinia decapetala*, *Calpurnia aurea*, *Carissa spinarum*, *Clematis hirsuta*, *Cynoglossum lanceolatum*, *Grewia ferruginea*, *Pittosporum viridiflorum* and *Psidium guajava* were the main medicinal plant species in this community type.

The medicinal plant species richness, diversity and evenness values of each plant community type in Anabe Forest patch is summarized in Table 17. The highest value of medicinal plant species richness (32) and medicinal plant species diversity (Shannon's diversity) (2.93) were

recorded for community one and highest medicinal plant species evenness (0.94) was highest for community type three.

Table 17. Medicinal plant species richness, diversity and evenness values of plant communities in Anabe Forest patch

Community types	Medicinal Species Richness (S)	Medicinal species diversity Shannon-Wiener Diversity Index (H')	Medicinal species evenness Shannon's evenness index (J)
1: *Cupressus lusitanica* - *Juniperus procera*	32	2.93	0.84
2: *Podocarpus falcatus* - *Pittosporum viridiflorum*	22	2.83	0.92
3: *Olea europaea* subsp. *cuspidata* - *Acacia abyssinica*	16	2.61	0.94

4.5. Medicinal plant species used for several purposes in Kalu District

From a total of 129 medicinal plant species documented in the District, 73 (56.59%) species were cited for various purposes other than their medicinal importance. The percentage of medicinal plant species for different purposes is summarized in Figure 16.

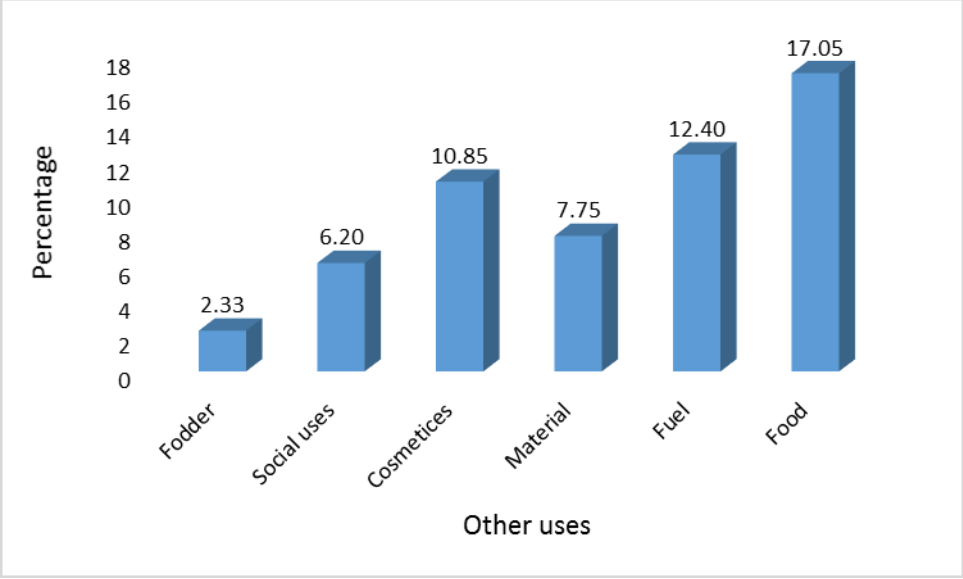

Figure 16. Medicinal plants species of Kalu District for different purposes

4.6. Ethnobotany of medicinal plants in Bati District

A total of 94 traditional medicinal plant species were reported from Bati district, of which three of the species were not able to be identified morphologically (Appendix 8). The 94 reported traditional medicinal plant species belong to 78 genera and 49 families containing 93 angiosperm and one gymnosperm families. A total of 76 species (81%) were mentioned for treating various human ailments whereas 11 (12%) species were reported for treating both human and livestock ailments and 7 (7%) species for treating different livestock ailments alone (Figure 17).

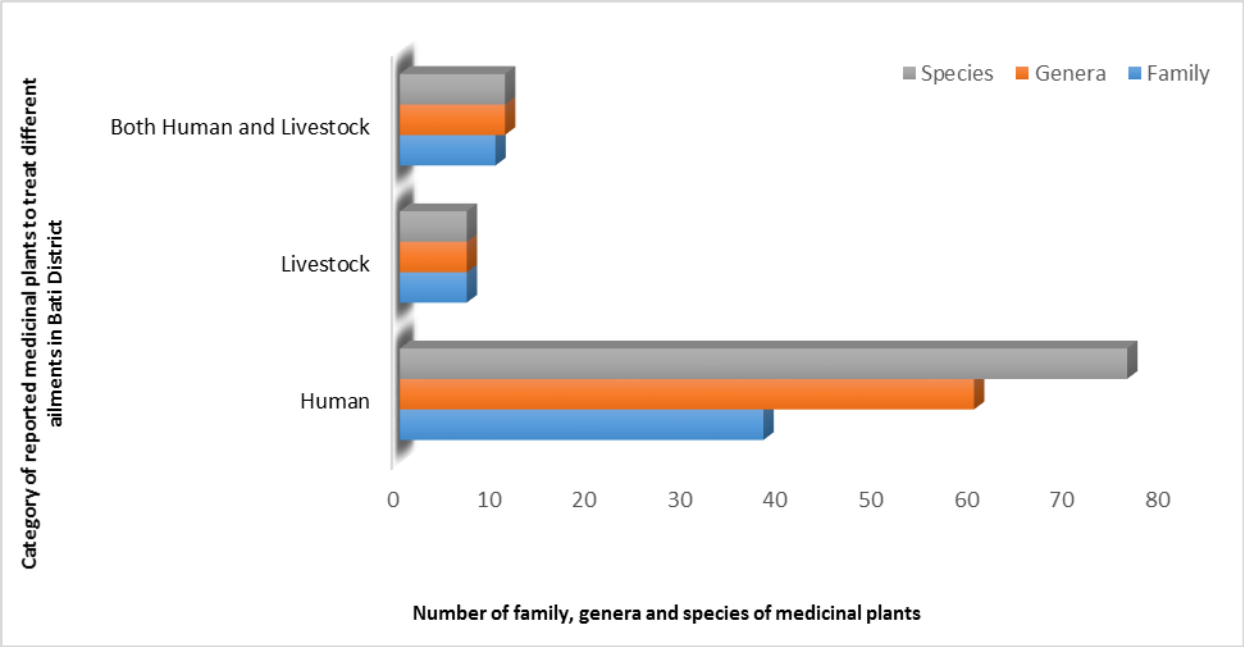

Figure 17. Number of families, genera and species of medicinal plants in Bati District used to treat human, livestock or both human and livestock ailments.

From the total reported medicinal plant species two (2.15%) of them were endemic to Ethiopia (Appendix 8). The family Fabaceae was placed in the first rank since it had the highest number of medicinal plant species (9 species, 9.6%) followed by Lamiaceae (8, 8.5%), Solanaceae (7, 7.5%) and Asteraceae (6, 6.4%) in the district. About 62% of the families were represented by more than one medicinal plant species (Figure 18).

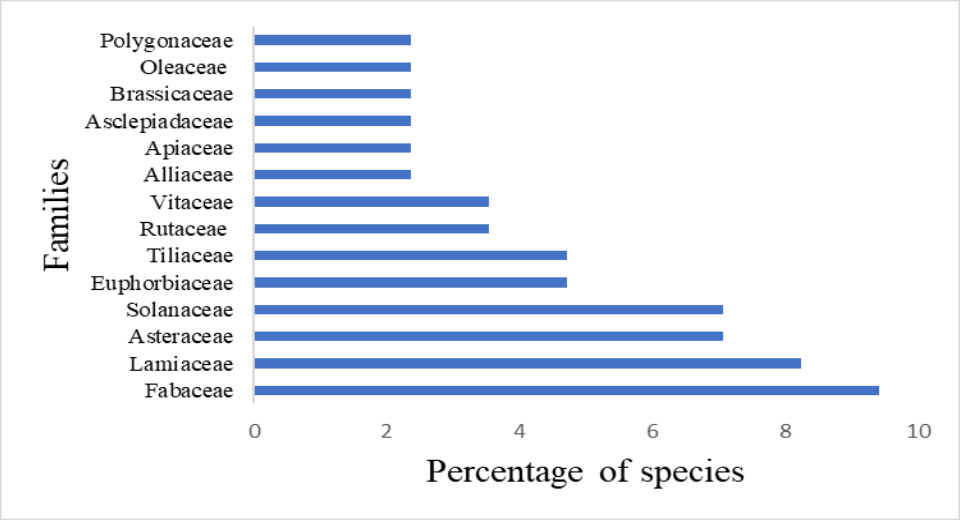

Figure 18. The families with the highest percentage of medicinal plant species in Bati District

4.6.1. Medicinal plants used traditionally to treat human ailments in Bati District

4.6.1.1. Diversity of reported medicinal plants

Eighty seven medicinal plant species that belongs to 71 genera and 46 families (86 angiosperms and 1 gymnosperm) were reported for treating various types of human ailments in Bati District (Appendix 8). From the reported total 87 medicinal plant species three of them were not identified morphologically. The family Fabaceae was represented by the highest number of species (8 species, 9.14%), followed by Lamiaceae (seven, 8.24%), Asteraceae and Solanaceae (six species each, 7.06%), Euphorbiaceae and Tiliaceae (four species each, 4.71%) and Rutaceae and Vitaceae (three species each, 3.53%). Six of the reported families, i.e. Alliaceae, Apiaceae, Asclepiadaceae, Brassicaceae, Oleaceae and Polygonaceae were represented with two species each, whereas each of the remaining 32 families were represented with only a single species. Thus, 62.35% of the families were represented by more than one medicinal plant species. The growth forms of the reported medicinal plant species revealed that herbs (33 species; 38.82%) were more dominant than shrubs (27; 31.8%) or trees (17; 20%) and climber, (both herbaceous and woody) (eight species, 9.42%).

4.6.1.2. Disease types treated using traditional herbal medicines

In Bati District a total of 58 human ailments were documented which were treated by different traditional medicinal plant species (Appendix 8). Fever/"Mich", Evil spirit, Abdominal pain/abdominal discomfort, Headache, Toothache, Evil eye , Wound/infection, Arthritis and Back pain were the most commonly reported ailments.

4.6.1.3. Plant parts used for preparing herbal remedies

The majority (29%) of remedy preparations for treating human ailments were reported to be prepared only from leaves parts, followed by roots (17%) alone, and stem wood (15%) (Figure 19). The collected plant parts in remedy preparation were dominantly fresh (64%), whereas dried parts were (26%) and the remaining 10% of remedies were prepared both from dried or fresh parts of medicinal plant species.

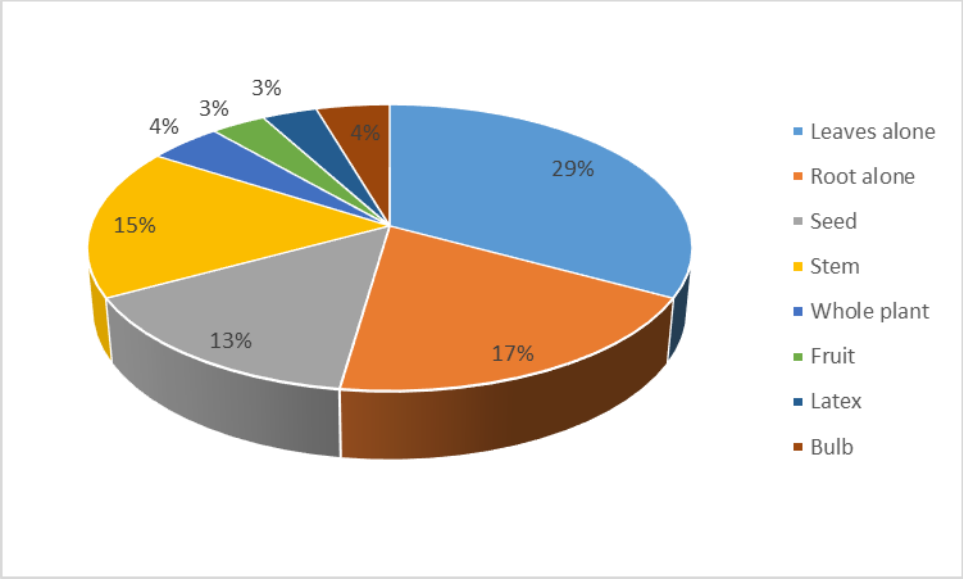

Figure 19. Plant parts used for remedy preparations to treat human ailments in Bati District (%)

4.6.1.4. Methods used to prepare remedies and appilication

A lots of remedy preparations were reported in the study district, among them crush and paste the crushed part/paste the crushed part and tie; and crush, homogenize with cold water and drink (21.01%) for each followed by boil the part and fumigate its smoke or inhale its steam (17.65%) were the major modes of remedy preparation for human ailments (Figure 20).

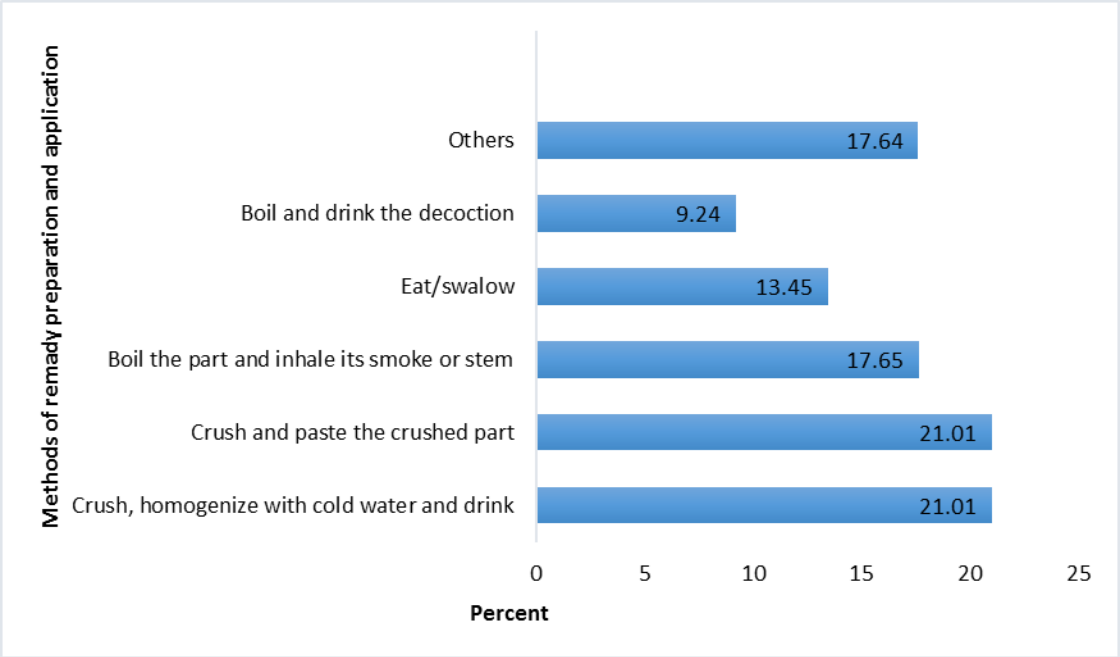

Figure 20. Methods of remedy preparation and application to treat human ailments in Bati District

4.6.1.5. Routes of administration

In the study district various routes of administration of medicinal plant preparations were reported for different human ailments. Among those preparations, oral application (52, 46%) was the most commonly used route of administration, followed by external application (34, 30%). The remaining remedies were administered through fumigation, dermal, nasal, auricular and optical routes of administration.

4.6.1.6. Dosages used for remedies and antidotes

In Bati District traditional medicinal plants were applied without any fixed standards. However, local people use different ways to estimate the dosage in medicinal preparation like their size of a finger, handful, spoonful, small coffee cups, plastic jags and glasses. Water, coffee, milk, yogurt and butter were the commonly reported antidotes for herbal preparations.

4.6.1.7. Marketability of medicinal plants

In Bati District, from the reported traditional medicinal plant species which are used for different human ailments 37 (42.5%) of them were available in the market. But, only eight species, i.e. *Clerodendrum myricoides*, *Echinops kebericho*, *Indigofera suaveolens*, *Lepidium sativum*, *Nicotiana tabacum*, *Otostegia integrifolia*, *Rumex abyssinicus* and *Tamarindus indica* were sold in markets for the purposes of their medicinal values. Whereas, the remaining reported medicinal plants were mostly sold for their non-medicinal usages but are sometimes also used as medicine when it is needed.

4.6.1.8. Consensus of medicinal plants

Some of the reported diseases in Bati District have a high informant consensus factor value. Back pain ailments (0.96) were found with the highest ICF values followed by Arthritis (0.94), and Abdominal pain/abdominal discomforts (0.84) (Table18).

Table 18. ICF values of traditional medicinal plants used for treating human ailments in Bati District

No	Disease category	No of Species	% all species	Use citations	% all use citations	ICF
1	Back pain	4	4.60	77	19.69	0.96
2	Arthritis	4	4.60	53	13.55	0.94
3	Abdominal pain/abdominal discomfort	7	8.05	39	9.97	0.84
4	Fever/"Mich"	14	16.09	71	18.16	0.81
5	Evil spirit	9	10.34	43	11.00	0.80
6	Tooth ache	7	8.05	25	6.39	0.75
7	Evil eye	6	6.90	19	4.86	0.72
8	Malaria	5	5.75	15	3.84	0.71
9	Head ache	7	8.05	21	5.37	0.70
10	Wound/wound infection	6	6.90	17	4.35	0.69
11	Dandruff	5	5.75	9	2.30	0.50

4.6.1.9. Fidelity level of medicinal plants used for treating human ailments

In the study district, the highest fidelity level was documented for *Terminalia brownii* (95.96%) followed by *Clerodendrum myricoides* (92.6%), *Nigella sativa* (83.53%) and *Ceratostigma abyssinicum* (80.95%) (Table 19). The highest fidelity level values recorded for *Terminalia brownii* was found under the Back pain ailment type. In contrast, the highest fidelity level values of *Clerodendrum myricoides* was found in the Arthritis disease type, and the highest fidelity level values of *Nigella sativa* and *Ceratostigma abyssinicum* were found in the Abdominal pain and under the febrile illness respectively.

Table 19. Fidelity level values of medicinal plants against human ailment in Bati District

No	Scientific name	Types of ailments	Ip*	Iu*	FL (%)*
1	*Terminalia brownii*	Back pain	95	99	95.96
2	*Clerodendrum myricoides*	Arthritis	75	81	92.60
3	*Nigella sativa*	Abdominal pain	71	85	83.53
4	*Ceratostigma abyssinicum*	Fever/"Mich"	17	21	80.95
5	*Withania somnifera*	Fever/"Mich"	45	61	73.80
6	*Zaleya pentandra*	Fever/"Mich"	11	15	73.33
7	*Olea europaea* subsp. *cuspidata*	Back pain	17	25	68.00
8	*Ehertia cymosa*	Wound infection	21	35	60.00
9	*Acalypha fruticosa*	Fever/"Mich"	9	21	42.86

*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

4.6.1.10. Direct matrix ranking on multipurpose medicinal plants

Direct matric ranking exercise on nine reported multipurpose medicinal plants was performed in order to evaluate the relative degree of threats of the given medicinal plants related to their usage. Accordingly, *Olea europaea* subsp. *cuspidata* was ranked first (most-threatened) followed by *Podocarpus falcatus* and *Ehretia cymosa* (Table 20). The results indicated that these medicinal plant species were reported to be used for treating various human ailments as well as for construction, firewood and agricultural tools than their medicinal usages.

Table 20. DMR score of medicinal plant species in Bati District

Use diversity	Agricultural tool	Construction	Fire wood	Char coal	Fodder	Fence	Medicine	Total	Rank
Olea europaea subsp. *cuspidata*	5	4	5	5	2	2	4	27	1
Podocarpus falcatus	4	5	4	3	2	3	2	23	2
Ehretia cymosa	4	4	4	2	3	2	3	22	3
Grewia trichocarpa	4	3	3	3	2	2	4	21	4
Grewia similis	4	3	3	3	2	2	3	20	5
Terminalia brownii	2	2	2	2	3	2	5	18	7
Tamarindus indica	2	2	3	3	2	3	2	17	8
Nuxia congesta	2	2	3	3	2	1	3	16	9
Premna schimperi	0	1	3	2	1	2	2	11	10

4.6.1.11. Preference ranking of selected plants for treating human ailments

Preference ranking exercise of six medicinal plant species that were claimed as effective to treat minor wound/wound infection in the district indicated, *Lawsonia inermis* was the most-preferred species followed by *Ehretia cymosa* and *Cyperus longus* respectively (Table 21).

Table 21. Results of preference ranking of six selected medicinal plants for treating minor wound/wound infection in Bati District

Medicinal plants for wound/wound infection	**Informants labelled A to J**											
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**Total score**	**Rank**
Lawsonia inermis	6	5	6	4	6	5	6	6	6	4	54	1
Ehretia cymosa	5	6	5	5	4	6	5	3	4	6	49	2
Cyperus longus	4	3	4	6	5	4	3	4	3	5	41	3
Solanum nigrum	3	4	2	3	3	2	4	5	5	2	33	4
Ximenia americana	2	2	3	2	2	3	2	2	2	3	23	5
Xanthium spinosum	1	1	1	1	1	1	1	1	1	1	10	6

4.6.2. Medicinal plants used in ethnoveterinary practice

4.6.2.1. Ethnoveterinary medicinal plant diversity in Bati District

A total of 18 medicinal plant species distributed in 18 genera and 16 families were documented for their ethnoveterinary uses in Bati District (Appendix 8). Of the total, 16.67% of the families were represented by two species, whereas the remaining 83.33% families had single-species representation. About the growth forms of the reported medicinal plant species which were important in treating various livestock ailments, shrubs were dominant (8 species, 44.44%), followed by trees (six, 33.33%), herbs (3, 16.67%) and climbers (one, 5.56%).

4.6.2.2. Types of livestock ailments

A total of 12 livestock ailments were mentioned in Bati District (Appendix 8). Out of the reported total livestock ailments which were treated by traditional medicinal plants in the study district, abdominal dryness, anthrax, diarrhea and eye disease were the most commonly mentioned livestock ailments.

4.6.2.3. Application of ethnoveterinary remedies

The reported traditional medicinal plant species which were applied for different livestock ailments in Bati District were claimed for diverse ailments affecting cattle, goats and camels. But the majority of the reported medicinal plant species (78.95%, 15 species) was applied to treat different cattle ailments (Appendix 8). Comparatively low number of species, two species for each (10.53%) were mentioned against goats and camels ailments.

4.6.2.4. Plant parts used for preparing ethnoveterinary remedy

Traditional people in the study district commonly reported the uses of leaves (68.42%) for remedy preparations, followed by roots (21.05%) (Figure 21). Medicinal plants preparations used for different livestock ailments in Bati District were reported to be gathered 100% from freshly collected plant parts of the traditional medicinal plant species.

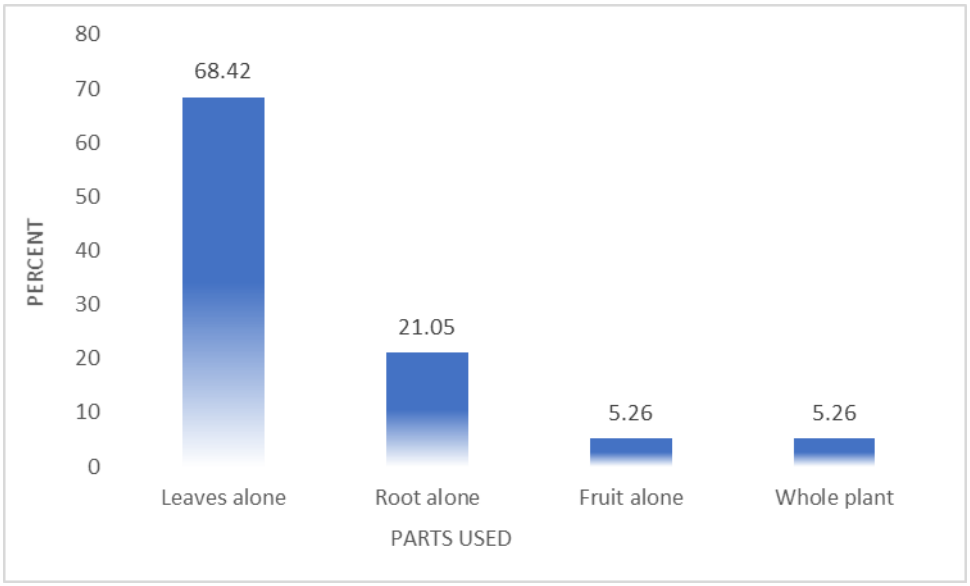

Figure 21. Plant parts used for livestock remedy preparation in Bati District

4.6.2.5. Methods used for preparing, administering and dosages of remedies

Remedy preparations for various livestock ailments in Bati District were processed in various methods. Crush/grinding and homogenizing remedies with cold water was the major mode of remedy preparation (40%), followed by feeding the preparation as forage (25%) (Figure 22). The most common way of administration in the study district was oral, external, nasal, optical and vaginal routes. However, oral application was the most-mentioned route of administration (13 preparations, 65 %), followed by external (3, 15%) and optical (2, 10%). There were no standardized doses in traditional medicinal plants preparation for livestock ailments in the district. However, people use different ways to estimate the amount on their preparation like handful or finger-sized measurements, plastic jugs and glasses for remedy preparation.

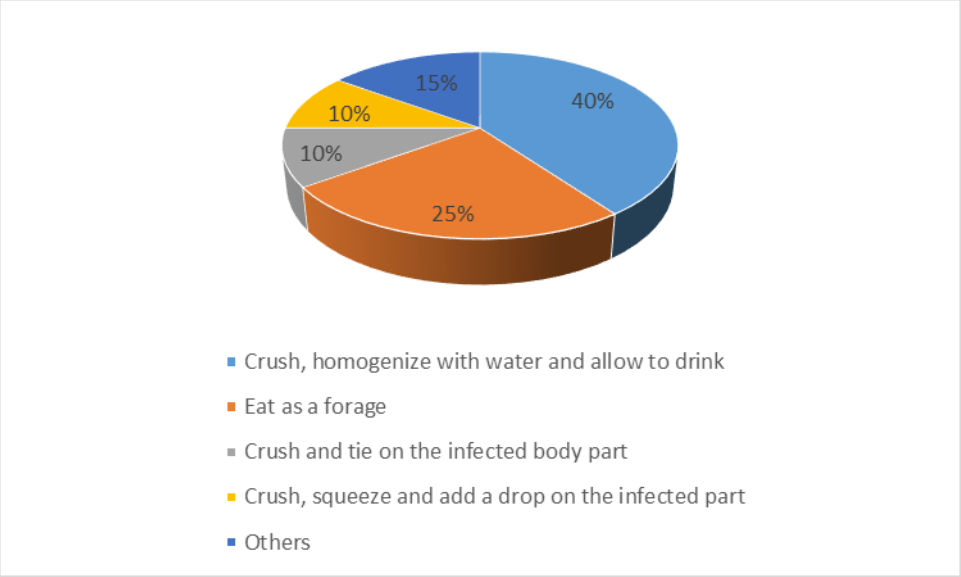

Figure 22. Methods of remedy preparation and administration for treating livestock ailments in Bati District

4.6.2.6. Marketability of ethnoveterinary medicinal plants

On the local market in the study district, some traditional medicinal plant species 16.67% (3 species) of the total ethnoveterinary plants which were *Olea europaea* subsp. *cuspidata, Terminalia brownii* and *Ziziphus spina-christi* were commonly available in the market and were sold basically for their non-medicinal purposes (Appendix 8). However, they were also rarely applied as a medicine for various ailments.

4.7. Medicinal plants and their distribution in Gerfa-ourene Forest patch

4.7.1. Medicinal plants in Gerfa-ourene Forest patch

In Gerfa-ourene Forest patch 32 plant species which belonging to 29 genera and 25 families were mentioned as traditional medicinal plants used in the study district (Appendix 2). These plants were composed of 13 (40.62%) shrubs, 8 (25%) trees, 5 (15.62%) herbs, 4 (12.5%) herbaceous climbers and 2(6.25%) lianas. The family Lamiaceae which was represented with five species (15.62%) was the family with the highest species representation followed by the famiy Tiliaceae with three species (9.37%). About 37.5% of the families in Gerfa-ourene Forest patch were represented by more than one medicinal plant species.

4.7.2. Distribution of medicinal plants across plant communities in Gerfa-ourene Forest patch

The claimed traditional medicinal plants which were found in Gerfa-ourene Forest patch were scattered in each of the identified plant community types. Community one (*Psydrax schimperiana* - *Juniperus procera* community type) composed of 23 (37.7%) traditionally medicinal plant species. This community type was the richest community type that contained more medicinal plant species in Gerfa-ourene Forest patch when compared with the other community types. *Achyranthes aspera, Carissa spinarum, Clerodendrum myricoides, Ehretia*

cymosa, Ocimum gratissimum and *Olea europaea* subsp. *cuspidata* were among the traditional plant species that were found in this community type. The *Prunus africana - Acokanthera schimperi* community type (community two) contained a total of 15 (39.47%) medicinal plant species. The dominant traditional medicinal plant species in this community type were *Carissa spinarum, Celtis africana, Cyperus longus, Cyphostemma adenocaule, Ehretia cymosa, Ocimum lamiifolium* and *Toddalia asiatica*. Community type three (*Acacia abyssinica - Pittosporum viridiflorum* community type) was found to contain about 16 (30.77%) different traditional medicinal plant species, of which *Asparagus africanus, Calpurnia aurea, Dodonaea angustifolia, Heteromorpha arborescens, Jasminium grandiflorum, Nuxia congesta* and *Tragia doryodes* were shown frequently in this community type.

The medicinal plant species richness, diversity and evenness values of each plant community type in Gerfa-ourne Forest patch is summarized in Table 22. The highest medicinal species richness (24) was recorded for community type one; medicinal species diversity (Shannon's diversity) (2.77) and medicinal species evenness (0.94) were highest for community one and community two respectively.

Table 22. Medicinal plant species richness, diversity and evenness values of plant communities in Gerfa-ourene Forest patch

Community types	**Medicinal Species Richness (S)**	**Medicinal species diversity Shannon-Wiener Diversity Index (H')**	**Medicinal species evenness Shannon's evenness index (J)**
1: *Psydrax schimperiana - Juniperus procera*	24	2.77	0.87
2:*Prunus africana - Acokanthera schimperi*	16	2.62	0.94
3: *Acacia abyssinica - Pittosporum viridiflorum*	17	2.59	0.91

4.8. Other Uses of medicinal plants in Bati District

In Bati District from the mentioned total of 94 traditional medicinal plant species, 58 (61.70%) of them were cited for their other uses in addition to their medicinal value. The diverse uses of the medicinal plant species in the study site is shown in Figure 23 below.

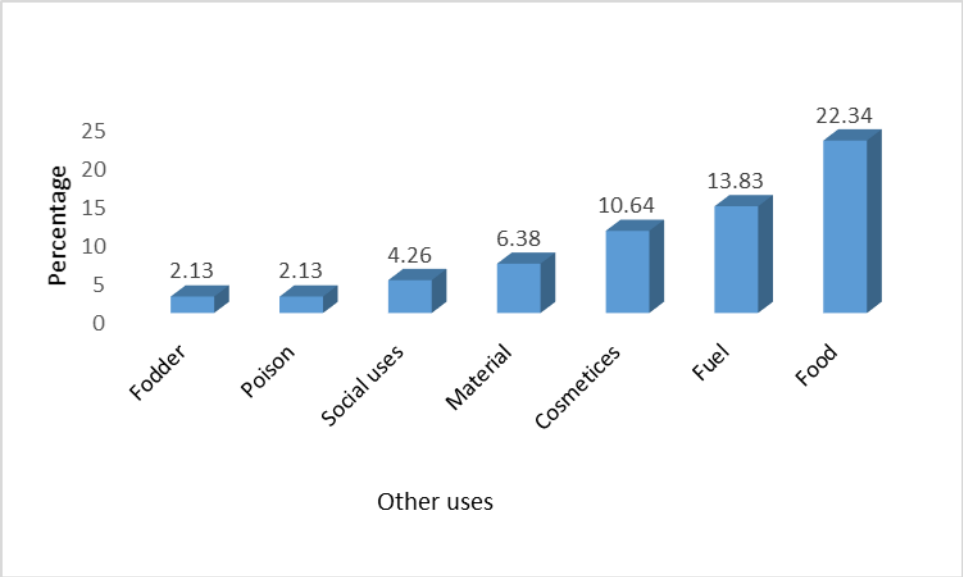

Figure 23. Other uses of medicinal plant species of Bati District

4.9. Conservation practice of medicinal plants in Kalu and Bati Districts

Local communities in Kalu and Bati Districts collect their medicinal plants mostly from the wild habitat. However, they didn't take part in conservation as well as any sustainable utilization of those resources for the upcoming. The wild harvested medicinal plants (68, 72.34%) in Kalu, (90, 69.77%) in Bati was at risk of erosion since there is no effort on *in situ* or *ex situ* conservation practice in the area.

4.10. Indigenous knowledge transfer in Kalu and Bati Districts

Transferring indigenous knowledge of traditional medicinal plants among traditional healers of the two districts was found mainly by word of mouth. Most of the time healers prefer their elder son (from the family members) to transfer the knowledge they gained on the traditional medicinal plants practice. However, very few healers (10%) also prefer to transfer their knowledge to their elder daughter. They kept their knowledge only within their family members. They have so many reasons to make it secret, most of them supposed that keeping the knowledge relates to healing power of the medicinal plants and others related it with income generations. They thought that if they share their knowledge with the other community members in their area they believed that they could lose their income from their knowledge of the traditional practice.

4.11. Women's plants and herbal plants used as a cosmetics in Kalu and Bati Districts

Medicinal plants in Kalu and Bati Districts were also reported for women's health and their uses as a cosmetics (Appendix 9). About 30.34% (44 species) of the medicinal plants of the study area were cited for various women's health problems as well as for herbal cosmetics. The species in this category belong to 39 genera and 31 families. The family Lamiaceae was represented by four species; families Asteraceae and Euphorbiaceae were represented by three species each; Aloaceae, Fabaceae and Tiliaceae were represented by two species each; whereas all the remaining families had only one species each. The listed 44 plants in the two districts were used for different types of natural cosmetics and various women's health problems. Eleven species (25%) were claimed for fragrance, seven (15.9%) plant species were used to treat Back pain/Arthritis ailment where as, 5 species (11.36%) were used for treating Retained placenta/Delay of placenta in both districts (Figure 24).

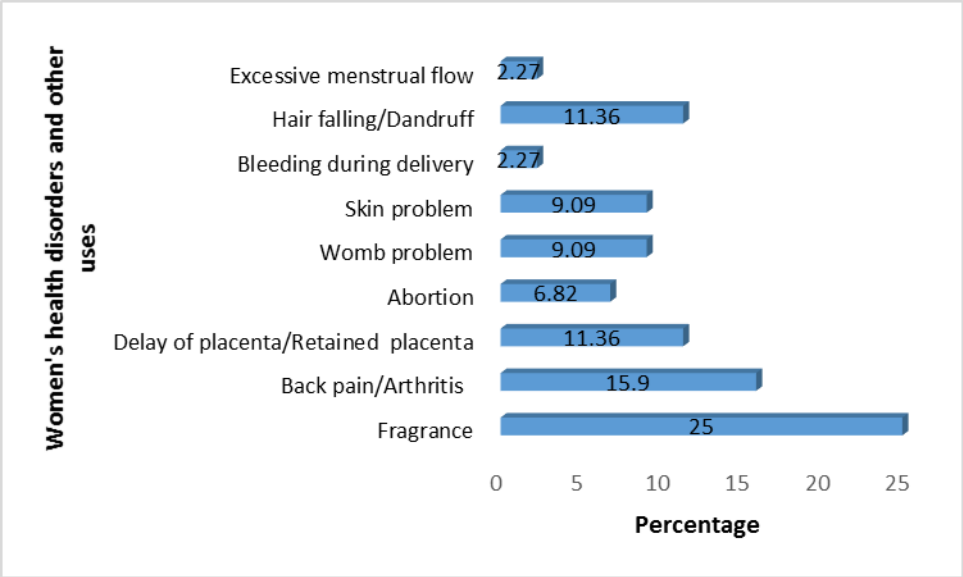

Figure 24. Plants on Women's health disorders and herbal cosmetics in Kalu and Bati Districts

4.12. Amplification and sequencing success

In this research, PCR amplification was 100% and the amplified products were used for sequencing. In total, 154 samples were included in this study, and were sequenced for three proposed barcode regions in the plastid genome (*rbcL* and *matK*) and nuclear genome (ITS) (Appendix 10). The BLAST algorithm was then used to compare medicinal plant sequences to the reference database. Sequencing success was relatively high for *rbcL* (97.4%) and ITS (96.1%), but relatively low for *matK* (75.97%) (Figure 25).

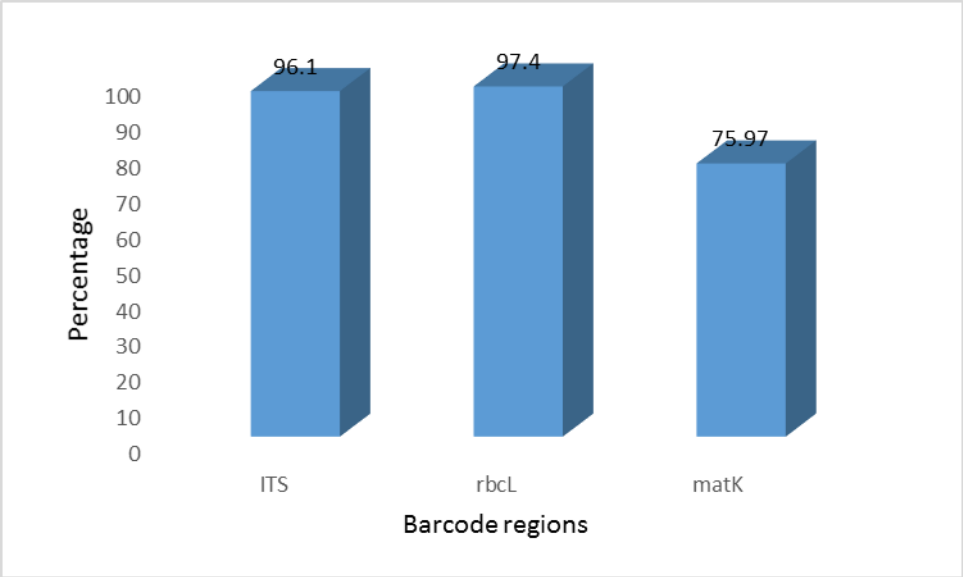

Figure 25. Sequence success of the three barcode regions

4.12.1. Barcoding identifications

The results from BLAST queries for the three regions showed that, there was no sequence variation between the barcoding identification and the proposed scientific name by the morphological identification for 67.5% (104 species) of the samples for ITS, 73.4% (113 species) of the samples for *rbcL* and 71.4% (110 species) of the samples for *matK*. Whereas, barcoding identification of 67.5% (104 species) of the samples for ITS, 65.6% (101 species) of the samples for *rbcL* and 63.6% (98 species) of the samples for *matK* were same genus with the proposed scientific name which was identified morphologically. Surprisingly, for 64.9% (100 species) of the samples for ITS, 61.04% (94 species) of the samples for *rbcL* and 64.9% (100 species) of the samples for *matK* there was no hit or no sequence in the reference database.

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 . Discussion

5.1.1. Plant diversity in Anabe and Gerfa-ourene Forest patches

5.1.1.1. Floristic composition

Results of floristic analysis showed that Anabe and Gerfa-ourene Forest patchs are rich in species composition as shown by the presence of 128 plant species which belong to 114 genera and 60 families (108 species contained in 97 genera and 52 families in Anabe Forest patch and 84 plant species representing 75 genera and 46 families in Gerfa-ourene Forest patch). The results of this study revealed that the Anabe Forest patch has higher species richness than some other Dry evergreen Afromontane forests in Ethiopia, such as Komto Forest (103 species) (Fekadu Gurmessa *et al.,* 2013), Abebaye Forest (88 species) (Haileab Zegeye *et al*., 2011) and Jibat Forest with 54 species (Tamrat Bekele, 1994). But in the case of Gerfa- ourene Forest patch its species richness was only higher than other Dry evergreen Afromontane forests in Ethiopia such as, Menagesha-Suba Forest with 82 species (Abate Zewdie, 2007) and Jibat Forest with 54 species (Tamrat Bekele, 1994). The number of species each in Anabe and Gerfa-ourene Forest patches are also less than that of many dry afromontane forests like Kuandisha forest (Abiyot Berhanu *et al*., 2017), Hugumburda-Gratkhassu National Forest Priority Area (Leul Kidane, 2015), Dense forest (Ermias Lulekal, 2014) and Borena Sayint National Park (Hussien Adal, 2014). The differences in species composition over different forests could be attributed to the variation of the site that the forests are found by different factors like, environmental variation, disturbance and forest size which are important factors that affect species composition of forests (Chen *et al.,* 2003). Moreover, disturbance (forest clearing and selective logging) was also reported as a very severe impact in central plateau of Shewa (Tamrat Bekele, 1993).

The highest number of species was documented for families Lamiaceae (9 species, 17%), Fabaceae (7 species, 13%) and Asteraceae, in Anabe Forest patch. Whereas, Lamiaceae (9 species, 20%), Poaceae (7 species, 15%) and Fabaceae (five species, 11%) in Gerfa-ourene Forest patch. Hence, having such families as the top species rich families of the two forests could be related to the fact that they are species rich families in the flora area, Ethiopia and Eritrea (Mesfin Tadesse, 2004; Ensermu Kelbessa and Sebsebe Demissew, 2014). Asteraceae was also shown to be well-represented in other montane forests in Ethiopia including Dense Forest (20 species, 27%) (Ermias Lulekal, 2014) and Komto forest (17 species, 9.44%) (Fekadu Gurmessa *et al.*, 2013).

Results also indicated that herbaceous species were abundantly found both in Anabe and Gerfa-ourene Forest patchs relative to the other growth forms. This agrees with other studies elsewhere in other Ethiopian montane forests (Leul Kidane, 2015; Ermias Lulekal 2014; Fekadu Gurmessa *et al*., 2013). The high number of herbaceous species richness may be attributed to the canopy cover of the forest patches. Herbaceous species cover is usually inversely proportional to canopy cover (Friis, 1986).

5.1.1.2. Plant communities and vegetation types in Anabe and Gerfa-ourene Forest patches

The identified three plant community types from each Anabe and Gerfa-ourene Forest patches show differences in species composition. Ingredients and the degree of disturbances in the area are among possibilities for being varied in each community (Urban *et al*., 2000; Whittaker *et al*., 2003). Anabe and Gerfa-ourene forest patches are exposed to human interference like the local communities across the forest to go from one station to the other. Moreover, people use the forest by itself as a source of fuelwood necessities though they do this illegally. Using the forest as a source of fuelwood is shown as a big problem in Gerfa-ourene Forest patch than Anabe Forest

patch. Hence, such disturbances by the local community affects the species diversity (Whittaker *et al*., 2003).

In Anabe Forest patch *Cupressus lusitanica-Juniperus procera* community type (Community 1) was composed of 75 species distributed in plots of higher altitudinal ranges relative to the others which is (2063 - 2286 m.a.s.l.). The upper canopy of the community type was dominated by *Cupressus lusitanica* and *Juniperus procera*. In this community high species richens is shown and there is also the existence of introduced exotic species like *Cupresus lusitanica*. Hence, the result indicated that since the year 1985, the area become one of the nationally protected lands for natural habitat and they may have grown this species at that time. The existence of *Juniperus procera* in the upper canopies indicated the 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; Ermias Lulekal, 2014). In this community type there was high medicinal plant composition (30, 39.47%) than the other identified community types which are used by the local people of the area. While in Gerfa-ourene Forest patch *Psydrax schimperiana - Juniperus procera* community type (Community 1) was found to be distributed between 1998 and 2162 m.a.s.l. It consisted of 61 species and the upper canopy of the community type was dominated by *Psydrax schimperiana* and *Juniperus procera*. This community was found to be the richest in medicinal plant composition contained 23 (37.7%) species of traditionally used medicinal plants as compared with the other communities.

The *Podocarpus falcatus - Pittosporum viridiflorum* community type in Anabe Forest patch and *Prunus Africana - Acokanthera schimperi* community type in Gerfa-ourene Forest patch (community two in both forests) were composed of 56, 37 species respectively. This community

types range from 2055 to 2240 m.a.s.l. and 1935 to 2059 m.a.s.l. correspondingly. In the upper canopy *Podocarpus falcatus* and *Pittosporum viridiflorum* at Anabe and *Prunus africana* and *Acokanthera schimperi* at Gerfa-ourene Forest patches were found abundantly. Plant species like *Ehretia cymosa* and *Prunus africana* were also found both in Anabe and Gerfa-ourene Forest patches in this community type. Moreover, *Hypoestes forskaolii* and *Salvia tiliifolia* were found to be common in the herbaceous layer of both forest patches in the community.

Olea europaea subsp. *Cuspidata* - *Acacia abyssinica* community type (community 3) in Anabe Forest patch and *Acacia abyssinica* - *Pittosporum viridiflorum* community type (community 3) in Gerfa-ourene Forest patch stretching from 2007 to 2074 m.a.s.l. and had 36 species, 2031 to 2118 m.a.s.l. and had 52 species respectively. *Olea europaea* subsp. *cuspidata* and *Acacia abyssinica* trees were dominant in the upper layer in Anabe Forest patch whereas *Acacia abyssinica* and *Pittosporum viridiflorum* trees were dominant in the upper layers of Gerfa-ourene Forest patch. Anabe and Gerfa-ourene Forest patches share some common species in the identified communities in the upper canopy like *Olea europaea* subsp. *cuspidata* and *Olinia rochetiana*. Communities 2 and 3 were found to accommodate about 19, 15, and 14, 16 ethnomedicinal plant species, respectively for Anabe and Gerfa-ourene Forest patches.

Altitudinal range of the identified community types in both forest patches, species composition, and type of dominant species in the upper canopies of the forests specified Anabe and Gerfa-ourene Forest patches belong to the category of dry evergreen Afromontane forest and grassland complex. Dry evergreen Afromontane forests lie between altitudinal ranges of 1800-3000 m.a.s.l. and consist of canopies dominated by *Podocarpus falcatus*, *Juniperus procera* and *Olea europea* subsp. *cuspidata*, which all found to be true for Anabe and Gerfa-ourene Forest patches (Zerihun Woldu, 1999 and Friis *et al*., 2011). These species were also mentioned to form the upper

canopies of different dry evergreen montane Afromontane forests in Ethiopia (Tamrat Bekele, 1993; Demel Teketay and Tamrat Bekele, 1995).

5.1.1.3. Species diversity in Anabe and Gerfa-ourene Forest patches

The highest Shannon-Wiener diversity was observed for community 2 (3.45) in Anabe Forest patch, where as in Gerfa-ourene Forest patch it was observed for community 3 (3.38). Community one had the highest value of species richness (86) and (62) for Anabe and Gerfa-ourene Forests patches respectively. In Anabe Forest patch the highest value of medicinal species richness (32) and Shannon's diversity (2.93) was recorded for community one and high medicinal species evenness (0.94) for community three was observed. Where as, in Gerfa-ourene Forest patch highest value of medicinal species richness (24) and Shannon's diversity (2.77) was recorded for community one and species evenness (0.94) were observed in community two. Accordingly, the high H' value of the described communities may relate to the relative differences in altitude and the degree of disturbances that occur in the given sites. Climatic dissimilarities and disturbances are very important factors which affects species diversity and evenness in a given forest (Feyera Senbeta and Demel Teketay, 2003).

5.1.1.4. Vegetation structure of Anabe and Gerfa-ourene Forest patches

Results in Anabe and Gerfa-ourene Forest patches show variations in density distributions. Accordingly, the observed value from a comparison of the ratio of density distribution of trees and shrubs in DBH>10cm and DBH>20 cm classes of the two forest paches were 2.12 and 1.09 for Anabe and Gerfa-ourene Forest patches respectively. Hence Anabe forest patch was found to be lower than that of some montane forests such as Chilimo (2.6) and Menagesha (2.3) (Tamrat Bekele, 1993), Masha Anderacha (2.4) (Kumlachew Yeshitela and Tamrat Bekele, 2002) where

as Gerfa-ourene Forest patch was found to be lower than the above mentioned forests and other forests like Dense Forest (1.5) (Ermias Lulekal, 2014) Mana Angetu (2.09) (Ermias Lulekal *et al*., 2008b) and Denkoro (1.90) (Abate Ayalew *et al*., 2006). The result on the overall proportion of trees and shrubs in Anabe and Gerfa-ourene Forest patches across their DBH classes indicates an inverted J-shape distribution. The inverted J-shape distributions across DBH classes are revealing that the forest is in healthy regenerating status (Silvertown and Doust, 1993). Similar findings have been reported elsewhere in Ethiopia (Feyera Senbeta, 2006; Dinkissa Beche, 2011; Desalegn Tadele *et al*., 2013; Abiyot Berhanu *et al*., 2017).

In Anabe and Gerfa-ourene Forest patches eight woody species from Anabe and ten woody species from Gerfa-ourene Forest patch were identified to be more dominant than others. The first five species, *Podocarpus falcatus, Ficus sur, Juniperus procera, Cupressus lusitanica* and *Olea europaea* subsp. *cuspidata* were ranked the five most dominant species accounting for 73.33% of the total basal area in Anabe Forest patch. Whereas, *Acacia abyssinica, Rhus retinorrhoea, Rhus glutinosa, Olea europaea* subsp. *cuspidata* and *Nuxia congesta* were dominant than the others in Gerfa-ourene Forest patch accounting for 33.53% of its total basal area. *Podocarpus falcatus, Juniperus procera* and *Cupressus lusitanica* in Anabe Forest patch and *Rhus retinorrhoea, Olea europaea* subsp. *cuspidata* and *Psydrax schimperiana* in Gerfa-ourene Forest patch were also mentioned in the list of the species which showed the highest densities but not the others. For those species which have high basal area but with lower density for example *Ficus sur* and *Olea europaea* subsp. *cuspidata* in Anabe Forest patch and *Acacia abyssinica* and *Juniperus procera* in Gerfa-ourene Forest patch were, it is due to some reasons which is related to their capability of regeneration, environmental conditions and human interference. For example the low density of *Juniperus procera* might be related to the very poor regeneration capacity under its own canopy (Tamrat Bekele, 1993). The highest density value for

Olea europaea subsp. *cuspidata* could be attributed to its relatively good regeneration capacity under shaded conditions in dry environments (Masresha Fetene and Yonas Feleke, 2001; Tamrat Bekele, 2005). This result is in agreement with that of the Gerfa-ourene Forest patch whereas not to the Anabe Forest patch, this might have happened due to human interference since *Olea europaea* subsp. *cuspidata* is used for multi purposes in the area.

The most frequent woody species in Anabe Forest patch was *Juniperus procera* that occurs in 80% of all quadrats sampled. *Podocarpus falcatus* (68%) and *Cupressus lusitanica* (66%) were also most frequent species following to *Juniperus procera*. Whereas, in Gerfa-ourene Forest patch *Euclea racemosa* was the most frequent species which occurs in 73.33% of all quadrats sampled. *Rhus glutinosa* (70%), *Dodonaea angustifolia* (53%) and *Prunus africana* (50%) were also among the most frequent species in the area. 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). The obtained result from Importance Value Index (IVI) analysis differentiated each woody species in its degree of dominance and classify hierarchically the plant communities in the given forests. The higher IVI value of *Podocarpus falcatus* and *Juniperus procera* in Anabe Forest patch, *Juniperus procera* and *Psydrax schimperiana* in Gerfa-ourene Forest patch than the other species were related to their high basal area. High density and high frequency together with high basal area indicate the overall dominance of a species in a vegetation (Lamprecht, 1989). The IVI analysis result could be the major factor to show dominance of a tree species in a forest ecosystem (Mueller-Dombois and Ellenberg, 1974). Therefore, in Anabe and Gerfa-ourene Forest patches higher IVI values of the above mentioned species showed that the overall dominance of these species in the vegetation in the study area.

5.1.1.5. Population structure of Anabe and Gerfa-ourene Forest patches

The results from population structure analysis of woody species in Anabe and Gerfa-ourene Forest patches revealed that 4 and 3 main representative patterns of density distribution of trees through different DBH classes for Anabe and Gerfa-ourene Forest patches respectively. Different population patterns of tree species are usually caused by various factors like selective cutting and disturbance (Demel Teketay, 2005a). The first pattern, which is unimodal or bell-shaped, both in Anabe and Gerfa-ourene Forest patches is highly attributed to poor regeneration and selective removal of individuals with lower and higher DBH classes; while populations in the middle classes are left. This pattern has rarely been reported in the DAF (Desalegn Tadele *et al*., 2013; Ermias Lulekal, 2014 and Abiyot Berhanu, 2017). 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 (Ermias Lulekal, 2014). The second population structure type was represented by the 'U' shaped pattern in Anabe Forest patch, where as in Gerfa-ourene Forest patch, it was represented by inverted-J shaped. The 'U' shaped pattern often accounted to selective cutting of medium-sized trees (Feyera Senbeta, 2006). But in the case of Anabe Forest patch (*Croton macrostachyus*) was not exposed to selective cutting. The inverted-J shaped in the second pattern for Gerfa-ourene Forest patch and forth pattern in Anabe Forest patch is usually an indicator of healthy population status of a species with good reproduction and recruitment (Demel Teketay, 2005a; Feyera Senbeta, 2006; Alemnew Alelign *et al*., 2007; Desalegn Tadele *et al*., 2013; Ermias Lulekal, 2014). The third pattern was a J shaped distribution in both Forest patchs. The J shaped pattern indicates a highly-disturbed forest with poor reproduction and selective removal of individuals with lower DBH classes (Tamrat Bekele, 1993; Feyera Senbeta, 2006). In the case of Anabe and Gerfa-ourene Forest patches as observed

and getting the information from the local community of the area the intermediate individuals are left in the population whereas lower DBH classes are removed for various uses like construction and farm implements (*Ehretia cymosa*) and (*Ekebergia capensis*) for firewood in Anabe Forest patch.

5.1.2. Medicinal plant species for humans in Kalu and Bati Districts

5.1.2.1. Diversity

Results revealed a total of 145 medicinal plant species used to treat both human and livestock ailments in Kalu and Bati Districts. Of this, 78 medicinal plant species are shared in common for both Kalu and Bati Districts. In Kalu District a total of 118 medicinal plant species belonging to 100 genera and 54 families were reported to be used for treating human ailments whereas, a total of 87 medicinal plant species belonging to 71 genera and 46 families (86 angiosperms, 1 gymnosperm) were reported to be used for treating human ailments in Bati District. Hence, results from both districts showed that, Kalu and Bati Districts are rich in medicinal plant diversity as shown in various ethnobotanical study of different parts of Ethiopia (Getu Alemayehu, 2017; Zewde Kassa, 2017; Ermias Lulekal, 2014).

The families Lamiaceae, Asteraceae, Fabaceae and Euphorbiaceae from Kalu and Fabaceae, Lamiaceae, Asteraceae and Solanaceae from Bati Districts have shown dominance when compared with other medicinal plant species. This could be attributed to their wider distribution and abundance in the flora area (Mesfin Tadesse, 2004; Hedberg *et al*., 2006). This is also confirmed by consistent recording of ethnomedicinal uses of species from the above-mentioned families in different 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).

5.1.2.2. Growth form and habitat

Majority of the medicinal plant species used for human ailments both in Kalu and Bati Districts were herbs. This may be due to the fact that herbs are easily available than shrubs and trees especially in the community's residential areas. Dominance of herbaceous species was also seen in most medicinal plant inventories in Ethiopia elsewhere which agrees with this findings (Mirutse Giday *et al*., 2003; Haile Yineger *et al*., 2007; Mirutse Giday *et al*., 2010; Ermias Lulekal, 2014; Getu Alemayehu, 2017).

5.1.2.3. Plant parts used and forms

In both Kalu and Bati Districts, leaves and roots were harvested respectively for majority of the remedy preparations. Hence, consuming of leaves of medicinal plants for most of the remedy preparations is good for the sustainability of the traditional medicinal plants in the area as compared to harvesting of roots. Using the leaf parts for traditional remedy preparations was also common in other findings elsewhere in Ethiopia (Mirutse Giday and Gobena Ameni, 2003; Abraha Teklay *et al.*, 2013 and Getu Alemayehu, 2017). But, utilization of roots for human medicinal plant preparations is risk for the corresponding medicinal plants to become threatened. Exploiting of roots of medicinal plants was also commonly reported by other ethnomedicinal studies elsewhere in Ethiopia (Dawit Abebe and Ahadu Ayehu, 1993; Getachew Addis *et al*., 2001; Haile Yineger *et al*., 2007; Tilahun Teklehaymanot, 2009 and Ermias Lulekal, 2014).

Results also indicated that, freshly collected plant parts (74%) and (64%) in Kalu and Bati Districts respectively were used dominantly in remedy preparations used against various human ailments. Other ethnomedicinal findings (Haile Yineger *et al*., 2007; Ermias Lulekal *et al*., 2008a; Ermias Lulekal, 2014 and Getu Alemayehu, 2017) have also indicated the wide use of fresh plant materials for various remedy preparations.

5.1.2.4. Marketability of medicinal plants

Large numbers of medicinal plant species (41.5%) and (42.5%) in Kalu and Bati respectively were accessed from different weekly and daily markets of the area. But, out of the claimed number only six species in Kalu and eight species in Bati were actually sold on markets for the purposes of their medicinal values. The remaining medicinal plants which were found in marketplaces were mainly sold for their non-medicinal uses but were also applied as medicine when needed. Six medicinal plant species *Clerodendrum myricoides, Echinops kebericho, Indigofera suaveolens, Lepidium sativum, Nicotiana tabacum* and *Otostegia integrifolia* were found both in Kalu and Bati Districts. Hence, the result indicates there is a close relation between the two districts based on the culture and as well as geographical location thus they adapt and share so many things like traditional medicinal plants. Studies in different parts of Ethiopia, such as that of Moa Megersa *et al.,* (2013) and Ermias Lulekal, (2014) have shown similar results.

5.1.2.5. Consensus on medicinal plant use

Highest ICF values for Back pain (0.94), (0.96) and Arthritis (0.93), (0.94) in Kalu and Bati Districts were recorded respectively. In contrast, the highest fidelity level values for *Withania somnifera* (93.5%) under the Fever/"Mich" ailment type and *Olea europaea* subsp. *cuspidata* (92.6%) in the Back pain disease type in Kalu District were obtained. Whereas, the highest fidelity level values recorded for *Terminalia brownii* (95.96%) under the Back pain ailment type and *Clerodendrum myricoides* (92.6%) in the Arthritis disease categories respectively in Bati District.

5.1.2.7. Direct matrix ranking exercises and preference ranking

Traditional medicinal plants in the study area like, *Olea europaea* subsp. *cuspidata*, *Ehretia cymosa* and *Grewia trichocarpa* in Kalu District showed the highest values/ranks for a number of multipurpose uses like for firewood, construction and charcoal in addition to their medicinal uses. Where as in Bati District, *Olea europaea* subsp. *cuspidata*, *Podocarpus falcatus* and *Ehretia cymosa* showed highest values/ranks for a number of multipurpose uses like construction, firewood and agricultural tools other than for their medicinal uses. Hence, the results depict that these multipurpose medicinal plant species are more exploited for their multipurpose uses than for their medicinal values at present. Thus, these traditional medicinal plants need urgent conservation attention to keep and protect them from damage and fast-declining. Haile Yineger *et al*., (2007) and Ermias Lulekal, (2014) have also reported high exploitation of multipurpose medicinal plants for uses other than their traditional medicinal importance in different parts of Ethiopia.

Informants were allowed to rank the most-preferred medicinal plant species in the study site to treat minor bleeding/bleeding during cutting. As a result *Achyranthes aspera*, *Croton macrostachyus* and *Solanum incanum* recorded highest values and hence found the most-preferred ones to treat bleeding in Kalu District. Where as in Bati District, *Lawsonia inermis*, *Ehretia cymosa* and *Cyperus longus* were recorded their highest values to treat wound respectively. Thus, this result may encourage further investigation of these species for their bioactive components against a given diseases.

5.1.3. Medicinal plants used in ethnoveterinary practice

5.1.3.1. Ethnoveterinary medicinal plant diversity

From the identified traditional medicinal plants which are important to treat different livestock ailments, plants like *Calpurnia aurea*, *Celtis africana*, *Dodonea angustifolia*, *Ehretia cymosa*, *Premna schimperi* and *Ziziphus spina-christi* were found in common in both the districts. Some species of the two districts, *Achyranthes aspera*, *Allium sativum*, *Calpurnia aurea*, *Dodonea angustifolia* and *Olea europaea* subsp. *cuspidata* were also reported in other works done in North central Ethiopia (Ermias Lulekal, 2014); and *Acacia mellifera*, *Allium sativum*, *Calpurnia aurea*, *Cyphostemma adenocaule*, *Dodonea angustifolia*, *Ehretia cymosa* and *Jasminium grandiflorum* in Amaro and Gelan districts, Southern Ethiopia (Getu Alemayehu, 2017). Similarity of medicinal plant species used in different communities can serve as an indicator for cultural knowledge sharing among different ethnic groups besides its status of distribution or accessibility in different areas.

5.1.3.2. Growth form, source and plant parts of ethnoveterinary plants

Results revealed that herbs were the most frequently used plant parts utilized for remedy preparation in Kalu District whereas, shrubs were widely used in Bati District. Previous ethnobotanical findings also depicted dominance of herbs and shrubs (Mirutse Giday *et al*., 2003; Haile Yineger *et al*., 2007). In contrast, other findings by Debela Hunde *et al*., (2006); Ermias Lulekal *et al*., (2008a); Fisseha Mesfin *et al.*, (2009) and Ermias Lulekal, (2014) reported dominance of shrubs in their investigations in different parts of the country. Results also revealed that people in the study area harvest the majority of their traditional medicinal plants for their livestock from the wild habitat (73.33% and 78%) for Kalu and Bati Districts respectively which is in agreement with results of many studies conducted elsewhere in the country (Getachew

Addis *et al*., 2001; Hareya Fassil, 2003; Mirutse Giday *et al.*, 2003; Mirutse Giday and Gobena Ameni, 2003; Kebu Balemie *et al*., 2004, Ermias Lulekal, 2014). Hence, the result indicated that there is the high level of threat to the wild medicinal plants in the study area due to habitat destruction and deforestation.

The most-collected plant parts used for ethnoveterinary remedy preparation in the study area were leaves, in both Kalu and Bati Districts. The common use of leaves by the community in the study area could be related to accessibility of this plant part for a long period of time as compared to other parts of the plant. Communities in the other parts of the country also mostly use leaves in the preparation of their remedies (Mesfin Tadesse *et al.*, 2005 and Mirutse Giday *et al.*, 2007). Using the leaves does not affect the plant's survival for the future compared to the collection of underground part, stem or whole part. In contrast roots are also reported to be harvest for remedy preparation in different parts of the country (Dawit Abebe and Ahadu Ayehu, 1993; Getachew Addis *et al.*, 2001; Haile Yineger *et al*., 2007; Ermias Lulekal *et al*., 2008a; Tilahun Teklehaymanot, 2009; Ermias Lulekal, 2014). Results also indicate that people in the study area both in Kalu and Bati Districts use freshly harvested plant parts (93.3% in Kalu and 100% in Bati) for remedy preparations. Similar findings were also investigated elsewhere in Ethiopia (Haile Yineger *et al.*, 2007; Mirutse Giday *et al.*, 2007; Ermias Lulekal *et al*., 2008a; Ermias Lulekal, 2014).

5.1.3.3. Types of livestock ailments, methods used for preparation of remedies and traditional diagnosis

For the identified veterinary ailments in both Kalu and Bati Districts, people used one or more medicinal plant species. Crushing the claimed traditional medicinal plants and homogenizing it with cold water was the major mode of remedy preparation (53.33% in Kalu and 40% in Bati).

Homogenizing traditional medicinal plants with water was also reported from other findings (Haile Yineger *et al*., 2007; Ketema Tolossa *et al*., 2013; Ermias Lulekal, 2014). Majority of the reported medicinal plant species (55.6% in Kalu and 78.95% in Bati) was applied to treat different cattle ailments. The reported relatively high number of medicinal plants mentioned for treating cattle ailments could be related to a higher occurrence of a number of cattle ailments in the study area. Similar findings were also reported in other ethnobotanical works in the country (Mirutse Giday and Gobena Ameni, 2003; Ermias Lulekal, 2014). There were no strict standard doses of herbal preparations reported by traditional healers for any of the preparations used to treat livestock ailments in both Kalu and Bati Districts. Haile Yineger *et al*., (2007) and Ermias Lulekal, (2014) also reported the lack of standardized doses in traditional prescriptions of livestock remedies elsewhere in the country.

5.1.3.4. Marketability of ethnoveterinary plants

From the reported ethnoveterinary plants only 13.33% (*Allium sativum* and *Brassica carinata*) in Kalu and 16.67% (*Olea europaea* subsp. *cuspidata*, *Terminalia brownii* and *Ziziphus spina-christi*) in Bati Districts were mainly sold in the weekly and daily markets of the two districts. But, still either of them were not sold for their medicinal uses, however, informants indicated that they apply them as medicine when needed. Accessibility of traditional medicinal plants in the market were also reported in various findings elsewhere in Ethiopia (Mirutse Giday *et al*., 2007; Ermias Lulekal, 2014).

5.1.4. Indigenous knowledge transfer on medicinal plants

Both in Kalu and Bati Districts the indigenous knowledge on the traditional medicinal plants is hold as a private secret for only the healers. Keeping the knowledge as a secret is related with a number of reasons. Some of them consider the knowledge as if it is given only for the restricted

family by blessing from God, others are also consider that if the indigenous knowledge is exposed for all, the medicinal plant by itself may get depleted. Likewise, members of traditional practitioners were also considered as the owner of that indigenous knowledge thus, they use it for generating their income. There are also other views that elderly people keep the indigenous knowledge as a big secret, for instance some of the traditional medicinal plants are poisons, while and have a big risk of using them. The trend of keeping indigenous knowledge on medicinal plants as a secret is also common in other ethnic groups in the country (Haile Yineger *et al*., 2007; Mirutse Giday *et al*., 2009; Tilahun Teklehaymanot, 2009; Ermias Lulekal, 2014).

Youngsters in both districts and people with different educational background related to using a traditional medicinal plant as a harmful culture and influenced by modernization to use and keep the traditional medicinal plants. They give a reason for opposing using a traditional medicinal plants related to its hygiene and dosage, however, people also preferring a traditional medicinal plants in the case of some diseases which are not treated by modern medicine or for those diseases which are not completely curable by modern medicine (e.g. chronic benign illnesses).

In contrast, now a days some of the young generations show a big interest in using traditional medicinal plants especially women related to keep their beauty by natural cosmetics, and for some women health problems that would happen with giving birth. Example, womb problems and back pain. As evidence, using a smoking bath of *Terminalia brownii* known as "woyeba-chis" or using a smoking bath of *Olea europaea* subsp. *cuspidata* which is known as "Etan" was the only cultural practices of the northern part of Ethiopia, specifically in Wollo's and Raya's (Raya-kobo and Raya-azebo) people, but now it becomes popular and very expensive type of beauty treatment in the biggest cities and towns of the country like Addis Ababa. Even it becomes a big business idea and practice for the cultural cosmetics and women prefer to it better

than the modern one by considering its benefit, being healthy and being beautiful. Regarding the lack of interest towards using and keeping traditional medicinal plants in the young generation is also shown in other findings which were reported by some investigators in other cultural groups in Ethiopia (Kebu Balemie *et al*., 2004; Ermias Lulekal *et al*., 2008a; Mirutse Giday *et al*., 2009; Ermias Lulekal, 2014).

5.1.5. Medicinal plant conservation practices

Majority of the traditional medicinal plants (72.34%) from Kalu and (69.77%) from Bati Districts were harvested from the wild environment. Hence, the practical overdependence of the community on the wild medicinal plants is a big risk of erosion for traditional medicinal plants in the study area and the knowledge linked to it. It means there is over-exploitation and improper harvesting techniques on medicinal plants in local communities in the two districts. As it was checked through direct observation and interviews with local people in the area the people are still dependent on the wild environment to collect the traditional medicinal plants. Similar results were also reported for traditional medicinal plants used by other ethnic groups in the country (Mirutse Giday *et al*., 2003; Haile Yineger *et al*., 2007; Ermias Lulekal *et al*., 2008a; Fisseha Mesfin *et al*., 2009; Mirutse Giday *et al*., 2009; Ermias Lulekal, 2014). People in the study area reported that they are cultivating medicinal plants in home gardens even though they were few. However, most of those medicinal plants that they are cultivating are not for the purpose of their therapeutic values other than their non-medicinal value.

Moreover, the community in the two districts have some believe in few of traditional medicinal plants, for example in plants like *Ehretia cymosa*, *Olea europaea* subsp. *cuspidata* and *Terminalia brownii* that they have a customary practices done at the time of marriage ceremony, thus this may contribute to conservation of those useful plants. In addition to this, they also have

a tradition of growing *Terminalia brownii* in front of their houses, which is as a sign of good chance, that they call it locally "telfona". In contrast, they were also practiced previously that at the time of conflict if someone is hurts to some body and becomes wounded, they were pay a lots of *Olea europaea* subsp. *cuspidata* stem wood as a compensation which is important to fumigate the injured person in Bati District, so this may also one of from the threats that influence medicinal plants natural habitats of the area and deforestation. Over-exploitation of traditional medicinal plants and improper harvesting techniques of the plants by the local communities and lack of deliberate *in-situ* or *ex-situ* conservation practices to protect the fast-eroding remedial plant resource were also reported in some investigations which were done in the country (Hareya Fassil, 2003; Fisseha Mesfin *et al*., 2009; Mirutse Giday *et al*., 2009; Ermias Lulekal, 2014). Hence, the result pertinent to conservation in this finding is an alarm to find a solutions to bring sustainable utilization and protection of the highly depleted local resources in that area, and/or development of locally sound propagation techniques for those medicinal plants found to be highly threatened in the wild either by *in-situ* or *ex-situ* conservation practice. According to Cunningham (1997), promotion of home gardening and cultivation of medicinal plants are recommended as a guarantee for continual survival of traditional medicinal plants for the coming generation.

5.1.6. Amplification and sequencing success

Sequencing success was high for *rbcL* (97.4%) and ITS (96.1%), but relatively low for *matK* (75.97%); perhaps indicating that a modified protocol is necessary for *matK* to be used as a molecular barcode. Similarly other studies have also shown that, *rbcL* gene had shown higher amplification efficiency and sequencing success rate compared to other selected plant characterization genes (CBOL Plant Working Group, 2009) and low success rates of *matK* have been also shown by others (Kress and Erickson, 2007, Fazekas *et al.* 2008).

On the other hand, the result showed that there was a sequencing failure for some of the samples. Hence, from the total 154 samples 37 samples for *matK* (nine of the samples were from the plant samples that were not distinguished by their morphology), 6 for ITS (all of them were morphologically identified) and 4 for *rbcL* (three of them were not distinguished by their morphology) showed a sequencing failure. As the result shown that, relatively the sequence failure for *matK* was high.

Among the 154 samples 14 of them were not distinguished by their morphology, hence, results suggested that plant samples that are not distinguishable by their morphology could be able to be identified by their DNA barcoding. From the 14 that were not distinguished by their morphology nine of the samples were the powder forms of three samples which were collected either of in their voucher form or by silica gel. Hence, these three samples were very important for comparison as a reference to their powder form, and the result suggested that for *Lawsonia inermis*, except one sample in *matK* for NAPL3, the BLAST query was 100% similar with that of its reference sample. For *Nicotiana tabacum*, only one sample which is NAPN2 in *rbcL* was similar by its genus in its BLAST query but others were with no sequence, or no hit. But for the powder form samples (NAPH1, NAPH2, and NAPH3) of the sample name NA142, which was not identified morphologically locally known as hakenur, the three powder forms give different results. After the BLAST query, for NAPH1, the sequence were similar with that of *Ligustrum australianum* for *rbcL* but there was no hit for ITS and no sequence for *matK*. For NAPH2, the BLAST query of the sequences for ITS and *matK* was *Morella pensylvanica* but no hit for *rbcL*. For the sample NAPH3, the result from the BLAST query was shown *Evolvulus alsinoides* for ITS and Morella rubra for *rbcL* but no sequence for *matK*. Hence, the results from the powder samples from the market for hakenur (NA142) is showed that there is no similarity with the result of the voucher. The BLAST query for hakenur as a reference sample (that was extracted from

voucher) is *Phyllanthus virgatus* for ITS and *Andrachne microphylla* for *rbcL* both are from family Phyllanthaceae but there was no hit for *matK*. Therefore, there is dissimilarity of the results which indicated us the powder samples from the market. Hence, the market sample may be adulterated and it needs a verification since, DNA barcoding is used for the authentication and quality assurance of raw plant material (Li *et al*., 2011).

Samples like ketenaju (NA143), yejibshenkurt (NA144) and birgud (NA145) in its local name which were collected from the market were identified by their DNA barcode. Consequently, the results presented in this report demonstrate for the sample NA143 (ketenaju), *Origanum majorana* for ITS in the BLAST query which is in the family Lamiaceae and which is exactly similar with the sample, *Acnistus arborescens* for *rbcL* which is in the Solanaceae family which is totally different from each other and *Origanum vulgare* for *matK* in the BLAST query in family Lamiaceae. For the sample yejibshenkurt (NA144) the BLAST query showed, for ITS *Proiphys amboinensis* which is in the Amaryllidaceae family and for *rbcL Crinum yemenense* which is also from the same family with the result of the ITS but the BLAST query did not showed any result for *matK*. For the sample birgud (NA145) the ITS result from the BLAST query showed that *Phialocephala lagerbergii*. *P. lagerbergii* is fungus and it belongs to the family vibrisseaceae. This fungus is characterized by a pigmented stipe, a terminal sporogenous head comprising fine hairs of metulae and phialides (Kirschner and Oberwinkkler, 1998). *P. lagerbergii* is mainly isolated from wood and wood pulp (Day *et al.*, 2012) and the sample birgud, which was a pieces of wood was taken from the market. Hence, possibility of fungal contamination in this market sample is expected and it may affect that the results of the markers.

5.2. Conclusion

Anabe and Gerfa-ourene Forest patches are rich in species composition having 128 plant species which belong to 114 genera and 60 families. Anabe Forest patch has more number of species (108 species contained 97 genera and 52 families) than Gerfa-ourene Forest patch (84 plant species representing 75 genera in 46 families). Therefore, hypothesis I is totally accepted.

The results further showed the two forest patches (Anabe and Gerfa-ourene Forest patches) are the main sources of traditional medicinal plants used to treat human and livestock ailments in Kalu and Bati districts as shown by harboring 25.5% and 22.06% of the total medicinal plant species recovered from the study area. The highest number of species was recorded for families Lamiaceae in Anabe and Gerfa-ourene Forest patches. Members of the family Lamiaceae are known by their often sweet- or spicy- smelling and their fascinating fragrance. Besides, the presecence of the family lamiaceae in the two forest patches may due to the fact that, in the Dry evergreen afromonatane forests, there is a successful pollination and dispersal.

There are three plant community types in both Anabe and Gerfa-ourene Forest patches. The *Cupressus lusitanica* - *Juniperus procera* community type in Anabe Forest patch (Kalu District) and *Psydrax schimperiana* - *Juniperus procera* community type in Gerfa-ourene Forest patch (Bati District) are the first richest plant communities among the plant communities found in the study area by having 75, 61 plant species respectively.

As suggested in hypothesis II, both Kalu and Bati Districts are very rich in their medicinal plant composition by having 145 medicinal plant species that belong to 116 genera and 62 families. The local communities also have good perception on traditional medicinal plants and the

associated indigenous knowledge used for the treatment of 49, 58 human and 9, 12 livestock ailments respectively.

Traditional medicinal plants in the study districts are also used for other multiple purposes such as cosmetics, firewood, construction, charcoal, and agricultural tools. Leaves and roots are the most frequently plant parts used for remedy preparation. Using of the root parts for various remedy preparations definitely affects the whole plant part, thus it need attention.

Local communities in the two study districts are mostly dependent on the wild habitat to collect their medicinal plants but they didn't show any concern on appropriate utilization of those resources for their future sustainability as well as on conservation of those traditional medicinal plants. Hence, medicinal plants are at risk of erosion and requiring enhanced conservation and sustainable use.

Kalu and Bati Districts are rich on "women's plants" and herbal plants used as cosmetics (44 species, belonging to 39 genera and 31 families) and, 25 % of the plants species were claimed for fragrance and prevention of rancidity of butter/protecting hair fall in both districts. Safety incidents (e.g. hygiene and dosage) are among reasons that young people are not interested in using and keeping traditional medicinal plants.

DNA barcoding method was attempted for identifying 154 plant materials (medicinal and cosmetics) including from markets with high percentage of success.

Possibility of fungal contamination and adulteration may have affected some of the processed medicinal plant samples obtained from the local market in the present study.

5.3. Recommendations

- Anabe and Gerfa-ourene Forest patches in Kalu and Bati ditricts respectively have several plants used for many purposes including for medicinal and cosmetic/body care purposes. However, currently the identified Forest patches are widely exposed for deforestation due to over exploitation of these plants. Hence, agricultural experts, *woreda* administrators and researchers should provide necessary awareness training on how the people can conserve the plants of the area along preservation of the local indigenous knowledge.

- Kalu and Bati districts are rich in medicinal plants used to treat human and livestock ailments. Thus, toxicity and bioactive component tests on the documented medicinal plants with high informant consensus and fidelity level value should be conducted to ensure the safety of the traditional medicinal plants (e.g. *Terminalia brownii*, *Clerodendrum myricoides*, *Ceratostigma abyssinicum*, *Withania somnifera*, *Clematis hirsute*, *Ehretia cymosa* and *Croton macrostachyus*).

- Kalu and Bati districts have 44 "women's plants" which are important for various health problems, body care and beautification. Therefore, concerned bodies such as researchers, health experts, administrators, agricultural experts and local communities should take and share a great responsibility to work on a wide range of documentation, promotion and conservation of the women's plants in the study districts.

- Local people in Kalu and Bati districts have used plants for many purposes. Consequently, the *woreda* and local administrators should work together with the community to give priority for the conservation of multipurpose medicinal plants such as

Olea europaea subsp. *cuspidata*, *Podocarpus falcatus* and *Grewia trichocarpa* to minimize the risk of erosion.

- Leaves and roots are the most frequently plant parts used for remedy preparation and using of root part is the major threat for the corresponding medicinal plant species. Thus, priority should be given on conservation of those medicinal plant species for their future existence.

- Designing a medicinal field gene bank for *in situ* and *ex situ* conservation strategies should be implemented in the study area which is very important on conserving the traditional medicinal and cosmetic plant species.

- To conserve traditional medicinal and cosmetic plants as well as to attract young people's attention on medicinal plants, hygiene and safety of the TMP should be ensured.

- Availability of barcode sequences for angiosperms on the online database is yet fragmentary, hence, further DNA barcoding for Ethiopian traditional medicinal plants should be done to get new reference samples for the database.

- For quality control of traditional medicinal plants, method of molecular authentication based on DNA barcoding sequences should be done in other areas.

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APPENDICES

Appendix 1. Semi-structured interview questions raised during interviews with informants, Kalu and Bati District

I. General information on respondents' name, age and occupation

1. Date_____Residence area (Village) _____Kebele code_____

2. Name of respondent_____Gender____Age____Serial No.__

2.1. Marital status_____Occupation (main job) _____

2.2. Religion: Muslim_____ Orthodox_____Protestant_____ others (specify) _____

2.3. For how long did you live in the area? A) Since birth B) For the last 20 years

C) For the last ten years D) for less than ten years

2.4. What is the last grade you attended (Educational background)? _____

II. Information related to the medicinal use of the plants

1. What are the most common diseases of humans in your area? _____
2. What are the most common diseases of livestock in your area? _____
3. Mention plant types used to treat a given disease in the area (give local names).

A. Plant used to treat only human diseases

a._____

b. _____

c. _____

B. Plants used to treat only livestock diseases

a._____

b._____

c._____

C. Plants used to treat both human and livestock diseases

a._____

b._____

c._____

4. What part/ parts of the medicinal plant (s) is/are used? (Mark an "X")

Flower (Fr) _____	Latex (Lt) _____
Fruit (Ft) _____	Whole plant (Wp)_____
Seed (Sd) _____	Leaf (L)_____
Sap (Sp) _____	Root (R) _____
Bark (B) _____	Stem (St)_____

5. What is the habit of the plant?

Tree (T)_____	Herb (H)_____
Liana (L)_____	Herbaceous climber(HC)_____
Shrub (S) _____	Herbaceous epiphyte (HE) _____

6. Where do the medicinal plants grow? (Place of collection?)

a. In home gardens _____,

b. Fallowed land _____,

c. In the forest _____.

d. Roadside_____,

e. Other (specify) _____

7. What is the method of preparation of medicinal plants? (Mark"X")

Fresh (F) _____	Dried (D)_____
Crushed (C)_____	Powdered (P) _____

Used alone (Ua) _____ Decoction (De)_____

Concoction (Cn) _____ Mixed with others or water (Mw) _____

8. Does the amount used/dosage vary among age groups, sex? If yes, state for each age groups and sex.
9. Is there any adverse effect (side effect) caused by the medicine? If yes, is/ are there any antidote (s) for those adverse effects?
10. How are the prepared remedies taken by the patient (s)/routs of administration? (Mark"X")

a. Dermal (D) _____ g. Eye(Y) _____

b. Anal (A) _____ h. Other (Specify) _____

c. Vaginal (V) _____

d. Nasal (N) _____

e. Oral (O) _____

f. Ear (E) _____

11. Which season of preferred for collection of medicinal plants in your area?
    a. Wet season _____
    b. Dry season_____
    c. All-the-year round _____
12. How is the plant part collected? (Including the amount collected at a time)
13. Are there conditions (example like pregnancy, menstruation period) that forbid the patient from taking the medicine?
14. Is/Are the medicinal plant (s) marketable? If so, where is their sources?
15. Are the medicinal plants easily accessible? If not, why?
16. Is there any interference between modernization and traditional medicinal plant use in the area? If so, how does modernization interfere with traditional medicinal system?

17. Who is frequently dependent more on traditional medicinal plants as compared to modern medicine? Why?
18. Are there taboos in using of some medicinal plants in the area?
19. Are there threats to the medicinal plants? If so what are the major problems associated with them in the area?
20. Are there traditional medicinal plants conservation methods in the area? If so list themethod of the conservation practices by the indigenous people.
21. Do the medicinal plants have any use other than medicine? If yes, state for each species.
22. Which medicinal plants species is commonly threatened in study area? _____
23. Are there plants known as women's plants? Does the concept exist in the community? If so, how is it referred to and what does it include? List plants that come under this category.
24. List out the local name of plants which are medicinally important as well as usable for beauty care in your area.
25. Indicate if there are non-medicinal plants used for beauty care in the area categorically (medicinal, smoke bath, perfumes, smoking in the room, birth control, inducing pregnancy, skin care, and hair dressing).
26. What part of these plants are used for beauty care?

Flower (Fr) _____ Latex (Lt) _____

Fruit (Ft) _____ Whole plant (Wp) _____

Seed (Sd) _____ Leaf (L) _____

Appendix 2. Floristic list of Anabe and Gerfa-ourene Forest patches, Kalu and Bati Districts

No	Scientific names	Family	Local name	Found in Anabe	Found in Gerfa	Altitude (m)	Voucher No.
1	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	Nech-girar	✓	✓	2082	NA04
2	*Acacia decurrens* Willd.	Fabaceae	Dekerens	✓		2050	NA06
3	*Acalypha Marissima* M.Gilbert**	Euphorbiaceae		✓	✓	2059	NA08
4	***Achyranthes aspera L.***	**Amaranthaceae**	**Dem-akurit**	✓	✓	**2269**	**NA12**
5	*Acokanthera schimperi* (A.DC.) Schweinf.	Apocynaceae	Kiraro	✓	✓	2184	NA11
6	*Actiniopteris semiflabellata* Pic.Serm.	Pteridaceae		✓		2161	NA13
7	*Allophylus abyssinicus* (Hochst.) Radlk.	Sapindaceae	Kekewe	✓		2142	NA14
8	***Aloe trichosantha* Berger**	**Aloaceae**	**Eret**	✓		**2125**	**NA99**
9	*Anagallis arvensis* L.	Primulaceae		✓		2082	NA15
10	***Asparagus africanus* Lam.**	**Asparagaceae**	**Yeset-kesit**	✓	✓	**2240**	**NA16**
11	*Asparagus racemosus* Willd	Asparagaceae	Yeset-kesit	✓	✓	2242	NA18
12	*Asplenium aethiopicum* (Burm.f.) Bech.	Aspleniaceae		✓	✓	2166	NA19
13	*Asplenium monanthes* L.	Aspleniaceae		✓	✓	2166	NA20
14	***Bersama abyssinica* Fresen.**	**Melianthaceae**	**Azamir**	✓	✓	**2164**	**NA100**
15	*Bidens pilosa* L.	Asteraceae	Chiguagot	✓	✓	2251	NA21
16	*Bothriochloa insculpta* (Hochst. ex A. Rich.) A.Camus	Poaceae		✓	✓	2082	NA22
17	*Cadaba farinosa* Forssk.	Capparldaceae	Dingay-seber		✓	2057	NA25
18	***Cadia purpurea* (Picc.) Ait.**	**Fabaceae**	**Enjiro**		✓	**1958**	**NA17**
19	***Caesalpinia decapetala* (Roth) Alston**	**Fabaceae**	**Kentafa**	✓	✓	**2182**	**NA10**
20	***Calpurnia aurea* (Ait.) Benth.**	**Fabaceae**	**Digita**	✓	✓	**2073**	**NA09**
21	*Campanula edulis* Forssk.	Campanulaceae		✓		2082	NA26
22	***Carissa spinarum* L.**	**Apocynaceae**	**Agam**	✓	✓	**2125**	**NA40**
23	*Cassipourea malosana* (Baker) Alston	Rhizophoraceae	Bune	✓		2164	NA27
24	***Celtis africana* Burm.f.**	**Ulmaceae**	**Fetekuma**	✓	✓	**2154**	**NA75**
25	***Ceratostigma abyssinicum* Asch.**	**Plumbaginaceae**	**Metirez**		✓	**1553**	**NA56**

26	*Cheilanthes farinosa* (Forssk.) Kaulf.	Pteridaceae		✓	✓	2111	NA28
27	***Clematis hirsuta* Perr. & Guill**	**Ranunculaceae**	**Azo-hareg**	✓	✓	**2076**	**NA07**
28	***Clerodendrum myricoides* (Hochst.) Vatke**	**Lamiaceae**	**Misiroch**		✓	**2182**	**NA53**
29	***Clutia abyssinica* Jaub. & Spach.**	**Euphorbiaceae**	**Feyele-fej**		✓	**2153**	**NA54**
30	*Commelina benghalensis* L.	Commelinaceae	Wof-anikir	✓	✓	2176	NA30
31	*Commelina latifolia* Hochst. ex A Rich.	Commelinaceae	Wof-anikir	✓	✓	2176	NA31
32	*Conyza schimperi* Sch. Bip. ex A. Rich.	Asteraceae	Yahiya-arity		✓	2182	NA32
33	*Cordia africana* Lam.	Boraginaceae	Wanza	✓		2056	NA33
34	***Croton macrostachyus* Del.**	**Euphorbiaceae**	**Bisana**	✓	✓	**2069**	**NA77**
35	*Cupressus lusitanica* Mill.	Cupressaceae	Yeferenji-tid	✓		2286	NA34
36	*Cynoglossum lanceolatum* Forssk.	Boraginaceae		✓		2066	NA38
37	***Cyperus longus* L.**	**Cyperaceae**	**Gondagondo**	✓	✓	**2164**	**NA05**
38	***Cyphostemma adenocaule* (Steud. ex A. Rich.) Desc. ex Wild & Drummond**	**Vitaceae**	**Milas-goligul**	✓	✓	**2052**	**NA138**
39	*Desmodium repandum* (Vahl) DC.	Fabaceae	Yayit-hareg	✓	✓	2253	NA39
40	***Dodonaea angustifolia* L. f.**	**Sapindaceae**	**Kitikita**	✓	✓	**2171**	**NA108**
41	*Doryopteris concolor* (Langsd & Fisch.) Kuhn in von der Decken	Pteridaceae		✓	✓	2157	NA42
42	*Dovyalis abyssinica* (A. Rich.) Warb.	Flacourtiaceae	Koshem	✓		2164	NA44
43	*Dovyalis caffra* (Hook. f. & Harv.) Hook. f.	Flacourtiaceae	Bahir-koshem	✓		2179	NA48
44	*Dovyalis verrucosa* (Hochst.) Warb.	Flacourtiaceae	Mietete	✓		2073	NA49
45	***Ehretia cymosa* Thonn.**	**Boraginaceae**	**Hulaga**	✓	✓	**2090**	**NA03**
46	*Ekebergia capensis* Sparrm.	Meliaceae	Sembo	✓	✓	2259	NA52
47	***Eucalyptus globulus* Labill**	**Myrtaceae**	**Nech-biharzaf**	✓		**2130**	**NA51**
48	***Euclea racemosa* Murr.** In subsp. schimperi (A. DC.) White	**Ebenaceae**	**Dediho**	✓	✓	**2073**	**NA02**
49	*Eulophia angolensis* (Rchb.f .) Summerh.	Orchidacea		✓		2111	NA55
50	*Ficus sur* Forssk.	Moraceae	Shola	✓		2188	NA57
51	*Flacourtia indica* (Burm. f.) Merr.	Flacourtiaceae		✓	✓	1935	NA58

52	*Galiniera saxifraga* (Hochst.) Bridson	Rubiaceae	Horsies	✓		2182	NA60
53	*Galinsoga Parviflora* Cav	Asteraceae		✓	✓	2224	NA64
54	***Galium aparinoides* Forssk.**	**Rubiaceae**	**Asheket**	✓		**2227**	**NA50**
55	*Geranium arabicum* Forssk.	Geraniaceae			✓	2112	NA67
56	*Gerbera piloselloides* (L.) Cass	Asteraceae		✓	✓	2269	NA69
57	***Grewia ferruginea* Hochst. ex A. Rich.**	**Tiliaceae**	**Lenquata**	✓	✓	**2059**	**NA23**
58	***Grewia similis* K. Schum.**	**Tiliaceae**	**Edbasa**		✓	**1998**	**NA80**
59	***Grewia trichocarpa* Hochst. ex A. Rich.**	**Tiliaceae**	**Haroresa**	✓	✓	**2052**	**NA24**
60	*Helichrysum schimperi* (Sch. Bip. ex A. Rich.) Moeser	Asteraceae		✓		2052	NA70
61	***Helinus mystacinus* (Ait.) E. Mey. ex Steud.**	**Rhamnaceae**	**Shemburit**		✓	**2093**	**NA137**
62	***Heteromorpha arborescens* (Spreng.) Cham. & Schlecht.**	**Apiaceae**	**Yejib-mirkuz**		✓	**2093**	**NA59**
63	*Hetropogon contortus* (L.) Roem. & Schult.	Poaceae	Bela sar		✓	2077	NA71
64	*Hyparrhenia collina* (Pilg.) Stapf	Poaceae	Sembelet	✓	✓	2263	NA72
65	***Hypoestes forskaolii* (Vahl) R. Br.**	**Acanthaceae**	**Tena-tebe**	✓	✓	**2227**	**NA81**
66	***Jasminium grandiflorum* L.**	**Oleaceae**	**Tembelel**	✓	✓	**2166**	**NA01**
67	*Juniperus procera* Hochst. ex Endl.	Cupressaceae	Yehabesha-tid	✓	✓	2236	NA73
68	***Justicia schimperiana* (Hochst. ex Nees) T. Anders.**	**Acanthaceae**	**Sensel**	✓		**2082**	**NA111**
69	***Kalanchoe densiflora* Rolfe**	**Crassulaceae**	**Lukaluke**	✓	✓	**2073**	**NA82**
70	***Kalanchoe petitiana* A. Rich.**	**Crassulaceae**	**Bunisike**	✓		**2162**	**NA143**
71	*Leucas deflexa* Hook. f.	Lamiaceae		✓	✓	2069	NA74
72	***Lippia adoensis* Hochst. ex Walp. ****	**Verbenaceae**	**Kessie**	✓		**2171**	**NA61**
73	***Maytenus arbutifolia* (A. Rich.) Wilczek**	**Celastraceae**	**Hatat**	✓	✓	**2125**	**NA29**
74	*Millettia ferruginea* (Hochst.) Bak. ******	Fabaceae	Birbira	✓		2224	NA76
75	***Momordica foetida* Schumach. ****	**Cucurbitaceae**	**Yekura-hareg**	✓		**2125**	**NA84**
76	***Myrsine africana* L.**	**Myrsinaceae**	**Kerchemo**	✓	✓	**2237**	**NA132**
77	***Nuxia congesta* R. Br. ex Fresen.**	**Loganiaceae**	**Asquar**		✓	**1940**	**NA86**
78	***Ocimum gratissimum* L.**	**Lamiaceae**	**Demakase**	✓	✓	**2182**	**NA62**
79	***Ocimum lamiifolium* Hochst. ex Benth.**	**Lamiaceae**	**Alem selala**	✓	✓	**2146**	**NA87**
80	***Olea europaea* L. subsp. *cuspidata* (Wall. ex G.Don) Cif.**	**Oleaceae**	**Woyira**	✓	✓	**2184**	**NA115**
81	*Olinia rochetiana* A. Juss.	Oliniaceae	Behe	✓	✓	2154	NA78

82	*Oplismenus hirtellus (L.) P. Beauv.*	Poaceae	Yeqoq-sar	✓	✓	2261	NA79
83	*Opuntia ficus-indica* (L.) Miller	Cactaceae	Yareb-kulikual	✓		2256	NA83
84	***Osyris quadripartita* Decn.**	**Santalaceae**	**Keret**	✓	✓	**2263**	**NA131**
85	***Otostegia fruticosa* (Forssk.) Schweinf. ex Penzig**	**Lamiaceae**	**Geram-tinjut**	✓		**2227**	**NA85**
86	*Pavetta oliveriana* Hiern	Rubiaceae	Yetotakula	✓		2179	NA89
87	*Pelargonium multibracteatum* Hochst. ex A. Rich.	Geraniaceae		✓		2269	NA90
88	*Pellaea calomelanos* (Sw.) Link	Pteridaceae		✓	✓	2267	NA91
89	*Pennisetum thunbergii* Kunth	Poaceae	Sindedo	✓		2251	NA92
90	*Persicaria decipiens* (R. Br.) K.L. Wilson	Polygonaceae		✓		2253	NA130
91	*Phagnalon abyssinicum* Sch. Bip. ex A. Rich.	Asteraceae	Nibwoded	✓		2178	NA46
92	*Phaulopsis imbricata* (Forssk.) Sweet	Acanthaceae	Derigu	✓	✓	2227	NA94
93	*Pimpinella hirtella* (Hochst.) A. Rich.	Apiaceae		✓		2166	NA95
94	*Pittosporum viridiflorum* Sims	Pittosporaceae	Kefeto	✓	✓	2154	NA63
95	*Plectranthus punctatus* (L.f.) L'Her.	Lamiaceae	Yedega-boter	✓	✓	2111	NA47
96	***Podocarpus falcatus* (Thunb.) R. B. ex. Mirb.**	**Podocarpaceae**	**Birbisa**	✓		**2247**	**NA116**
97	*Polygala abyssinica* Fres.	Polygalaceae		✓	✓	2153	NA96
98	***Premna schimperi* Engl.**	**Lamiaceae**	**Checho**	✓	✓	**2085**	**NA35**
99	***Prunus africana* (Hook. f.) Kalkm.**	**Rosaceae**	**Tikur-enchet**	✓	✓	**2240**	**NA97**
100	***Psidium guajava* L.**	**Myrtaceae**	**Zeythuna**	✓		**2069**	**NA88**
101	***Psydrax schimperiana* (A. Rich.) Bridson**	**Rubiaceae**	**Seged**	✓	✓	**2090**	**NA98**
102	***Rhamnus prinoides* L'Herit.**	**Rhamnaceae**	**Gesho**	✓		**2227**	**NA36**
103	*Rhus glutinosa* A. Rich.	Anacardiaceae	Embis	✓	✓	2227	NA101
104	*Rhus natalensis* Krauss	Anacardiaceae	Debebosha	✓	✓	2256	NA102
105	*Rhus retinorrhoea* Oliv.	Anacardiaceae	Tilem		✓	2087	NA103
106	*Rhus vulgaris* Meikle	Anacardiaceae	Debebosha	✓		2044	NA104
107	***Rosa abyssinica* Lindley**	**Rosaceae**	**Kega**	✓	✓	**2142**	**NA37**
108	***Rubia cordifolia* L.**	**Rubiaceae**	**Minchero**	✓	✓	**2078**	**NA117**
109	*Rubus apetalus* Poir.	Rosaceae	Injore		✓	2180	NA105
110	***Rumex nepalensis* Spreng.**	**Polygonaceae**	**Tulit**	✓	✓	**2251**	**NA65**

111	*Salvia tiliifolia* Vahl	Lamiaceae	Shaebiya	✓	✓	2069	NA106
112	*Satureja punctata* (Benth.) Briq.	Lamiaceae		✓	✓	2263	NA107
113	*Senna siamea* (Lam.) Irwin & Barneby	Fabaceae	Yeferenj-digita	✓		2237	NA109
114	*Setaria megaphylla* (Steud.) Th. Dur. & Schinz	Poaceae	Sikoke-sar	✓	✓	2076	NA110
115	*Sida tenuicarpa* Vollesen	Malvaceae	Chifirig	✓	✓	2073	NA112
116	*Sida ternata* L. f.	Malvaceae	Lancha	✓		2149	NA113
117	***Smilax anceps* Willd.**	**Smilacaceae**	**Ginchret**	✓	✓	**2052**	**NA66**
118	***Solanum benderianum* Schimper ex Dammer**	**Solanaceae**	**Sejerel-jin**		✓	**2088**	**NA41**
119	*Sporobolus pyramidalis* P. Beauv.	Poaceae	Tef-sar		✓	2119	NA114
120	*Stephania abyssinica* (Dillon & A. Rich.) Walp.	Menispermaceae			✓	2093	NA118
121	*Teclea simplicifolia* (Engl.) Verdoon	Rutaceae	Hatesa	✓		2182	NA119
122	*Themeda triandra* Forssk.	Poaceae		✓	✓	2154	NA120
123	*Thymus schimperi* Ronniger	Lamiaceae	Tosign		✓	2144	NA121
124	***Toddalia asiatica* (L.) Lam.**	**Rutaceae**	**Gura-kemele**	✓	✓	**2166**	**NA43**
125	***Tragia doryodes* M. Gilbert**	**Euphorbiaceae**	**Abilalit**	✓	✓	**2137**	**NA122**
126	***Verbascum sinaiticum* Benth.**	**Scrophulariaceae**	**Ketetena**		✓	**2171**	**NA68**
127	***Verbena officinalis* L.**	**Verbenaceae**		✓		**2251**	**NA93**
128	***Zehneria scabra* (Linn. f.) Sond.**	**Cucurbitaceae**	**Hareg_resa**	✓		**2176**	**NA45**

** Endemic species

N:B- Species in **Bold** are used for traditional medicinal uses in the Districts

Appendix 3. Basal area (m2/ha) of trees and shrubs, their contribution (%) in Anabe Forest patch

Species name	BA (m2/ha)	Percentage
Podocarpus falcatus (Thunb.) R. B. ex. Mirb.	291.57	32.33
Ficus sur Forssk.	127.02	14.08
Juniperus procera Hochst. ex Endl.	102.40	11.35
Cupressus lusitanica Mill.	83.64	9.27
Olea europaea L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	56.86	6.30
Acacia abyssinica Hochst. ex Benth.	40.85	4.53
Croton macrostachyus Del.	37.75	4.19
Ekebergia capensis Sparrm.	30.09	3.34
Millettia ferruginea (Hochst.) Bak.	21.55	2.39
Ehretia cymosa Thonn.	12.92	1.43
Eucalyptus globulus Labill	10.29	1.14
Allophylus abyssinicus (Hochst.) Radlk.	7.03	0.78
Psydrax schimperiana (A.Rich.) Bridson	6.92	0.77
Acokanthera schimperi (A.DC.) Schweinf.	6.84	0.76
Calpurnia aurea (Ait.) Benth.	6.40	0.71
Pittosporum viridiflorum Sims	6.09	0.68
Bersama abyssinica Fresen.	6.05	0.67
Premna schimperi Engl.	5.30	0.59
Maytenus arbutifolia (A. Rich.) Wilczek	5.24	0.58
Grewia ferruginea Hochst. ex A. Rich.	5.19	0.58
Olinia rochetiana A. Juss.	4.28	0.47
Psidium guajava L.	4.16	0.46
Prunus africana (Hook. f.) Kalkm.	4.00	0.44
Acacia decurrens Willd	3.49	0.39
Grewia trichocarpa Hochst. ex A. Rich.	3.14	0.35
Celtis africana Burm.f.	2.89	0.32
Cordia africana Lam.	2.63	0.29
Teclea simplicifolia (Engl.) Verdoon	2.03	0.23
Dodonaea angustifolia L. f.	1.83	0.20
Cassipourea malosana (Baker) Alston	1.82	0.20
Myrsine africana L.	1.57	0.17

Appendix 4. Frequency of tree and shrub species with DBH > 2 cm in Anabe Forest patch

Scientific name	Freqency	Relative Frequency
Acacia abyssinica Hochst. ex Benth.	26	4.42
Acacia decurrens Willd	4	0.68
Acokanthera schimperi (A.DC.) Schweinf.	2	0.34
Allophylus abyssinicus (Hochst.) Radlk.	6	1.02
Bersama abyssinica Fresen.	22	3.74
Calpurnia aurea (Ait.) Benth.	26	4.42
Cassipourea malosana (Baker) Alston	4	0.68
Celtis africana Burm.f.	6	1.02
Cordia africana Lam.	4	0.68
Croton macrostachyus Del.	12	2.04
Cupressus lusitanica Mill.	66	11.22
Dodonaea angustifolia L. f.	12	2.04
Ehretia cymosa Thonn.	10	1.70
Ekebergia capensis Sparrm.	2	0.34
Eucalyptus globulus Labill	2	0.34
Ficus sur Forssk.	16	2.72
Grewia ferruginea Hochst. ex A. Rich.	6	1.02
Grewia trichocarpa Hochst. ex A. Rich.	2	0.34
Juniperus procera Hochst. ex Endl.	80	13.61
Maytenus arbutifolia (A. Rich.) Wilczek	38	6.46
Millettia ferruginea (Hochst.) Bak.	2	0.34
Myrsine africana L.	58	9.86
Olea europaea L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	40	6.80
Olinia rochetiana A. Juss.	8	1.36
Pittosporum viridiflorum Sims	22	3.74
Podocarpus falcatus (Thunb.) R. B. ex. Mirb.	68	11.56
Premna schimperi Engl.	8	1.36
Prunus africana (Hook. f.) Kalkm.	10	1.70
Psidium guajava L.	6	1.02
Psydrax schimperiana (A.Rich.) Bridson	8	1.36
Teclea simplicifolia (Engl.) Verdoon	12	2.04

Appendix 5. Basal area (m2/ha) of trees and shrubs, their contribution (%) in Gerfa-ourene Forest patch

Species name	BA (m2/ha)	Percentage
Acacia abyssinica Hochst. ex Benth.	65.26	7.10
Rhus retinorrhoea Oliv.	64.06	6.97
Rhus glutinosa A. Rich.	63.14	6.87
Olea europaea L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	59.23	6.44
Nuxia congesta R. Br. ex Fresen.	56.46	6.14
Acokanthera schimperi (A.DC.) Schweinf.	56.06	6.10
Juniperus procera Hochst. ex Endl.	54.78	5.96
Cadia purpurea (Picc.) Ait.	52.76	5.74
Psydrax schimperiana (A.Rich.) Bridson	48.21	5.24
Ekebergia capensis Sparrm.	47.02	5.11
Croton macrostachyus Del.	44.09	4.80
Pittosporum viridiflorum Sims	36.22	3.94
Prunus africana (Hook. f.) Kalkm.	33.15	3.61
Calpurnia aurea (Ait.) Benth.	26.88	2.92
Ehretia cymosa Thonn.	26.53	2.89
Rhus natalensis Krauss	24.85	2.70
Olinia rochetiana A. Juss.	23.30	2.53
Celtis africana Burm.f.	22.14	2.41
Dodonaea angustifolia L. f.	17.69	1.92
Grewia ferruginea Hochst. ex A. Rich.	17.18	1.87
Grewia trichocarpa Hochst. ex A. Rich.	17.09	1.86
Euclea racemosa Murr. In subsp. schimperi (A. DC.) White	16.71	1.82
Maytenus arbutifolia (A. Rich.) Wilczek	15.95	1.73
Premna schimperi Engl.	15.68	1.71
Flacourtia indica (Burm. f) Merr.	14.96	1.63

Appendix 6. Frequency of tree and shrub species with DBH > 2 cm in Gerfa-ourene Forest patch

Scientific name	Frequency	Relative Frequency
Acacia abyssinica Hochst. ex Benth.	33.33	4.33
Acokanthera schimperi (A.DC.) Schweinf.	30.00	3.90
Cadia purpurea (Picc.) Ait.	40.00	5.19
Calpurnia aurea (Ait.) Benth.	43.33	5.63
Celtis africana Burm.f.	26.67	3.46
Croton macrostachyus Del.	16.67	2.16
Dodonaea angustifolia L. f.	53.33	6.93
Ehretia cymosa Thonn.	20.00	2.60
Ekebergia capensis Sparrm.	3.33	0.43
Euclea racemosa Murr.	73.33	9.52
Flacourtia indica (Burm. f.) Merr.	6.67	0.87
Grewia ferruginea Hochst. ex A. Rich.	6.67	0.87
Grewia trichocarpa Hochst. ex A. Rich.	3.33	0.43
Juniperus procera Hochst. ex Endl.	40.00	5.19
Maytenus arbutifolia (A. Rich.) Wilczek	33.33	4.33
Nuxia congesta R. Br. ex Fresen.	20.00	2.60
Olea europaea L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	40.00	5.19
Olinia rochetiana A. Juss.	26.67	3.46
Pittosporum viridiflorum Sims	43.33	5.63
Premna schimperi Engl.	13.33	1.73
Prunus africana (Hook. f.) Kalkm.	50.00	6.49
Psydrax schimperiana (A.Rich.) Bridson	40.00	5.19
Rhus glutinosa A. Rich.	70.00	9.09
Rhus natalensis Krauss	23.33	3.03
Rhus retinorrhoea Oliv.	13.33	1.73

Appendix 7. List of medicinal plants in Kalu District: scientific name; family; local name; growth form (GF); plant parts used (PU); used for; ailment treated; type; route of administration (RA); mode of preparation, dosage and way of application of remedies

No	Scientific name	Family	Local name	GF	PU	Used for	Ailment treated	Type	RA	Mode of preparation, dosage and way of application of remedies
1	*Acacia seyal* Del.	Fabaceae	Wachu-girar	T	L	Ls	Bloating	F	Or	Crush the fresh leaves, homogenize with water and allow to drink for cattle
2	*Achyranthes aspera* L.	Amaranthaceae	Telenji	H	L; R	Hu; Ls	Bleeding during cutting, Bleeding during delivery; Eye diseases	F	Or; Op	Crush the fresh leaves and tie on the injured part, Crush the fresh leaves then drink; Chew the fresh root and spit the liquid to the infected eye
3	*Allium cepa* L.	Alliaceae	Key-shinkurt	H	Bu	Hu	Cough	F	Or	Mix with *Allium sativum* and eat
4	*Allium sativum* L.	Alliaceae	Nech-shinkurt	H	Bu	Hu; Ls	Cough; Camel diseases	F	Or	Eat the fresh bulb at the bed time; Crush the fresh bulb and mix with water then allow to drink
5	Aloe sp.	Aloaceae	Eret	H	St; R	Hu	Back pain; Evil eye; Arthritis	F/D	Fu	Mix with stem of *Terminalia brownii* then fumigate the smoke at the bed time
6	*Aloe trichosantha* Berger	Aloaceae	Eret	H	Lat; St; R	Hu	Eye diseases; Malaria; Evil spirit	F; F;F	Op; Or; Fu	Little amount of latex applied under the lower lashes; Drink little amount of latex (a teaspoon); Smoke the dried root around the home

7	*Artemisia absinthium* L.	Asteraceae	Arrity	H	L	Hu	Abdominal pain	F	Or;Ex	Boil the fresh leaves and drink the decoction; Important as fragnance
8	*Asparagus africanus* Lam.	Asparagaceae	Yeset-kesit	S	L	Hu	Eviel-sprit	F	Ex	Crush the fresh leaves and add water and spray around the area
9	*Bersama abyssinica* Fresen.	Melianthaceae	Azamir	T	St	Hu	Eviel-sprit	F	Fu	Mix with fresh stem of *Terminalia brownii* and fumigate the smoke
10	*Brassica carinata* A.Br.	Brassicaceae	Gomenzer	H	S	Hu; Ls	Abdominal pain and vomiting; Bloating	D	Or; Or	Grind the roasted seed, mix half spoon of the powder with a cup of water and drink (it is not advisable for pregnant women); Grind and mix with water and allow to drink for cattle
11	*Brassica nigra* (L.) Koch	Brassicaceae	Senafich	H	S	Hu	Abortion; Malaria	D	Or; Or	Crush homogenize with water and drink; Crush, homogenize with water and pack 1-3 days, mix with socked Cicer arietinum or Vicia faba then eat every morning for 3-7 consecutive days before eating any food
12	*Caesalpinia decapetala* (Roth) Alston	Fabaceae	Kenterifa	S	L	Hu	Swelling	F	Ex	Crush the fresh leaves and tie on the swelled part
13	*Calotropis procera* (Ait.) Ait.f.	Asclepiadaceae	Kobohas	S	Lat	Hu	Hemorrhoid; Ringworm	F	Dr	Paint the latex
14	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	Digita	S	L	Hu; Ls	Fever/"Mich" & Gastritis; Tick infestation	F	Or; Ex	Crush the fresh leaves homogenize with a glass of cold water and drink; Crush the fresh leaves then pest the body
15	*Capsicum annuum* L.	Solanaceae	Karia/ belew	H	Fr	Hu	Abdominal parasite	F	Or	Mix with Allium sativum and Allium cepa and eat

										with “enjera”
16	*Carica papaya* L.	Caricaceae	Papaye	T	L	Hu	Vomiting	F	Or	Boil and drink concoction
17	*Carissa spinarum* L.	Apocynaceae	Agam	S	R	Hu	Back pain; Evil eye; Arthritis	D/F	Fu	Dried or fresh root mix with root of Aloe sp, stem of Clerodendrum myricoides, Croton macrostachyus and Terminalia brownii then fumigate the smoke
18	*Catha edulis* (Vahl) Forssk. ex Endl.	Celastraceae	Chat	T	L	Hu	Fever/”Mich”; Evil sprit	F	Fu; Ex	The fresh leaf mix with the fresh leaves of Eucalyptus camaldulensis/Eucalyptus globules, boil and inhale its steam at the bed time; Chew the fresh leaf, pray on it and spit on the one who sick at the time of “wedaja” ceremony
19	*Celtis africana* Burm.f.	Ulmaceae	Fetekuma	T	L	Ls	Abdominal dryness	F	Or	Eat as forage at the time of famine
20	*Ceratostigma abyssinicum* Asch.	Plumbaginaceae	Metirez	S	Wp; L&R; R	Hu	Rabies; Infertility; Urine retention	D; D; F	Or	Crush, cream the powder to the bread which is prepared from Eragrostis tef “key-Tef” then eat; Crush, boil and cool then mix honey(Key mar) drink for to stop fertility for women; Boil the root and drink three glasses before eating food in the morning
21	*Chenopodium murale* L.	Chenopodiaceae	Amedmado	H	L	Hu	Wound	F	Ex	Crush the fresh leaves and tie on the wounded head part
22	*Cicer arietinum* L.	Fabaceae	Shimbra	H	S	Hu	Malaria	D	Or	Soaked the dray seed in water for a day, filter it and mix with crushed fresh bulb of Allium sativum and crushed

										dray seed of Brassica nigra then eat for 5/7 consecutive days before eating any food every morning
23	*Citrus limon* (L.) Burm. f	Rutaceae	Lomie	T	Fr	Hu	Snake/scorpion poison	F	Or	Drink the juice
24	*Citrus medica* L.	Rutaceae	Tringo	T	Fr	Hu	Eviel-sprit	F	Or	Eat the fruit
25	*Citrus sinensis* (L.) Osb.	Rutaceae	Birtukan	T	Fr	Hu	Fever/"Mich"	F	Fu	Boil the fresh leaves and inhale the smoke
26	*Clematis hirsuta* Perr. & Guill	Ranunculaceae	Azo-hareg	C	L	Hu	Tumor	F	Ex	Crush the fresh leaf and tie on it
27	*Cleome gynandra* L.	Capparidaceae	Chenopodium	H	L	Hu	Ear problem (Infestation to insects)	F	Au	Crush the fresh leaves, filter and add 1-3 drops to the ear
28	*Clerodendrum myricoides* (Hochst.) Vatke	Lamiaceae	Misiroch	S	St&R	Hu	Arthritis; Evil eye	F	Fu	Mix with stem wood of Terminalia brownie and fumigate its smoke
29	*Clutia abyssinica* Jaub. & Spach.	Euphorbiaceae	Feyele-fej	S	St	Hu	Jaundice	F	Or	Avoiding the bark from the fresh root, insert the root in the bowl and mix with crushed fresh leaves of Rumex nervosus then add water the stir slowly the concoction in front of the patient then allow to drink for consecutive three days
30	*Coffea arabica* L.	Rubiaceae	Buna	T	S	Hu	Abdominal pain and diarrhea	D	Or	Crush the roasted seed and mix with fresh butter then eat
31	*Commicarpus plumbagineus* (Cav.) Standley	Nyctagynaiceae	Habune	H	L; L; L&R	Hu	Eye-spot; Swelling; Wound infection	F	Op; Ex; Ex	Crush the fresh leaves, squeeze and add a drop in the eye; Crush the fresh leaves and tie on the swelled part; Crush the fresh leaves

										and root tie on the wound
32	*Coriandrum sativum* L.	Apiaceae	Dimbilal	H	L	Hu	Kidney problem	F	Or	Boil and drink concoction
33	*Croton macrostachyus* Del.	Euphorbiaceae	Bisana	T	R; R; Rb; L; Lat; L	Hu	Abortion; Evil spirit; Fever/"Mitch"; Ringworm; Bleeding	F;D;F;F;F	Va; Fu; Ex; Ex; Dr; Ex	Peel the fresh root and insert to the womb; The dried root bark mix with the dried bark of Euclea racemosa then fumigate the smoke; When you go during sunny day take fresh leaf under your cloth in your body to prevent fever; Smear the latex to the infected part; Crush the fresh leaves hold it on the blooded part
34	*Cucumis dipsaceus* Ehrenb. ex Spack	Cucurbitaceae	Yemidir-embuay	H	R	Hu	Boil	F	Ex	Crush the fresh root then tie on the infected part
35	*Cucurbita pepo* L.	Cucurbitaceae	Duba	H	Fr, S	Hu	Gastritis; Tapeworm	F; D	Or	Boil the fresh fruit cool and eat; Roasted the dray seeds then eat
36	*Cymbopogon citratus* (DC.) Stapf	Poaceae	Teje-sar	H	Wp	Hu	Dandruff	F/D	Ex	Crush and mix with fresh butter and apply on head; It also prevent the butter from rancidity and give it a good odor.
37	*Cynoglossum lanceolatum* Forssk.	Boraginaceae	Yemich/nolocal	H	L	Hu	Eye diseases	F	Op	Crush the fresh leaves, squeeze and add drops on the infected eye
38	*Cyperus longus* L.	Cyperaceae	Gondagondo	H	Bu	Hu	Wound	D	Ex	Roasted, mixes with a fresh butter then apply to the head. It also prevents rancidity of butter and has good aroma
39	*Cyphostemma adenocaule* (Steud. ex A.	Vitaceae	Milas-goligul	H	R	Ls	Eye diseases	F	Au	Crush the fresh root, squeeze and add one drop on the infected eye

	Rich.) Desc. ex Wild & Drummond									
40	*Datura stramonium* L.	Solanaceae	Benj	H	S	Hu	Toothache	D	Or	Roast the dry seeds and hold with teeth
41	*Dodonaea angustifolia* L. f.	Sapindaceae	Kitikita	T/S	L	Ls	Bone fracture	F	Ex	Crushed the fresh leaf and tie on the broken bone until it recovery
42	*Echinops kebericho* Mesfin **	Asteraceae	Kebericho	H	R	Hu	Fever/"Mich"; Evil sprit	D	Fu	Smoke the dray root and fumigate during night time
43	*Ehretia cymosa* Thonn.	Boraginaceae	Hulaga	T	L	Hu; Ls	Fever/"Mich"; Abdominal dryness	F	Fu;Or	Boil the fresh leaf and inhale its smoke or steam; Eat as a forage at the time of famine
44	*Ethulia gracilis* Del.	Asteraceae	Merarito	H	L	Hu	Diarrhea and vomiting	F	Or	Mix the fresh root with fresh root of Rhus natalensis and Verbascum sinaiticum, crush and homogenize with water then drink
45	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae	Key-biharzaf	T	L	Hu	Fever/"Mich"	F	Fu	Boil the fresh leaves and inhale its steam at the bed time
46	*Eucalyptus globulus* Labill	Myrtaceae	Nech-biharzaf	T	L	Hu	Fever/"Mich"	F	Fu	Boil the fresh leaves and inhale its steam at the bed time
47	*Euclea racemosa* Murr.	Ebenaceae	Dediho	S	L	Hu	Tonsilitis & Evalitis	F	Or	Crush the fresh leaf and drink a tea spoon
48	*Euphorbia hetrophylla* L.	Euphorbiaceae	Wofram-antirifa	H	Lat	Hu	Hemorrhoid	F	Ex	Applied the latex to the affected body
49	*Euphorbia tirucalli* L.	Euphorbiaceae	Kesema	S	Lat	Hu	Hemorrhoid	F	Ex	Applied the latex to the affected body
50	*Ferula communis* L.	Apiaceae	Kumen	H	L&R	Hu	Urine retention	F	Or	Boil the fresh leaves and drinks the decoction/Crush

										the fresh leaves and drink the juicy part/ Eat the fresh root
51	*Galium aparinoides* Forssk.	Rubiaceae	Asheket	H	Wp	Ls	Leech	F	Or	Insert on the throat of the cattle
52	*Grewia ferruginea* Hochst. ex A. Rich.	Tiliaceae	Lenquata	T	B	Hu	Louse; Hair falling	F	Ex	Immerse the internal part of the fresh bark in water then applied the jell to the hair for not less than 2/3 hours; Immerse the internal part of the fresh bark in water then applied the jell to the hair for not less than 2/3 hours, it makes the hair root very strong and prevents the hair from falling out, it is also important to make the hair very shine and being a curl for youngsters' hair.
53	*Grewia similis* K. Schum.	Tiliaceae	Edbasa	T	St	Hu	Teeth ache	F	Or	Use it as a teeth brush
54	*Grewia trichocarpa* Hochst. ex A. Rich.	Tiliaceae	Haroressa	T	St	Hu	Teeth ache	F	Or	Use it as a teeth brush
55	*Grewia villosa* Willd.	Tiliaceae	Hegomide	S	Ba	Hu	Louse; Hair falling	F	Ex	Immerse the internal part of the fresh bark in water then applied the jell to the hair
56	*Guizotia abyssinica* (L.f.) Cass.	Asteraceae	Nug	H	S	Hu	Cough	F	Or	Crush, mix with water then boil and drink during the night time
57	*Helinus mystacinus* (Ait.) E. Mey. ex Steud.	Rhamnaceae	Shemburit	H	S	Hu	Evel eye	F	Or	Crush the fresh leaves and drink
58	*Heteromorpha*	Apiaceae	Yejib-mirkuz	S	St	Hu	Fever/"Mich"	F	Or	Boil the fresh steam wood,

	arborescens (Spreng.) Cham. & Schlecht.									cool and filter, then mix with honey and drink
59	*Hypoestes forskaolii* (Vahl) R. Br.	Acanthaceae	Tnea-teby	H	L	Hu	Snake bite	F	Or	Crush the fresh leaves and drink the juice
60	*Impatiens tinctoria* A. Rich.	Balsaminaceae	Ensesula	H	Bu	Hu	Cracking feet and hand; Arthritis	F	Ex	Crush the fresh root, add lemon juice then warmed over fire and cool, and insert the hand and feet in the bowl at least for two hours. As a result, it decorates the palm of hands, nails and feet. Moreover, it makes smooth for hands and the feet. It also relieves pain for people with arthritis.
61	*Indigofera suaveolens* Jaub. & Spach	Fabaceae	Yadal-chiraro	S	Wp	Hu	Evil sprit	D/F	Ex	Smoke fumigate the home
62	*Jasminum grandiflorum* L.	Oleaceae	Tembelel	C	L&St; L&Fl; L	Hu	Toothache;Herpes zoster	F	Or; Ex	Fresh stem wood used as a teeth brush and the fresh leaf hold with teeth; Chewing the leaf and spit the sap to the infected part
63	*Jatropha curcas* L.	Euphorbiaceae	Ayderike	T	Lat; Wp	Hu	Minor Bleeding; Preventing snake	F	Ex	Smear the latex on the bleeding part of the body; Planting as a fence to avoid snake
64	*Justicia schimperiana* (Hochst. ex Nees) T. Anders.	Acanthaceae	Sensel/Timuga	S	L	Hu	Scabies; Wound infection; Jaundice	F	Ex; Ex; Or	The fresh leaves mix with Calpurnia aurea, crush and apply to the whole body for cattle; Fresh leaves mix with fresh leaves of Ehertia cymosa then tie to the infected part;

										Crush the fresh leaves homogenize with a cup of cold water and drink
65	*Kalanchoe densiflora* Rolfe	Crassulaceae	Lukaluke	H	L	Hu	Fever/"Mich"	F	Or/Fu	Crush the fresh leaf, squeeze and drink /boil and fumigate the smoke
66	*Kalanchoe petitiana* A. Rich.	Crassulaceae	Bunsike	H	Wp	Hu	Scabies	D	Ex	Crush mix with honey and apply
67	*Kleinia odora* (Forssk.) DC.	Asteraceae	Duea	S	St	Hu	Evil sprit	Fu	F/D	Fumigate the smoke
68	*Laggera tomentosa* (Sch. Bip. ex A. Rich.) Olive. & Hiern**	Asteraceae	Alashume	S	L	Hu	Fever/"Mich"	F; D	Fu; Ex	Boil the fresh leaves and fumigate the smoke;It is also used as a fragrance by dray crush and mix with fresh butter for its pleasant aroma
69	*Lawsonia inermis* L.	Lythraceae	Hena	T	L	Hu	Head ache	D	Ex	Dried leaves are ground and boiled with strong tea then applied the paste to the hade for the whole night. Moreover, it also uses for coloring of the hair and strengthen the root and prevent the hair from falling out; In addition, it also uses for decorating hands and feet by giving colors for palms of the hands, the nails and feet. Hence, to do so dried leaves of the plant are ground and boiled with strong tea and add lemon juice then the warm paste is applied to the hands and feet.
70	*Lepidium sativum* L.	Birassicaceae	Feto	H	S	Hu	Internal diseases	D	Or	Crush after mixing it with Allium sativum, Nigella sativa and Ruta chalepensis

										then combine with honey, after seven days eat one spoon per day for consecutive seven days before eating any food early in the morning
71	*Linum usitatissimum* L.	Linaceae	Teliba	H	S	Hu	Gastritis; Back pain; Constipation	D	Or	Boil the dray seed make it cool and drink; Crushed the roasted seed mix with warm water and drink at the bed time both for back pain & constipation
72	*Lippia adoensis* Hochst. ex Walp. **	Verbenaceae	Kessie	S	L	Hu	Tinia corpores	F	De	Rub the infected area with the fresh leaves
73	*Malva Verticillata* L.	Malvaceae	Lit/Lut	H	Sb	Hu	Dandruff	F	Ex	Crush the stem bark and apply the jell on the head
74	*Maytenus arbutifolia* (A. Rich.) Wilczek	Celastraceae	Hatat	S	L	Hu	Fever/"Mich"	F	Fu	Mixes with fresh leaves of Ehertia cymosa then boil and fumigate the smoke at the bed time
75	*Melia azedarach* L.	Meliaceae	Nim	T	L	Hu	Malaria	F	Or	Crush the fresh leaves and homogenize with little water and drink
76	*Melilotus messanensis* (L.) All.	Fabaceae	Egug	H	Wp	Hu	Dandruff	D	Ex	Crushed mix with the fresh butter and apply on the infected part, has also good aroma
77	*Mentha longifolia* (L.) Hudson	Lamiaceae	Erigolega	H	R	Hu	Toothache	F	Or	Crush and hold by teeth, is also important as fragnance
78	*Momordica foetida* Schumach.	Cucurbitaceae	Yekura-hareg	H	L	Hu	Abdominal problem	F	Or	Crush homogenize with water and drink
79	*Myrsine africana* L.	Myrsinaceae	Kerchemo	S	L	Hu	Malaria	F	Or	Boil the fresh leaves, mix with boiled butter and drink one glass

80	*Myrtus communis* L.	Myrtaceae	Ades	S	L	Hu	Teeth ache	D	Ex	Teeth ache, Use it as a tooth brush, use as fragnance
81	*Nicotiana tabacum* L.	Solanaceae	Timbaho	H	L; Wp	Hu	Leech; Evil spirit	F; D	Na; Ex	Crushed, squeezed and sniff; Crushed and sniff the powder/crushed and smoke in the house
82	*Nigella sativa* L.	Ranunculaceae	Tikurmetafet	H	S	Hu	Abdominal Pain; For any internal diseases	D	Or	Crush mix with the seed of Lepidium sativum and crushed Allium sativum then combine with honey and eat early in the morning before eating any food for consecutive 5/7 days one spoon per day; Take 3/5/7 seeds per day early in the morning before eating any food always
83	*Ocimum americanum* L.	Lamiaceae	Ashekute	S	L& Fl	Hu	Wound	D/F	Ex	Crush, mix with fresh butter and apply on head. It is also used to make butter to have a pleasant smell at the time of using on the head and it is used for having a pleasant smell by holding it under the close or simply holding it.
84	*Ocimum gratissimum* L.	Lamiaceae	Damakaseae	S	L	Hu	Fever/"Mich"	F	Or	Crush the fresh leaves, mix with a cup of coffee and drink
85	*Ocimum lamiifolium* Hochst. ex Benth.	Lamiaceae	Alemselala	S	L	Hu	Eye diseases; Fever/"Mich"	F	Op; Or	Crush the fresh leaves, mix with a cup of coffee and drink
86	*Ocimum urticifolium* Roth	Lamiaceae	Alemselala	S	L	Hu	Fever/"Mich"	F	Or	Crush the fresh leaf and paint the liquid in to the eye; Crush the fresh leaves, mix with a cup of coffee and

										drink
87	*Olea europaea* L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	Oleaceae	Woyra	T	L; L; St	Hu	Bleeding; Evalitis; Back pain	F; F;F	Ex; Or; Fu	Crush the fresh leaf, tie on the bleeding part of the body; Crush the fresh leaf and drink the juicy part; Fumigate the fresh stem wood after delivery at the time of postpartum recovery
88	*Osyris quadripartita* Decn.	Santalaceae	Keret	S	L	Hu; Ls	Hyper pigmentation; Mitch/Fever	F	Ex	Mix with Myrtus communis then grind then add fresh butter and paint the infected part; Mix with fresh root of Verbascum sinaiticum, Ximenia americana and fresh leaf of Jasminium grandiflorum then crush, homogenize with cold water and drink
89	*Otostegia integrifolia* Benth.	Lamiaceae	Tinjut	S	L&St;L	Hu	Flea; Abdominal pain	D;F	Ex; Or	Smoke the dray steam and leaves, then fumigate the house; Crush the fresh leaves homogenize with water and drink
90	*Persicaria decipiens* (R. Br.) K.L. Wilson	Polygonaceae	Yebab	H	L	Hu	Snake bite	F	Or	Snake bite; Crush the fresh leaves and drink
91	*Phagnalon abyssinicum* Sch. Bip. ex A. Rich.	Asteraceae	Nibwoded	S	L	Hu	…	F	Ex	Brush the beehive by the leaves then it helps to multiply themselves more
92	*Pittosporum viridiflorum* Sims	Pittosporaceae	Kefeto	T	L	Hu	Pest control	F	Ex	The fresh leaves mix with fresh leaves of Bersama abyssinica, Clematis simensis, Calotropis procera and Toddalia asiatica, crush and spray it to crops on

										farm land
93	*Plectranthus punctatus* (L.f.) L'Her.	Lamiaceae	Yedega-boter	H	L	Hu	Fever/"Mich"	F	Fu	Boiling and inhaling the smoke
94	*Premna schimperi* Engl.	Lamiaceae	Checho	T/S	L	Ls	Leech	F	Or	Crush the fresh leaves, homogenize with water and allow drinking to cattle
95	*Psidium guajava* L.	Myrtaceae	Zeytun	T	Fr	Hu	Diarrhea	F	Or	Eat the fruit
96	*Punica granatum* L.	Punicaceae	Roman	T	Fr	Hu	Abdominal problem	F	Or	Eat the fruit
97	*Rhamnus prinoides* L'Herit.	Rhamnaceae	Gesho	T	L	Hu	Tonsillitis	F	Or	Chew the fresh leaves and spit the liquid to the mouth of the kid
98	*Ricinus communis* L.	Euphorbiaceae	Agulo	S	L	Hu	Wound	F	Ex	Crush the fresh leaves and tie on the infected part
99	*Rosa abyssinica* Lindley	Rosaceae	Kega	S	R	Hu	Arthritis	F	Fu	Smoke the fresh root and fumigating
100	*Rubia cordifolia* L.	Rubiaceae	Minchiro	C	R	Hu	Fever/"Mich"	F	Fu	Boil and inhale its smoke
101	*Rumex abyssinicus* Jacq.	Polygonaceae	Mokimoko	H	R	Hu	Cancer	D	Or	Crush boil and drink
102	*Rumex nepalensis* Spreng.	Polygonaceae	Tulit	H	R	Hu	Delay of placenta	F	Va	Wash the fresh root and insert to the womb
103	*Rumex nervosus* Vahl	Polygonaceae	Embacho	S	L; L	Hu	Eye diseases (yeayin bigur); Eye diseases	F; F	Op; Op	Crush the fresh leaves, squeeze, mix the liquid with the yolk of the egg and dray then mix again with crushed Alloy of Antimony and applied under the lower and upper lashes of the eye; Crush the fresh leaves, squeeze and add a little drop to the eye

104	*Ruta chalepensis* L.	Rutaceae	Tenadam	H	L	Hu	Fever/"Mich"	F	Or	Crush the fresh leaves and mix with a cup of coffee and drink
105	*Schinus molle* L.	Anacardiaceae	Kundo berbere	T	L	Hu	Abdominal pain and vomiting; Fever/"Mich"	F	Or; Fu	Crush the fresh leaves, homogenize with cold water and drink; Fresh leaves mix with leaves of Carica papaya and Zehneria scabra, boil and inhale its steam at the bed time
106	*Sesamum orientale* L.	Pedaliaceae	Selit	H	S	Hu	Back pain	F	Or	Crush the dray seed, boil Sorghum bicolor (Mokake/Gorad) and Cicer arietinum then mix all in one and eat to prevent a back pain during post partum period
107	*Sida schimperiana* Hochst. ex A. Rich.	Malvaceae	Chifrig	S	Wp	Hu	Fever/"Mich"	F	Fu	Boil and inhale its smoke or steam
108	*Silene macrosolen* A. Rich.	Caryophylaceae	Wogert	H	R	Hu	Evil sprit	D	Fu	Burn the dray root and fumigate during night time
109	*Smilax anceps* Willd.	Smilacaceae	Ginchirit	C	L	Hu	Evel eye	L	Or	Crush the fresh leaves, filter and drink a cup of coffee
110	*Solanum incanum* L.	Solanaceae	Embuay	S	L;St	Hu	Bleeding; Scabies	Na; Fu	F;D	Crush the fresh leaf and sniff /Crush and sniff the powder; Burn the dried stem and fumigate children with this problem
111	*Solanum nigrum* L.	Solanaceae	Awut	H	L	Hu	Wound	Ex	F	Crush and apply to the infected part
112	*Terminalia brownii* Fresen.	Combretaceae	Woyiba	T	St;L	Hu	Back pain; Womb problem; Arthritis; Sleeping	Fu; Ex	F	Adding the stem wood on little fire, fumigating the smoke by covering the whole body without face by

							problem; Ageing; Avoiding unwanted fat from the body; Evil eye; Fatigue; Skin problem; Swelling			blanket and another cover which is made from the skin of an ox/cow. At the time of smoking bath, applying fresh butter on a head and to whole body to avoid dryness of skin is must. In addition, drinking yogurt/ hot drinks which are prepared from oat or other crops and eating a food which is prepared from Cicer arietinum, Sesamum orentale and Sorghum bicolor or porridge is essential especially in postpartum recovery; Crushed and tie on the infected part, also important as fragnance
113	*Tragia doryodes* M. Gilbert	Euphorbiaceae	Abilalit	H	R	Hu	Delay of placenta	Na	F	Mix the fresh root with fresh root of Kalanchoe petitiana, crush and sniff
114	*Trigonella foenum-graecum* L.	Fabaceae	Abish	H	S	Hu	Constipation; Mussel problem & dislocated bone; Fever/"Mich	Or; Ex;Ex	D	Crush, mix with water for overnight filter it and stir with honey/sugar, then drink; Crush, mix with water for overnight filter it and stir, then tie on the injured body part to relax the mussel; Burn and fumigate its smoke at the bed time
115	*Urtica simensis* Steudel **	Urticaceae	Sama	H	St; L	Hu	Abortion and retained placenta; Gastritis	Va; Or	F	Peel the bark from the fresh steam then insert to the womb; Boil the fresh leaves cool and eat before eating any food in the morning
116	*Verbascum sinaiticum* Benth.	Scrophulariaceae	Ketetna	H	Wp	Ls	Bloating/gogobsa	Or	F	The fresh one, mix with Withania somnifera, crush, homogenize with water and

										allow to drink
117	*Verbena officinalis* L.	Verbenaceae	Atuch	H	L	Hu	Hemorrhoids	Ex	F	Rub the fresh leave to the infected area
118	*Vicia faba* L.	Fabaceae	Bakela	H	S	Hu	Malaria	Or	D	Immerse the dray seed in water for a day, filter it and mix with crushed fresh bulb of Allium sativum and crushed dray seed of Brassica nigra then eat for 5/7 consecutive days before eating any food early in the morning
119	*Withania somnifera* (L.) Dunal	Solanaceae	Hede-budiha	S	L&R	Hu	Fever/"Mich"	Ex	F	Crush the fresh leaves then smeared the whole body/boil the fresh root and fumigate the smoke; both are during the night time
120	*Xanthium strumarium* L.	Asteraceae	Yemogn-fikir	H	L	Hu	Tinia corpores	Ex	F	Crush the fresh leaf, rub the infected part
121	*Ximenia americana* L.	Olacaceae	Enkoy	S	L	Hu	Evalitis; Herpes zoster	Or; Ex	F	Chew the fresh leaf and swallow; Chew the fresh leaf and spit the liquid to the infected part
122	*Zaleya pentandra* (L.) Jeffrey	Aizoaceae	Aredo	H	Wp	Ls	Bloating	Or	F	Crush the fresh one, mix with water and allow to drink
123	*Zehneria scabra* (Linn. f.) Sond.	Cucurbitaceae	Haregresa	H	Wp	Hu	Fever/"Mich"	Fu	F	Boil and fumigate the smoke during the night time
124	*Zingiber officinale* Roscoe	Zingiberaceae	Zinjibil	H	Rh	Hu	Toothache; Cough; Abdominal pain	Or	F	Hold the fresh rhizome by teeth; Boiled the rhizome, then drink as a tea; Crush the fresh rhizome then swallow
125	*Ziziphus spina-christi* (L.) Desf.	Rhamnaceae	Kurkura	T	L	Ls; Hu;Hu	Retained placenta; Dandruff; Acne	Or; Ex;Ex	F;F/D;F/D	Crushed, homogenize with cold water and allow to drink; Crushed, squeezed then applied the liquid to the head after washing then wash

										after an hour. Use as a facial mask and it cleans the skin, opens pores and removes old cells in addition riding the acne
126			Birgud	T	…	Hu	Impotency (Female)	Fu	D	Crush and fumigate the smoke, has also good aroma
127			Hakenur	H	Wp	Hu	Headache	D	Na	Crush and sniff the powder
128			Ketenaju	H	L&Fl	Hu	Dandruff	D/F	Ex	Crush, mix with fresh butter and apply on head; It has also pleasant aroma and used as a fragrance
129			Yejibshenkurt	H	Bu	Hu	Evil sprit	F	Fu	Crush and fumigate the smoke

Key: Growth form Tree (T); Shrub (S); Herb (H); Climber (C). Plant part used (Leaf, L; Root, R; Stem wood, St; Fruit, Fr; Bark, B; Flower, Fl; Bulb, Bu; Rhizome, Rh; Latex, Lat; Whole plant, Wp; Seed, S). Used for (Livestock, Ls; Human, Hu); Type (Dry, D; Fresh, F). RA (Oral, Or; Dermal, De; Nasal, Na; Optical, Op; Auricular, Au; Vaginal, Va; External, Ex; Fumigation, Fu)

** Endemic species

Appendix 8. List of medicinal plants in Bati District: scientific name; family; local name; growth form (GF); plant parts used (PU); used for; ailment treated; type; route of administration (RA); mode of preparation, dosage and way of application of remedies

No	Scientific name	Family	Local name	Growth form	PU	Used for	Ailment treated	Type	RA	Mode of preparation, dosage and way of application of remedies
1	*Acacia mellifera* (Vahl) Benth.	Fabaceae	Sebensa	S	L	Camel / Ls	Constipation	F	Or	Fresh leaves allow to eat
2	*Acalypha fruticose* Forssk	Euphorbiaceae	Erigy	S	L	Hu	Fever/"Mich"; Head ache	F	Fu	Boil the fresh leaf and fumigate the smoke
3	*Achyranthes aspera* L.	Amaranthaceae	Telenji	H	L	Hu	Bleeding during cutting; Bleeding during delivery	F	Ex; Or	Crush the fresh leaves and tie on the injured part; Crush the fresh leaves then drink
4	*Aerva javanica* (Burm.f.) Schultes	Amaranthaceae	Chiwuciwe	S	L	Camel / Ls	Eye infection	F	Op	Chew the fresh leaves and spit on the infected eye
5	*Allium cepa* L.	Alliaceae	Key-shinkurt	H	Bu	Hu	Scorpion bite	F	Ex	Burn the bulb and rub on the bited part

6	*Allium sativum* L.	Alliaceae	Nech-shinkurt	H	Bu	Hu	Evil eye; Cough; Hypertension; Headache; Scabies	F	Or;Or; Ex	Crush the fresh bulb, mixing with fresh root of *Solanum incanum* and *Withania somnifera* then add water and drink; Eat the fresh bulb at the bed time(for both Cough and Hypertension); apply the oil on the head; Crush, mix with animal fat and apply for consecutive seven days (washing before applying it is necessary)
7	*Aloe trichosantha* Berger	Aloaceae	Eret	H	Lat; St	Hu	Malaria; Evil spirit	F; D	Or; Fu	Drink the latex (a teaspoon); Smoke the dried root around the home
8	*Artemisia absinthium* L.	Asteraceae	Arrity	H	L	Hu	Tonsilitis	F	Or;Ex	Crush the fresh leaves and spit on the mouth of the child; Used as fragrance
9	*Asparagus africanus* Lam.	Asparagaceae	Yeset kesit	S	L	Hu	Swelling	F	Ex	Crush the fresh leaves and tie on the swelled part
10	*Brassica nigra* (L.) Koch	Brassicaceae	Senafich	H	S	Hu	Headache; Malaria	D	Na; Or	Crush and sniff little amount; Crush, homogenize with water and pack 1-3 days, mix with socked *Cicer arietinum* or *Vicia faba* then eat every morning for 3-7 consecutive days before eating any food

11	*Cadia purpurea (*Picc.) Ait	Fabaceae	Enjiro	S	St; L; R; L & R	Hu; Ls; Hu; Hu	Tooth ache; Flea and louse; Stomachache; Fever/"Mich"	F	Or; Ex; Or; Or	The fresh stem wood used as a teeth brush; Crush the fresh leaf then paint the skin; Fresh root is chewed and swallowed; Mix with small amount leaf of *Calpurnia aurea* then drink the concoction
12	*Calotropis procera*	Asclepiadaceae	Tobia	S	Lat	Hu	Hemorrhoid	F	Dr	Paint the latex
13	*Calpurnia aurea*	Fabaceae	Digita/ Chekka	S	S; L	Hu; Ls	Excessive menstrual flow; Tick infestation	D; F	Or; Ex	Crush dried three seeds homogenize with a cup of cold water and drink; Crush the fresh leaves then pest the body
14	*Capsicum annuum*	Solanaceae	Karia/ belew	H	S	Hu	Retained placenta; Abdominal parasite	D	Fu	Burn the seed and inhale its smoke; Mix with *Allium sativum* and *Allium cepa* and eat with "enjera"
15	*Carica papaya*	Caricaceae	Papaye	T	S, St, Fr	Hu	Abdominal parasites; "Ykola kusil"; Headache	D; F; F	Or; Ex; Ex	Crush the dried seed, mix the powder with a cup of honey then eat 1 spoon every morning before eating any food; Split the steam wood and smear the liquid to the wound; Take the fleshy part and apply on the head
16	*Carissa spinarum*	Apocynaceae	Agam	S	R	Hu	Back pain; Evil eye; Arthritis	D/ F	Fu	Dried or fresh root mix with root of Aloe sp, stem of *Clerodendrum myricoides*, *Croton macrostachyus* and *Terminalia brownii* then fumigate the smoke
17	*Catha edulis*	Celastraceae	Chat	T	L	Hu	Evil spirit	F	Ex	Chew the fresh leaf, pray on it and spit on the one who sick at the time of "wedaja" ceremony
18	*Celtis africana*	Ulmaceae	Fetekuma	T	L	Ls	Diarrhea	F	Or	Crush, homogenize with cold water and allow drinking

19	*Ceratostigma abyssinicum*	Plumbaginaceae	Metirez	S	Wp	Hu	Fever/"Mich" & diarrhea	F	Or	Crush, homogenize with cold water, filter and drink a cup of coffee
20	*Cicer arietinum*	Fabaceae	Shimbra	H	S	Hu	Malaria	D	Or	Soaked the dray seed in water for a day, filter it and mix with crushed fresh bulb of Allium sativum and crushed dray seed of Brassica nigra then eat for 5/7 consecutive days before eating any food every morning
21	*Cissus quadrangularis* L.	Vitaceae	Gnagnatu	C	St	Hu	Pest-control	F	Ex	Crush the fresh stem and mix the crops
22	*Cissus rotundifolia* (Forssk.) Vahl	Vitaceae	Chobe	C	R	Hu	Gastritis	F	Or	Take little amount of it, crush and homogenize with water, drink ½ a cup
23	*Citrus limon*	Rutaceae	Lomie	T	Fr	Hu	Abdominal pain	F	Or	Drink the juice
24	*Clerodendrum myricoides*	Lamiaceae	Misiroch	S	St & R; St	Hu	Arthritis & evil eye; Teeth ache	F	Fu; Or	Mix with stem wood of Terminalia brownie and fumigate its smoke; Use it as a teeth brush
25	*Cucumis dipsaceus*	Cucurbitaceae	Yemidir-embuay	H	R	Hu; Hu&Ls; Hu	Kidney problem; Fever/"Mich"; Diarrhea	F	Or	Crush __cm of the fresh root mix with one glass of honey, add three glass of water then drink at the bed time for three consecutive days; Crush __cm of the fresh root with Artemisia absinthium leaves then add a cup of water for human and add the amount for the livestock and mix with half litter of water then allow to drink; Crush __cm of the fresh root then mix with a cup of coffee and drink

26	*Cyperus longus*	Cyperaceae	Gonda-gondo	H	Bu	Hu	Wound	D	Ex	Roasted, mixes with a fresh butter then apply to the head. It also prevents rancidity of butter and used as fragrance
27	*Cyphostemma adenocaule*	Vitaceae	Milas-goligul	C	R	Hu	Snake bite	F/D	Ex	Hold the fresh/dray root in your pocket to prevent snake bite
28	*Dodonaea angustifolia*	Sapindaceae	Kitikita	S	L	Ls	Retained placenta	F	Or	Crushed, homogenize with cold water and allow the animal to drink it
29	*Echinops kebericho***	Asteraceae	Kebericho	H	R	Hu	Fever/"Mich"; Evil sprit	D	Fu	Smoke the dray root and fumigate during night time
30	*Ehretia cymosa*	Boraginaceae	Hulaga	T	L	Hu; Hu;Ls	Wound('Liffe'/ Telakef)/infection; Fever/"Mich"; Abdominal dryness	D/ F; F	Ex; Fu; Or	Grind then mix with fresh butter and tie on the finger/tie on the injured part; Boil the fresh leaf and inhale its smoke or steam; Eat as a forage at the time of famine
31	*Euclea racemosa*	Ebenaceae	Dediho	S	Rb; R; R; L; L	Hu;Ls; Hu:Hu; Hu	Toothache; Anthrax/Abakorime;Bloody diarrhea; Tinia corpores;Tonsilitis & Evalitis	F	Or;Or; Or;Dr; Or	Hold the bark of the fresh root on teeth; The fresh root mix with the roots of Acokanthera schimperi, Terminalia brownii, Lepidium sativum, Olea europaea, Cadia purpurea and Allium sativum then Crush and homogenize with water and allow to drink; Mix the fresh root with the fresh root of Rhus

										natalensis crush and homogenize with water then drink a tea spoon; Crush the root bark and apply to the infected part; Mix the fresh root with the fresh root of Rhus natalensis, crush and homogenize with water then drink a tea spoon; Crush the fresh leaf and drink a tea spoon
32	*Ferula communis*	Apiaceae	Kumen	H	L & R	Hu	Urine retention	F	Or	Boil the fresh leaves and drinks the decoction/Crush the fresh leaves and drink the juicy part/ Eat the fresh root
33	*Grewia ferruginea*	Tiliaceae	Lenquata	T	B	Hu	Louse; Hair falling	F	Ex	Immerse the internal part of the fresh bark in water then applied the jell to the hair for not less than 2/3 hours; Immerse the internal part of the fresh bark in water then applied the jell to the hair for not less than 2/3 hours, it makes the hair root very strong and prevents the hair from falling out, it is also important to make the hair very shine and being a curl for youngsters' hair, since, having a twist hair is common culture for the youngsters male especially in the boundary of the study area since they share common culture with the Afar region.
34	*Grewia similis*	Tiliaceae	Edbasa	T	St	Hu	Teeth ache	F	Or	Use it as a teeth brush

35	*Grewia trichocarpa*	Tiliaceae	Haroressa	T	St	Hu	Teeth ache	F	Or	Use it as a teeth brush
36	*Grewia villosa*	Tiliaceae	Hegomide	S	B	Hu	Louse; Hair falling; Jaundice	F	Ex	Mix the fresh root with the fresh root of *Grewia ferruginea*, insert all in one bowl, split the root bark from the root in front of the patient by adding water, then if its color is changed in to yellowish repeat for consecutive three days, lastly the patient wash by the water which is mixed in the bowl or he should role in the goats feces.
37	*Guizotia abyssinica*	Asteraceae	Nug	H	S	Hu	Cough	F	Or	Crush, mix with water then boil and drink during the night time
38	*Heteromorpha arborescens*	Apiaceae	Yejib-mirkuz	S	St	Hu	Fever/"Mich"	F	Or	Boil the fresh steam wood, cool and filter, then mix with honey and drink
39	*Huernia macrocarpa*	Asclepiadaceae	Kulikoloch o	H	St	Hu	Tumor	F	Ex	Crushed the fresh stem and tie to the infected part
40	*Impatiens tinctoria*	Balsaminaceae	Ensesula	H	Bu	Hu	Cracking feet and hand; Arthritis	F	Ex	Crush the fresh root, add lemon juice then warmed over fire and cool, and insert the hand and feet in the bowl at least for two hours. As a result, it decorates the palm of hands, nails and feet. Moreover, it makes smooth for hands and the feet. It also relieves pain for people with arthritis.
41	*Indigofera coerulea* Roxb.	Fabaceae	Jimet	S	L	Hu	Eye diseases	F	Op	Crush the fresh leaves and squeeze then add a drop at the infected eye
42	*Indigofera suaveolens*	Fabaceae	Yadalchiraro	S	Wp	Hu	Evil sprit	D/F	Ex	Smoke fumigate the home, it has also good fragrance
43	*Jasminum grandiflorum*	Oleaceae	Tembelel	C	L; L & Fl	Ls; Hu	Fever/"Mich"; Tapeworm	F; D	Or	The fresh leaf mix with fresh leaf of *Osyris quadripartite*, crush and add half litter of water then drink; Grind

										the dried flower and leaf then add water to the powder and drink
44	*Jatropha curcas*	Euphorbiaceae	Jatroba	T	L; Lat	Hu	Pest control; Minor Bleeding	F	Ex	Mix the fresh leaves with fresh leaves of Clematis simensis, fresh root of Cadia purpurea and the stem wood of Euphorbia abyssinica (one k.g) for each of them, crush and combine with urine of cattle (20-25 Ls) then pack for one month and spray on the crops by mixing water; Smear the latex on the bleeding part of the body
45	*Kalanchoe densiflora*	Crassulaceae	Lukaluke	H	R; L; L & R	Hu; Hu;Ls	Gastritis; Atadafe(Arifetu); Wound	F	Or;Or ; Ex	Crush the fresh root, add two cup of water then filter and drink; Crush the fresh leaf, squeeze and drink; Crush the fresh leaf and root then penetrate the skin of the cattle by the lower side of their neck then insert the crushed leaf and through it
46	*Laggera tomentosa* **	Asteraceae	Alashume	S	L	Hu	Fever/"Mich"	F; D	Fu; Ex	Boil and fumigate the stem; Crush then mix with fresh butter for its pleasant aroma as a fragrance
47	*Lawsonia inermis*	Lythraceae	Hena	T	L	Hu	Wound; Fire burn; Leprosy; Head ache; Malaria	D; F	Ex, Or	Crushed add water, stir and apply on the infected part (for wound, fire burn and leprosy); Dried leaves are ground and boiled with strong tea then applied the paste to the hade for the whole night. Moreover, it also uses for coloring of the hair and strengthen the root and prevent the hair from falling out; Boil the fresh leaf and drink the decoction when cool for consecutive 3 days before eating any

										food early in the morning; Moreover, it also uses for decorating hands and feet by giving colors for palms of the hands, the nails and feet. Hence, to do so dried leaves of the plant are ground and boiled with strong tea and add lemon juice then the warm paste is applied to the hands and feet.
48	*Lepidium sativum*	Birassicaceae	Feto	H	S	Hu	Any abdominal discomfort	D	Or	Mix the dray seed with honey then eats early in the morning before eating any food for three/seven consecutive days.
49	*Linum usitatissimum*	Linaceae	Teliba	H	S	Hu	Gastritis	D	Or	Boil the dray seed make it cool and drink
50	*Melilotus messanensis*	Fabaceae	Egug	H	S	Hu	Herpes zoster	D	Dr	Crush the dray seed, mix with fresh butter then apply to the infected part. It is also important for preserving butter from rancidity and gives a good smell.
51	*Myrtus communis*	Myrtaceae	Ades	S	L	Hu	Headache	D	Ex	Mix with the dray leaf of *Artemisia Absinthium*, crushed then add fresh butter and tie on head, used as fragrance
52	*Nicotiana tabacum*	Solanaceae	Timbaho	H	Wp	Hu	Evil spirit	D	Na;Ex	Crushed and sniff the powder/ crushed and smoke in the house
53	*Nigella sativa*	Ranunculaceae	Tikurmetafet	H	S	Hu	Headache; Ear problem; Abdominal Pain; For any internal diseases	D	Ex/Na; Au; Or	Apply the oil on the area/crush the seed cover by a piece of close and sniff; Add 3 drops on ear until it gets cure; Crush mix with the seed of *Lepidium sativum* and crushed *Allium sativum* then combine with honey and eat early in the morning before eating any food for consecutive 5/7 days one

										spoon per day; Take 3/5/7 seeds per day early in the morning before eating any food always
54	*Nuxia congesta* R.Br.Ex Benth.	Loganiaceae	Asiquar	T	St	Hu	Irritation of the skin	D/F	Fu	Fumigate the smoke
55	*Ocimum americanum*	Lamiaceae	Ashekute	S	L & Fl	Hu	Dandruff	D/F	Ex	Crush, mix with fresh butter and apply on head. It is also used to make butter to have a pleasant smell at the time of using on the head and it is used for having a pleasant smell by holding it under the close or simply holding it.
56	*Ocimum gratissimum*	Lamiaceae	Damakaseae	S	L	Hu	Fever/”Mich”	F	Or	Crush the fresh leaves, mix with a cup of coffee and drink
57	*Ocimum lamiifolium*	Lamiaceae	Alemselala	S	L	Hu	Fever/”Mich”	F	Or	Crush the fresh leaves, mix with a cup of coffee and drink
58	*Ocimum urticifolium*	Lamiaceae	Alemselala	S	L	Hu	Fever/”Mich”	F	Or	Crush the fresh leaves, mix with a cup of coffee and drink
59	*Olea europaea* L. subsp. *cuspidata*	Oleaceae	Woyra	T	St; St; L	Hu;Hu; Ls	Injury; Back pain; Abdominal dryness	F/D; F; F	Fu;Fu; Or	Fumigate the wound following mechanical injury; Fumigate the fresh stem wood after delivery at the time of postpartum recovery; Eat as a forage at the time of famine
60	*Osyris quadripartita*	Santalaceae	Keret	S	L	Ls	Evel-eye	F	Or	Crush the fresh leaf, homogenize with cold water and drinkCrush the fresh leaf, homogenize with cold water and drink
61	*Otostegia integrifolia*	Lamiaceae	Tinjut	S	L & St	Hu	Evil sprit	D	Fu	Smoke the dray steam and leaves then fumigate the house

62	*Plectranthus punctatus*	Lamiaceae	Yedega-boter	H	L	Hu	Fever/"Mich"	F	Fu	Boiling and inhaling the smoke
63	*Podocarpus falcatus (Thunb.)R.B. ex.Mirb.*	Podocarpaceae	Zigiba	T	L	Hu	Dandruff; Tinea nigra	D	Ex	Crush the dray leaves, mix with water /fresh butter and apply on the infected area
64	*Premna schimperi*	Lamiaceae	Checho	T	L	Ls	Leech	F	Or	Crush the fresh leaves, homogenize with water and allow drinking to cattle
65	*Punica granatum*	Punicaceae	Roman	T	Fr	Hu	Evil sprit; Kidney-problem	F	Or	Eat the fruit
66	*Rosa abyssinica*	Rosaceae	Kega	S	R	Hu	Excessive menstrual flow	F	Fu	Smoke the fresh root and fumigating
67	*Rubia cordifolia*	Rubiaceae	Minchiro	C	R	Hu	Fever/"Mich"	F	Fu	Boil and inhale its smoke
68	*Rumex abyssinicus*	Polygonaceae	Mokimoko	S	R	Hu	Cancer	D	Or	Boil and drink the decoction
69	*Rumex nervosus*	Polygonaceae	Embacho	S	St	Hu	Hemorrhoids	D	Ex	Burn the stem wood then rub the infected part with the burned stem wood
70	*Ruta chalepensis*	Rutaceae	Tenadam	S	L	Hu	Abdominal pain	F	Or	Crush the fresh leaves and mix with a cup of coffee and drink
71	*Sesamum orientale*	Pedaliaceae	Selit	H	S	Hu	Back pain	F	Or	Crush the dray seed, boil Sorghum bicolor (Mokake/Gorad) and Cicer arietinum then mix all in one and eat to prevent a back pain during post partum period

72	*Silene macrosolen*	Caryophyllaceae	Wogert	H	R	Hu	Evil sprit; Excessive menstrual flow	D	Fu	Burn the dray root and fumigate during night time; Dray root mix with dray root of Rosa abyssinica then fumigate the smoke during night time
73	*Smilax anceps*	Smilacaceae	Ginchirit	C	L	Hu	Evel eye	F	Or	Crush the fresh leaves, filter and drink a cup of coffee
74	*Solanum hastifolium* Hochst.ex Dunal in DC.	Solanaceae	Kolochebit	S	R	Hu	Abdominal pain	F	Or	Chew the fresh root and swallow
75	*Solanum incanum*	Solanaceae	Embuay	S	R; Fr	Ls	Eye disease;Leeches	F	Op;Na	Mix with fresh root of Solanum hastifolium chew together and spit the sap on the infected eye; Allow to sniff the liquid which is found in the fruit for cattle
76	*Solanum benderianum* Schimper ex Dammer	Solanaceae	Sejerel-jin	S	L	Hu	Evel eye	F	Fu	Boil and inhale its smoke
77	*Solanum nigrum*	Solanaceae	Awut	H	L	Hu	Wound	F	Ex	Crush and tie on the wounded part
78	*Talinum portulacifolium* (Forssk.) Aschers. ex Schweinf.	Portulacaceae	Impotency	H	Rb	Hu	Impotency	F	Or	Eat the root bark
79	*Tamarindus indica* L.	Fabaceae	Roka	T	Fr	Hu	Abdominal parasite	F	Or	Immerse in the water overnight and stir then filter and drink

80	*Terminalia brownii* Fresen.	Combretaceae	Woyiba	T	St;L;L	Hu;Hu; Ls	Back pain; Womb problem; Arthritis; Sleeping problem; Ageing; Avoiding unwanted fat from the body; Evil eye; Fatigue; Skin problem; Malaria; Abdominal dryness	F	Fu; Or; Or	Adding the stem wood on little fire, fumigating the smoke by covering the whole body without face by blanket and another cover which is made from the skin of an ox/cow. At the time of smoking bath, applying fresh butter on a head and to whole body to avoid dryness of skin is must. In addition, drinking yogurt/ hot drinks which are prepared from oat or other crops and eating a food which is prepared from Cicer arietinum, Sesamum orentale and Sorghum bicolor or porridge is essential especially in postpartum recovery; Boil and drink the decoction when cool before eating food early in the morning, one glass per day for consecutive three days; Eat as a forage at the time of famine, used as fragnance
81	*Toddalia asiatica* (L.) Lam.	Rutaceae	Yedega-gimero	L	R	Hu	Evil eye; Evil sprit	D; D/F	Or; Fu	The drayed root mix with dried root of Echinops kebericho and dried liver of Hyena, crush all in one and add one cup of water to half spoon of the powder and drink; The dried/fresh root mix with dried/fresh root of Withania somnifera and Carissa spinarum then fumigate the smoke for 3/7 days
82	*Tragia doryodes*	Euphorbiaceae	Abilalit	C	R	Hu	Eye diseases (“Yehaya”)	F	Ex	Prepare 2/3 pieces of fresh roots then tie it on the forehead of

										children
83	*Trigonella foenum-graecum*	Fabaceae	Abish	H	S	Hu	Scaleropes; Constipation; Mussel problem & dislocated bone	D	Or; Or; Ex	Boil, filter and drink a glass early in the morning and at the bed time until being healthy; Crush 3 Kgs then add 1Kg wheat flour boil and drink a glass at the bed time by mixing it with fresh butter and honey; Crush, mix with water for overnight filter it and stir, then tie on the injured body part to relax the mussel
84	*Verbascum sinaiticum*	Scrophulariaceae	Ketetna/yahiya-jamo	H	R	Hu	Retained placenta	F	Or	Crush the fresh root, homogenize with water and drink
85	*Withania somnifera*	Solanaceae	Hede-budiha	S	R	Hu	Toothache	F	Or	The fresh root hold with teeth
86	*Xanthium spinosum* L.	Asteraceae	Yesetaf	H	L	Hu	Wound	F	Ex	Crush the fresh leaves and tie on it
87	*Xanthium strumarium*	Asteraceae	Yemogn-fikir	H	L	Hu	Dandruff	F	Ex	Crush the fresh leaves and apply to the head
88	*Ximenia americana*	Olacaceae	Enkoy	S	L	Hu	Wound infection; Water born diseases	F	Ex; Or	Chew the fresh leaf and tie on the wounded part; Crush the fresh leaf, homogenize with little water and pack for 7 days then drink for 3/7 days every morning a cup per a day
89	*Zaleya pentandra*	Aizoaceae	Aredo	H	Wp	Hu; Ls	Fever/ ”Mich” & feeling discomfort; Poor mothering	F	Or; Va	Crush the fresh root, mix with cold water and drink; Crush the fresh root then insert to the womb of the cattle
90	*Zingiber*	Zingibera	Zinjibil	H	Rh	Hu	Malaria;	F	Or	Mix the fresh rhizome with Allium

	officinale	ceae					Toothache; Cough; Abdominal pain			sativum and Ruta chalepensis crush and add with honey then eat; Hold the fresh rhizome by teeth; Boiled the rhizome, then drink as a tea; Crush the fresh rhizome then swallow
91	*Ziziphus spina-christi*	Rhamnaceae	Kurkura	T	L	Ls;Ls; Hu;Hu	Abdominal dryness; Retained placenta; Dandruff; Acne	F	Or;Or;Ex; Ex	Eat as forage at the time of famine; Crushed, homogenize with cold water and allow to drink; Crushed, squeezed then applied the liquid to the head after washing then wash after an hour. Use as a facial mask and it cleans the skin, opens pores and removes old cells in addition riding the acne
92			Birgud	T	St. Ba	Hu	Impotency(for female)	D	Fu	Fumigate the smoke at the bed time, used as fragrance
93			Hakenur	H	Wp	Hu	Headache	D	Na	Crush and sniff the powder
94			Ketenaju	H	L & Fl	Hu	Dandruff	D/F	Ex	Crush, mix with fresh butter and apply on head; It has also pleasant aroma and used as a fragrance

Key: Growth form Tree (T); Shrub (S); Herb (H); Climber (C). Plant part used (Leaf, L; Root, R; Stem wood, St; Fruit, Fr; Bark, B; Flower, Fl; Bulb, Bu; Rhizome, Rh; Latex, Lat; Whole plant, Wp; Seed, S). Used for (Livestock, Ls; Human, Hu); Type (Dry, D; Fresh, F). RA (Oral, Or; Dermal, De; Nasal, Na; Optical, Op; Auricular, Au; Vaginal, Va; External, Ex; Fumigation, Fu)

Key ** Endemic species

Appendix 9. Plants on Women's health disorders and herbal cosmetics in Kalu and Bati Districts

No	Scientific name	Family	Local name	PU	Ailment treated/ Plant used	Type	RA	Mode of preparation, dosage and way of application of remedies
1	*Achyranthes aspera*	Amaranthaceae	Telenji	L	Bleeding during delivery	F	Va; Or	Crush the fresh leaves and insert to the womb, Crush the fresh leaves then drink
2	Aloe sp.	Aloaceae	Eret	St; R	Back pain; Arthritis	F/D	Fu	Mix with stem of *Terminalia brownii* then fumigate the smoke at the bed time
3	*Aloe trichosantha*	Aloaceae	Eret	St; R	Back pain; Arthritis	D/F	Fu	Smoke and fumigate
4	*Artemisia absinthium*	Asteraceae	Arrity	L	Fragrance	F	Ex	Important as fragrance
5	*Brassica nigra*	Brassicaceae	Senafich	S	Abortion	D	Or	Crush homogenize with water and drink
6	*Capsicum annuum*	Solanaceae	Karia/belew	S	Retained placenta	D	Fu	Burn the seed and fumigate its smoke
7	*Carissa spinarum*	Apocynaceae	Agam	R	Back pain; Arthritis	D/F	Fu	Fumigate the smoke
8	*Ceratostigma abyssinicum*	Plumbaginaceae	Metirez	Wp	Infertility of women	D	Or	Crush, boil and cool then mix honey(Key mar) drink for to stop fertility for women
9	*Clerodendrum myricoides*	Lamiaceae	Misiroch	St&R	Arthritis	F	Fu	Fumigate its smoke
10	*Croton macrostachyus*	Euphorbiaceae	Bisana	R; L	Abortion; Bleeding during delivery	F	Va	Peel the fresh root and insert to the womb; Crush the fresh leaves and insert to the womb
11	*Cymbopogon citratus*	Poaceae	Teje-sar	Wp	Fragrance	F/D	Ex	Crush and mix with fresh butter and apply on head; It also prevent the butter from rancidity and give it a good odor
12	*Cyperus longus*	Cyperaceae	Gondagondo	Bu	Fragrance	D	Ex	Roasted, mixes with a fresh butter then apply to the head. It also prevents rancidity of butter
13	*Grewia ferruginea*	Tiliaceae	Lenquata	B	Hair falling	F	Ex	Immerse the internal part of the fresh bark in water then applied the jell to the hair for not less than 2/3 hours, it makes the hair root very strong and prevents the hair from falling out, it is also important to make the hair very shine and being a curl for youngsters' hair
14	*Grewia villosa*	Tiliaceae	Hegomide	Ba	Hair falling	F	Ex	Immerse the internal part of the fresh bark in water then applied the jell to the hair
15	*Impatiens tinctoria*	Balsaminaceae	Ensesula	Bu	Cracking feet and hand; Arthritis	F	Ex	Crush, add lemon juice then warmed over fire and cool, insert the hand and feet in the bowl at least for two hours. As a result, it decorates the palm of hands, nails and feet. Moreover, it makes smooth for hands and the feet. It also

								relieves pain for people with arthritis
16	*Indigofera suaveolens*	Fabaceae	Yadal-chiraro	Wp	Fragrance	D	Ex	Smoke and fumigate
17	*Justicia schimperiana*	Acanthaceae	Sensel/Timuga	R	Womb problem	F	Ex	Smoke and fumigate
18	*Kleinia odora*	Asteraceae	Duea	St	Fragrance	F/D	Fu	Fumigate the smoke
19	*Laggera tomentosa*	Asteraceae	Alashume	L	Fragrance	D	Ex	Dray, crush and mix with fresh butter for its pleasant aroma
20	*Lawsonia Inermis*	Lythraceae	Hena	L	Coloring hair, hands and feet	D	Ex	Crush dried leaves, add water and boiled with strong tea then applied the paste to the hade for the whole night. Ground laves, add water and lemon juice, boiled with strong tea then the warm paste is applied to the hands and feet
21	*Malva Verticillata*	Malvaceae	Lit/Lut	Sb	Making the hair shine	F	Ex	Crush the stem bark and apply the jell on the head
22	*Melilotus messanensis*	Fabaceae	Egug	Wp	Fragrance	D	Ex	Crushed mix with the fresh butter for its pleasant aroma
23	*Mentha longifolia*	Lamiaceae	Erigolega	L	Fragrance	D	Ex	Holding under the close or simply holding it for its pleasant aroma
24	*Myrtus communis*	Myrtaceae	Ades	L	Fragrance	D	Ex	Crushed and mix with the fresh butter to get the pleasant aroma
25	*Nuxia congesta*	Loganiaceae	Asiquar	St	To make skin clear	D/F	Fu	Fumigate the smoke
26	*Ocimum americanum*	Lamiaceae	Ashekute	L& Fl	Fragrance	D/F	Ex	Crush and mix with fresh butter to make butter to have a pleasant smell at the time of using on the head and it is used for having a pleasant smell by holding it under the close or simply holding it
27	*Olea europaea* subsp. *cuspidata*	Oleaceae	Woyra	St	Back pain	F	Fu	Fumigate the fresh stem wood after delivery at the time of postpartum recovery
28	*Osyris quadripartita*	Santalaceae	Keret	L	Hyper pigmentation	F	Ex	Mix with *Myrtus communis* leaves then grind and add fresh butter and paint the infected part
29	*Otostegia integrifolia*	Lamiaceae	Tinjut	Wp	Fragrance	D/F	Fu	Smoke and fumigate
30	*Podocarpus falcatus*	Podocarpaceae	Zigiba	L	To make hair roots strong	D	Ex	Crush the dray leaves, mix with water /fresh butter and apply on the head
31	*Ricinus communis*	Euphorbiaceae	Agulo	S	To make hair manageable	D	Ex	Crush the dry seed extract the oil and apply to the hair
32	*Rosa abyssinica*	Rosaceae	Kega	R	Excessive menstrual flow and Arthritis	F	Fu	Smoke the fresh root and fumigating

33	*Rumex nepalensis*	Polygonaceae	Tulit	R	Delay of placenta	F	Va	Wash the fresh root and insert to the womb
34	*Sesamum orientale*	Pedaliaceae	Selit	S	Back pain	F	Or	Crush the dray seed, boil *Sorghum bicolor* and *Cicer arietinum* then mix all in one and eat to prevent a back pain during post-partum period it is locally known as "sattu"
35	*Silene macrosolen*	Caryophylaceae	Wogert	R	Excessive menstrual flow	D	Fu	Mix the dray root with dray root of *Rosa abyssinica* then fumigate the smoke during night time
36	*Terminalia brownii*	Combretaceae	Woyiba	St; L	Back pain; Womb problem; Arthritis; Sleeping problem; Ageing; Avoiding unwanted fat from the body; Fatigue; Skin problem	F	Fu	Fumigating the smoke by covering the whole body without face by blanket and another cover which is made from the skin of an ox/cow. At the time of smoking bath, applying fresh butter on a head and the whole body to avoid dryness of skin is must
37	*Tragia doryodes*	Euphorbiaceae	Abilalit	R	Delay of placenta	F	Na	Mix the fresh root with fresh root of *Kalanchoe petitiana* then crush and sniff
38	*Urtica simensis*	Urticaceae	Sama	St	Abortion and retained placenta	F	Va	Peel the bark from the fresh steam then insert to the womb
39	*Verbascum sinaiticum*	Scrophulariaceae	Ketetna/yahiyajamo	R	Retained placenta	F	Or	Crush the fresh root, homogenize with water and drink
40	*Zaleya pentandra*	Aizoaceae	Aredo	Wp	Womb problem	F	Va	Crush the fresh leaves and insert to the womb
41	*Ziziphus spina-christi*	Rhamnaceae	Kurkura	L	Dandruff; Acne	D/F	Ex	Crushed, squeezed and applied the liquid to the head then wash after an hour. Use as a facial mask
42	……	…….	Birgud	St	Impotency(Female)	D	Fu	Crush and fumigate the smoke
43	……..		Ketenaju	L&Fl	Fragrance	D/F	Ex	Crush, mix with fresh butter and apply on head for its pleasant aroma and used as a fragrance
44	…….		Yejibshenkurt	Bu	Womb problem	F	Fu	Crush and fumigate the smoke

Appendix 10. Total medicinal plant species and their DNA barcoding sequences in three barcode regions

Voucher (Collector + Number)	**nrITS**	**rbcL**	**matK**	**Remark**
	BLAST	**BLAST**	**BLAST**	
NA01_*Acacia mellifera*	No sequence	*Acacia senegal*	*Acacia sieberiana*	
NA02_*Acacia seyal*	*Acacia xanthophloea*	No sequence	*Acacia borleae*	
NA03_*Acalypha fruticosa*	*Acalypha australis*	*Acalypha glabrata* var. pilosa	*Acalypha rhomboidea*	
NA04_*Achyranthes aspera*	*Achyranthes aspera*	*Achyranthes aspera*	*Achyranthes aspera*	
NA05_*Aerva javanica*	*Aerva javanica*	*Aerva javanica*	*Aerva javanica*	
NA06_*Allium cepa*	*Allium roylei*	*Allium sativum*	*Allium cepa*	
NA07_*Allium sativum*	*Allium sativum*	*Allium sativum*	*Allium sativum*	
NA08_*Aloe* sp*	No hit	*Aloe vera*	*Aloe dyeri*	
NA09_*Aloe trichosantha*	*Aloe cremnophila*	*Aloe volkensii*	*Aloe rauhii*	
NA10_*Artemisia absinthium*	*Artemisia judaica*	*Artemisia capillaris*	*Artemisia salsoloides*	
NA100_*Phagnalon abyssinicum*	*Phagnalon abyssinicum*	*Phagnalon niveum*	*No sequence*	
NA101_*Pittosporum viridiflorum*	*Pittosporum glabratum*	*Pittosporum lancifolium*	*Pittosporum viridiflorum*	
NA102_*Plectranthus punctatus*	No sequence	No sequence	No sequence	
NA103_*Afrocarpus falcatus*	No hit	No hit	No sequence	
NA104_*Premna schimperi*	No hit	*Premna obtusifolia*	*Premna microphylla*	
NA105_*Psidium guajava*	*Psidium guajava*	*Psidium guajava*	*Psidium guajava*	
NA106_*Punica granatum*	No hit	No hit	*Punica granatum*	
NA107_*Rhamnus prinoides*	No hit	*Rhamnus prinoides*	*Rhamnus cathartica*	
NA108_*Ricinus communis*	*Ricinus communis*	*Ricinus communis*	*Ricinus communis*	
NA109_*Rosa abyssinica*	*Rosa abyssinica*	*Rosa dumalis*	*Rosa abyssinica*	
NA11_*Asparagus africanus*	*Asparagus africanus*	No hit	*Asparagus altissimus*	
NA110_*Rubia cordifolia*	*Rubia hangii*	*Rubia membranacea*	*Rubia cordifolia*	
NA111_*Rumex abyssinicus*	*Rumex ephedroides*	*Rumex utahensis*	No hit	

NA112_*Rumex nepalensis*	No sequence	No hit	No hit	
NA113_*Rumex nervosus*	*Rumex hastatus*	*Rumex nepalensis*	No sequence	
NA114_*Ruta chalepensis*	*Ruta chalepensis*	*Ruta graveolens*	No sequence	
NA115_*Schinus molle*	*Schinus montanus*	*Schinus molle*	*Schinus molle*	
NA116_*Sesamum indicum*	*Sesamum indicum*	No sequence	No sequence	
NA117_*Sida schimperiana*	*Sida cordata*	No sequence	No sequence	
NA118_*Silene macrosolen*	*Silene cretica*	*Silene schafta*	*Silene tunicoides*	
NA119_*Smilax anceps*	No sequence	No sequence	No sequence	
NA12_*Bersama abyssinica*	*Bersama abyssinica*	*Bersama lucens*	*Bersama tysoniana*	
NA120_*Solanum benderianum*	No hit	No sequence	*Solanum virginianum*	
NA121_*Solanum hastifolium*	No sequence	*Solanum melongena*	*Solanum anguivi*	
NA122_*Solanum incanum*	No hit	*Solanum virginianum*	*Solanum sp.*	
NA123_*Solanum nigrum*	*Solanum villosum*	No hit	*Solanum retroflexum*	
NA124_*Talinum portulacifolium*	*Talinum fruticosum*	*Talinum paniculatum*	No hit	
NA125_*Tamarindus indica*	No sequence	*Tamarindus indica*	No hit	
NA126_*Terminalia brownii*	*Terminalia brownii*	No hit	*Terminalia bursarina*	
NA127_*Toddalia asiatica*	*Toddalia asiatica*	*Toddalia asiatica*	*Toddalia asiatica*	
NA128_*Tragia doryodes*	No hit	No hit	No hit	
NA129_*Trigonella foenum-graecum*	*Trigonella foenum-graecum*	No hit	*Trigonella foenum-graecum*	
NA13_*Brassica carinata*	*Brassica carinata*	No sequence	*Brassica nigra*	
NA130_*Urtica simensis*	*Urtica simensis*	*Urtica sp.*	*No hit*	
NA131_*Verbascum sinaiticum*	*Verbascum cheiranthifolium*	No hit	*Verbascum carmanicum*	
NA132_*Verbena officinalis*	*Verbena officinalis*	No sequence	*Verbena brasiliensis*	
NA133_*Vicia faba*	No hit	*Vicia faba*	No sequence	
NA134_*Withania somnifera*	No hit	*Withania somnifera*	*Withania somnifera*	
NA135_*Xanthium spinosum*	No hit	*Xanthium spinosum*	No sequence	
NA136_*Xanthium strumarium*	*Xanthium strumarium*	*Xanthium strumarium*	No sequence	
NA137_*Ximenia americana*	*Ximenia americana*	No sequence	*Ximenia americana*	
NA138_*Zaleya pentandra*	*Zaleya pentandra*	*Zaleya pentandra*	No hit	

NA139_*Zehneria scabra*	*Zehneria* sp.	*Zehneria bodinieri*	*Zehneria perrieri*	
NA14_*Brassica nigra*	No hit	No hit	*Brassica nigra*	
NA140_*Zingiber officinale*	*Zingiber officinale*	*Zingiber montanum*	No sequence	
NA141_*Ziziphus spina-christi*	*Ziziphus spina-christi*	*Ziziphus spina-christi*	No sequence	
NA142_*Hakenur**	*Phyllanthus virgatus*	*Andrachne microphylla*	No hit	
NA143_*Ketenaju**	*Origanum majorana*	*Acnistus arborescens*	*Origanum vulgare*	
NA144_*Yejibshenkurt**	*Proiphys amboinensis*	*Crinum yemenense*	No sequence	
NA145_*Birgud**	*Phialocephala lagerbergii*	No sequence	No sequence	
NA15_*Cadia purpurea*	*Cadia purpurea*	*Cadia pedicellata*	*Cadia purpurea*	
NA16_*Caesalpinia decapetala*	*Caesalpinia decapetala*	No hit	*Caesalpinia crista*	
NA17_*Calotropis procera*	*Calotropis procera*	*Calotropis procera*	*Calotropis procera*	
NA18_*Calpurnia aurea*	*Calpurnia sericea*	*Calpurnia aurea*	*Calpurnia sericea*	
NA19_*Capsicum annuum*	*Capsicum sp.*	*Capsicum annuum*	*Capsicum campylopodium*	
NA20_*Carica papaya*	No hit	*Carica papaya*	No hit	
NA21_*Carissa spinarum*	*Carissa carandas*	No hit	*Carissa sp.*	
NA22_*Catha edulis*	*Catha edulis*	No hit	No hit	
NA23_*Celtis africana*	*Celtis africana*	*Celtis africana*	*Celtis occidentalis*	
NA24_*Ceratostigma abyssinicum*	No sequence	No sequence	No sequence	
NA25_*Chenopodium murale*	No hit	No hit	*Chenopodium urbicum*	
NA26_*Cicer arietinum*	*Cicer arietinum*	*Cicer arietinum*	*Cicer arietinum*	
NA27_*Cissus quadrangularis*	No hit	*Cissus quadrangularis*	*Cissus quadrangularis*	
NA28_*Cissus rotundifolia*	No sequence	No sequence	*Cissus rotundifolia*	
NA29_*Citrus limon*	*Citrus aurantiifolia*	*Citrus aurantiifolia*	*Citrus excels*	
NA30_*Citrus medica*	*Citrus aurantiifolia*	*Citrus limon*	*Citrus medica*	
NA31_*Citrus sinensis*	No hit	*Citrus x paradisi*	*Citrus maxima*	
NA32_*Clematis hirsuta*	*Clematis longicauda*	*Clematis brachiata*	*Clematis longicauda*	
NA33_*Cleome gynandra*	*Cleome gynandra*	*Cleome gynandra*	*Cleome gynandra*	
NA34_*Rotheca myricoides*	*Rotheca commiphoroides*	No hit	*Rotheca serrata*	

NA35_*Clutia abyssinica*	No sequence	*Clutia monticola*	*Clutia pulchella*	
NA36_*Coffea arabica*	*Coffea arabica*	No hit	*Coffea arabica*	
NA37_*Boerhavia plumbaginea*	*Boerhavia repanda*	*Boerhavia erecta*	*Boerhavia erecta*	
NA38_*Coriandrum sativum*	No hit	No hit	No sequence	
NA39_*Croton macrostachyus*	*Croton sp.*	*Croton laevifolius*	*Croton sp.*	
NA40_*Cucumis dipsaceus*	*Cucumis ficifolius*	*Cucumis sativus*	*Cucumis dipsaceus*	
NA41_*Cucurbita pepo*	*Cucurbita environmental*	No sequence	*Cucurbita pepo*	
NA42_*Cymbopogon citratus*	*Cymbopogon flexuosus*	*Cymbopogon flexuosus*	*Cymbopogon caesius*	
NA43_*Cynoglossum lanceolatum*	*Cynoglossum germanicum*	*Cynoglossum officinale*	*Cynoglossum amabile*	
NA44_*Cyperus longus*	No hit	No sequence	No sequence	
NA45_*Cyphostemma adenocaule*	No hit	*Cyphostemma digitatum*	*Cyphostemma serpens*	
NA46_*Datura stramonium*	*Datura stramonium*	*Datura stramonium*	*Datura stramonium*	
NA47_*Dodonaea viscosa* subsp. *angustifolia*	*Dodonaea viscosa*	*No sequence*	*Dodonaea viscosa subsp. angustifolia*	
NA48_*Echinops kebericho*	*Echinops talassicus*	*Echinops blanchianus*	*Echinops ritro*	
NA49_*Ehretia cymosa*	*Ehretia laevis*	*Ehretia amoena*	*Ehretia resinosa*	
NA50_*Ethulia gracilis*	No sequence	No sequence	No sequence	
NA51_*Eucalyptus camaldulensis*	*Eucalyptus flindersii*	*Eucalyptus grandis*	*Eucalyptus grandis*	
NA52_*Eucalyptus globulus*	*Eucalyptus pulverulenta*	*Eucalyptus globulus*	*Eucalyptus yarraensis*	
NA53_*Euclea racemosa*	No hit	No sequence	No hit	
NA54_*Euphorbia hetrophylla*	*Euphorbia cyathophora*	No hit	*Euphorbia cyathophora*	
NA55_*Euphorbia tirucalli*	*Euphorbia tirucalli*	*Euphorbia decorsei*	*Euphorbia tirucalli*	
NA56_*Ferula communis*	No hit	No sequence	No sequence	
NA57_*Galium aparinoides*	No sequence	*Galium aparine*	No sequence	
NA58_*Grewia ferruginea*	*Grewia occidentalis*	*Grewia similis*	*Grewia sulcate*	
NA59_*Grewia similis*	*Grewia occidentalis*	*Grewia similis*	*Grewia erythraea*	
NA60_*Grewia trichocarpa*	*Grewia occidentalis*	No sequence	*Grewia bicolor*	
NA61_*Grewia villosa*	*Grewia occidentalis*	*Grewia villosa*	*Grewia falcistipula*	
NA62_*Guizotia abyssinica*	*Guizotia abyssinica*	*Guizotia abyssinica*	*Guizotia abyssinica*	
NA63_*Helinus mystacinus*	*Helinus integrifolius*	*Helinus integrifolius*	*Helinus integrifolius*	

NA64_*Heteromorpha arborescens*	No sequence	No hit	*Heteromorpha trifoliate*	
NA65_*Huernia macrocarpa*	No sequence	No sequence	No sequence	
NA66_*Hypoestes forskaolii*	*Hypoestes triflora*	*Hypoestes sp.*	*Hypoestes sp.*	
NA67_*Impatiens tinctoria*	*Impatiens repens*	*Impatiens noli*	*Impatiens poculifer*	
NA68_*Indigofera coerulea*	*Indigofera cavallii*	No hit	*Indigofera sphaerocarpa*	
NA69_*Indigofera suaveolens*	*Indigofera suaveolens*	*Indigofera sp.*	*Indigofera sp.*	
NA70_*Jasminum grandiflorum*	*Jasminum grandiflorum*	*Jasminum grandiflorum*	*Jasminum grandiflorum*	
NA71_*Jatropha curcas*	*Jatropha curcas*	*Jatropha gossypiifolia*	*Jatropha curcas*	
NA72_*Justicia schimperiana*	*Justicia pseudorungia*	No sequence	*Justicia gendarussa*	
NA73_*Kalanchoe densiflora*	No sequence	No hit	No sequence	
NA74_*Kalanchoe petitiana*	*Kalanchoe petitiana*	No sequence	No sequence	
NA75_*Kleinia odora*	*Kleinia neriifolia*	No sequence	No sequence	
NA76_*Laggera tomentosa*	*Laggera crispata*	*Laggera alata*	No sequence	
NA77_*Lawsonia inermis*	*Lawsonia inermis*	*Lawsonia inermis*	*Lawsonia inermis*	
NA78_*Lepidium sativum*	*Lepidium sativum*	*Lepidium apetalum*	*Lepidium sativum*	
NA79_*Linum usitatissimum*	*Linum usitatissimum*	No hit	*Linum lewisii*	
NA80_*Lippia adoensis*	No sequence	*Lippia alba*	*Lippia javanica*	
NA81_*Malva verticillata*	*Malva moschata*	*Malva parviflora*	No sequence	
NA82_*Maytenus arbutifolia*	No sequence	No hit	*Maytenus arbutifolia*	
NA83_*Melia azedarach*	No sequence	*Melia azedarach*	No sequence	
NA84_*Melilotus messanensis*	No hit	*Melilotus officinalis*	*Melilotus altissimus*	
NA85_*Mentha longifolia*	No hit	No sequence	*Mentha longifolia*	
NA86_*Momordica foetida*	*Momordica dioica*	No sequence	*Momordica sp.*	
NA87_*Myrsine africana*	*Myrsine africana*	*Myrsine subsessilis*	*Myrsine Africana*	
NA88_*Myrtus communis*	*Myrtus communis*	*Myrtus communis*	*Myrtus communis*	
NA89_*Nicotiana tabacum*	*Nicotiana tabacum*	No hit	*Nicotiana tabacum*	
NA90_*Nigella sativa*	*Nigella sativa*	*Nigella sativa*	*Nigella sativa*	
NA91_*Nuxia congesta*	No sequence	*Nuxia congesta*	No hit	
NA92_*Ocimum americanum*	*Ocimum basilicum*	*Ocimum filamentosum*	No sequence	

NA93_*Ocimum gratissimum*	No sequence	*Ocimum gratissimum*	No sequence	
NA94_*Ocimum lamiifolium*	*Ocimum selloi*	*Ocimum gratissimum*	No sequence	
NA95_*Ocimum gratissimum*	*Ocimum gratissimum*	*Ocimum gratissimum*	*Ocimum gratissimum*	
NA96_*Olea europaea* subsp. *cuspidata*	*Olea europaea subsp. cuspidata*	*Olea europaea subsp. cuspidata*	*Olea europaea subsp. Cuspidate*	
NA97_ *Osyris lanceolata*	No sequence	No hit	No sequence	
NA98_*Rydingia integrifolia*	No sequence	No sequence	No sequence	
NA99_*Persicaria decipiens*	*Persicaria japonica*	*Persicaria glabra*	*Persicaria pensylvanica*	
NA146_NAPH1 (Hakenur)**	No hit	*Ligustrum australianum*	No sequence	
NA147_NAPH2 (Hakenur) **	*Morella pensylvanica*	No hit	*Morella pensylvanica*	
NA148_NAPH3 (Hakenur) **	*Evolvulus alsinoides*	*Morella rubra*	No sequence	
NA149_*NAPL1 (Lawsonia inermis)* **	*Lawsonia inermis*	*Lawsonia inermis*	*Lawsonia inermis*	
NA150_*NAPL2 (Lawsonia inermis)* **	*Lawsonia inermis*	*Lawsonia inermis*	*Lawsonia inermis*	
NA151_*NAPL3 (Lawsonia inermis)* **	*Lawsonia inermis*	*Lawsonia inermis*	No sequence	
NA152_NAPN1*(Nicotiana tabacum)* **	No sequence	No sequence	No sequence	
NA153_NAPN2 *(Nicotiana tabacum)* **	No sequence	*Nicotiana attenuata*	No sequence	
NA154_NAPN3 *(Nicotiana tabacum)* **	No hit	No sequence	No sequence	

Key: *Morphologically not identified

**The powder form of the given sample

Appendix 11. Photographs showing field activities in Kalu and Bati Districts

Interviewing informants at different study sites

Collecting plant specimens with informants


Focus group discussion with the informants


Bati weekly Market

" Boleqiya"(a place which used for fumigating *Terminalia brownie*, locally known as "woyba" and women at the time of fumigating *T. brownie*

"Awliaw" tree (The largest *Podocarpus falcatus* tree which is found at Anabe Forest patch, 12.77 meters in circumference