Ethnobotany of wild and semi-wild edible and medicinal plants used by the Maale and Ari ethnic groups, Southern Ethiopia

BERHANE KIDANE MENGESHA

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Propositions

1. Traditional knowledge secrecy is a barrier for promotion and conservation of wild herbaceous medicinal plants in home gardens.

(this thesis)

2. The introduction of improved varieties of vegetables affects the acceptance of wild vegetables.

(this thesis)

3. Biological soil and water conservation practices are more important than physical conservation practices in degraded slopped landscapes.

4. The social cost of irrigation is higher than the economic gain in the lowland areas of developing countries

5. To be a good leader, it is better to be a good listener than a good speaker.

6. If you want to go far without serious interruptions, it is important to respect your neighbors.

Propositions belonging to the thesis, entitled "Ethnobotany of wild and semi-wild edible and medicinal plants used by the Maale and Ari ethnic groups in southern Ethiopia"

Berhane Kidane Mengesha

Wageningen, 06 April, 2022

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Berhane Kidane Mengesha

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Dedicated
To

My late father, Kidane Mengesha Bisrat

My late mother, Kebebush Gebremariam Woldemichael

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1

General introduction

1.1 Significance of wild/semi-wild edible and medicinal plants

Ethiopia is endowed with rich plant diversity (IBC, 2007; EBI, 2014). It is also known for its extraordinary agrobiodiversity resulting from its varied geography, ethnic diversity and food culture (Edwards, 1991; Kahsay, 2004; Wiersinga de Jager, 2009; Solomon et al., 2020). These diverse plant resources are distributed over different habitats and play an important role particularly in the livelihoods of rural communities (Gentry, 1982; Gaston 2000; Sajem and Gosai, 2006). Wild and semi-wild food and medicinal plants from these diverse plant resources are important component and are essential elements in the food security and health of notably tribal communities living in rural and semi-urban settings (Ray et al., 2020).

The term "wild" is defined in various ways, often based on the context of a research undertaken (for example FAO, 1999; Mengistu, 2008; Friis, 2010). The term "wild" in this thesis is used to refer to plants that are growing in natural environments without human interference, while the term "semi-wild" is applied to plants that are indigenous, or introduced and naturalized to the environment while being nurtured through encouragement and tolerance by humans in their crop fields, home gardens or farm borders.

Wild and semi-wild plants have been important dietary components for most societies and their uses have gradually evolved in response to local preferences and cultures as well as changes in the life styles of users (Tata Ngome, 2017). Among the wild plants, leafy vegetables and fruits play a safety net roles in filling food gaps when cultivated crops are scarce (CTA, 2007; Valvi and Rathod, 2011), and serve as additional sources of vitamins, minerals, trace elements and essential amino acids (Kwenin et al., 2011; Vorster, 2007) besides contributing to meet macronutrient and energy needs (Deshmukh & Waghmod, 2007; Motlhanka & Makhabu, 2011). They are also used to make beverages (FAO, 1991) and other products employed for specific purposes (Motlhanka et al., 2008; Tabuti et al., 2004), for example to detoxify poisonous yams (CTA, 2007). By supplementing important micro-nutrients to the diet, they also play an important role in reducing occurrence of diseases caused by nutrient deficiency. Furthermore, by collecting and marketing wild and semi-wild fruits, people especially rural women and children earn additional income (Kalaba, 2009; Effiong and Udo, 2010) hence the plants also contribute to local livelihood improvement.

Wild plants have served humans for thousands of years as source of both preventive and curative medicinal preparations (Dery et al., 1999; Gurib-Fakim, 2006; Malla and Chhetri, 2009; Naik et al., 2012. The World Health Organization (WHO), for example, estimates that 80% of the world's population continues to rely on traditional medicine for their primary health care because modern drugs are either unobtainable or unaffordable (Gurib-Fakim, 2006). WHO also

encourages promoting traditional herbal remedies in national healthcare programs because such drugs are available at reasonable price and are comparatively safe, and also people have faith in such remedies (Khajuria and Agarwal, 2006). Additionally, there is a growing interest worldwide in natural or herbal remedies (Huie, 2002). Moreover, substances derived from medicinal plants continued to be the basis for a large proportion of commercial medications used today (Balunas and Kinghorn, 2005; Dar et al., 2017). Rural communities also depend on traditional medicines in treating livestock diseases and parasites. This is important as livestock production contributes directly to peoples' livelihoods through income, food, employment, transport, draft power, manure, savings and insurance, and indirectly by increasing the social status of owners (Mirkena et al., 2019). In Ethiopia, livestock production plays a crucial role in the national economy at large (Wanzala et al, 2005; Steinfeld et al., 2010; Behnke and Metaferia, 2011; Duguma et al., 2012). However, livestock production continues to be affected by different types of diseases that undermine its productivity in Ethiopia (MOA, 2012). Thus, better understanding of the use of ethnoveterinary plants in treating livestock diseases and parasites is believed to play positive role in supporting livestock production particularly in areas where modern veterinary services are unavailable.

1.2 Problem statement

Plant resources are used for different purposes in Ethiopia (IBC, 2007). Among the different uses, food and medicinal uses are important elements that contribute to the maintenance and improvement of livelihoods of local communities. The practical use as food or medicine is believed to be associated with local communities' traditional knowledge which has been accumulated through years of experiences and is transferred from generation to generation. Traditional knowledge is a culture of a society and believed to be unique to specific communities despite the existence of exchange of knowledge between cultures.

Wild and semi-wild fruits and leafy vegetables are regularly used as food and are essential components of the traditional dishes in many rural farming communities of Ethiopia (Asfaw, 2009). Yet knowledge gaps remain and the urgency to document knowledge regarding the traditional use of wild and semi-wild plants for food and medicine is increasingly recognized. The following four points highlight this.

First, studies have thus far been limited to few forest dependent communities. The study need to cover even more communities and areas where the use of wild and semi-wild plants continues to be an important source of medicine for humans and livestock. A review by Lulekal et al. (2011) indicated that ethnobotany studies were limited only to a small number of communities in Ethiopia. As a result, our knowledge in this regard remains limited (Balemie & Kebebew, 2006;

Mengistu & Hager, 2008; Addis, 2009). Yet the country is a home to more than 80 ethnic group that have developed and accumulated traditional knowledge in the use of plants for food and medicine.

Second, few studies carried out in Ethiopia focused on documenting the use of wild and semi-wild plants for food and medicine, and fewer attempted to understand local level threats affecting plant diversity and traditional knowledge (Tolasa, 2007). Thus, little attention has so far been given to examine the links between those threats and the different types of uses of these plants. Documenting this is timely, urgent and essential as plant resources are being lost in many areas due to population growth, deforestation and land use changes, environmental degradation, urbanization and acculturation (Giday et al., 2009, SCBD, 2005). The depletion of plant resources may lead not only to decline but also to extinction of plant species (Anyinam, 1995; Cox, 2000). For example, Ensermu et al. (1992) listed 120 threatened endemic plant species in Ethiopia. The decline and extinction of plant species may also lead to loss of the traditional knowledge which is associated with the identification and use of such species.

Third, though studies and field level observations show that communities in different areas manage and use plant resources in different ways, we know little whether use and management of the resources vary with differences in gender and age category of users. Understanding this could help in designing improved management and use options that are suitable to gender and age groups of users and in formulating policy to support responsible and sustainable use of these resources as also stated by Thapa (2005) and Idowu et al. (2012).

Fourth, our knowledge on the marketing of wild and semi-wild edible and medicinal plants in Ethiopia is also scanty as there are few ethnobotanical studies documented marketing of medicinal plants (e.g. Giday et al., 2009; Tolassa, 2007). The studies were cross-sectional in nature and did not demonstrate systematically factors that affect marketing of traditional wild and semi wild edible and medicinal plants. This is an important element in resources management and may have implication on sustainability of the natural resources. Studies that highlight currently prevailing marketing practices, availability of products to be marketed (i.e. the type of plant part marketed), where, by whom and how it is being marketed, volumes sold, how they are used, factors affecting marketing, etc. are hardly known. This is particularly true for communities residing in Southern Ethiopia that have largely remained isolated due to distance from main cities and under development of roads.

Therefore, this research was designed to help contribute to filling the knowledge gap in the two ethnobotanically unstudied ethnic groups (Maale and Ari) in southern Ethiopia. The aim of the present research was to document ethnobotany of wild edible and medicinal plants in these two ethnic groups and generate information that would support efforts to better conserve, manage and use of wild and semi-wild food and medicinal plant resources.

1.3 Research objectives and research questions

The general objective of the research was to study ethnobotany of wild and semi-wild edible and medicinal plants used by the Maale and Ari ethnic groups. Specifically, the study aimed to: (i) identify plant species used for food and medicine by the two communities and assess if seasonal variations exist in use; (ii) recognize factors that determine use of these plant resources; (iii) distinguish factors that are threatening the availability of these plant resources; (iv) assess knowledge differentiation if any between ethnic groups and gender, and across age groups; (v) document knowledge transfer mechanisms, efforts to domesticate and cultivate along with the prevailing marketing practices of wild and semi-wild edible and medicinal species by the two ethnic groups.

To achieve these objectives, the study addressed the following research questions:

1. Which wild and semi-wild edible leafy vegetables and fruits bearing species are harvested and used by Maale and Ari ethnic groups? Are there seasonal differences in use of these plants?
2. Which medicinal and ethnoveterinary plants are used by the two ethnic groups and for what purposes they are used for?
3. Do the two ethnic groups differ in their knowledge and use of wild and semi-wild edible and medicinal plants? What socio-economic and demographic factors significantly influence the use of wild and semi-wild plants?
4. What are farmers' motives for the possible transition of wild leafy vegetables and/or fruits to semi-wild or even cultivated conditions?
5. What are the mechanisms of edible and medicinal plant knowledge transfer among different social groups and how are these plants marketed?
6. What factors threaten wild and semi-wild leafy vegetables, fruits and medicinal plant resources availability in the study area?

1.4 Hypothesis

The study was designed to test the following hypotheses.

Hypothesis 1. There exists no difference between the Maale and Ari ethnic groups in the use of edible wild and semi-wild leafy vegetables and fruit species.

Hypothesis 2. There exists no difference between Maale and Ari ethnic groups in the use of human medicinal and ethnoveterinary species.

Hypothesis 3. There exists no difference in wild and semi-wild edible plant use knowledge between age and gender groups.

1.5 Rationale for the selection of Maale and Ari ethnic groups

There are four major reasons why the Maale and Ari ethnic groups were selected for this study. These are:

- The two ethnic groups, which are bordering each other, are ethnobotanically unstudied and their full wealth of knowledge have not yet been sufficiently studied.

- The two ethnic groups are located far from the centre of the country (indicated on the map) and still use and dependent on medicinal and wild edible plants. Studying knowledge potential areas will help us to produce information that will help us to generate more information, effectively contribute to science, to preserve indigenous knowledge and also contribute for decision makers for their policy formulation and analysis.

- As modernization and urbanization is rapidly spreading to Southern Ethiopia, the urgent need to document ethnobotanical knowledge is crucial before it is lost. Also, the impacts of climate variability and change are being felt more severely in southern Ethiopia, and there is fear that it will affect plant resources uses and knowledge of the two ethnic groups before we understand and document them.

- Earlier understanding of the area and culture of the studied communities by the author helped to easily communicate and generate information within a PhD period. Moreover, additional ethnobotanical knowledge of the author is considered as an asset and contributed a lot (this is additional input for the study). Studying ethnobotanical

knowledge in communities where one knows the culture gives additional advantage for the author to have more intimate discussion, and to document the ethnobotanical knowledge that communities have been dependent on for ages.

1.6 Research Methodology

1.6.1 Description of the study area

The study area is situated in the Southern Nations, Nationalities and People's Region (SNNPR), in southern Ethiopia (Fig. 1.1). The regional state comprises the highest number of ethnic groups (ca. 55) in the country. The research focused on the Maale and Ari ethnic groups, which are found in Debub Omo zone of the SNNPR. The Maale people speak *malló mucci* (Amha, 2001) whereas the Ari speak *Araf* language and both languages belong to the Omotic language family (Yintiso, 1995; Kebede, 2009). According to the National Census conducted in 2007, the population of Maale people was 84,657 and the population of the Debub Ari people was 212 389 (CSA, 2008), and the population size has since been growing at a rate about 2.6 % p.a. which is the national average.

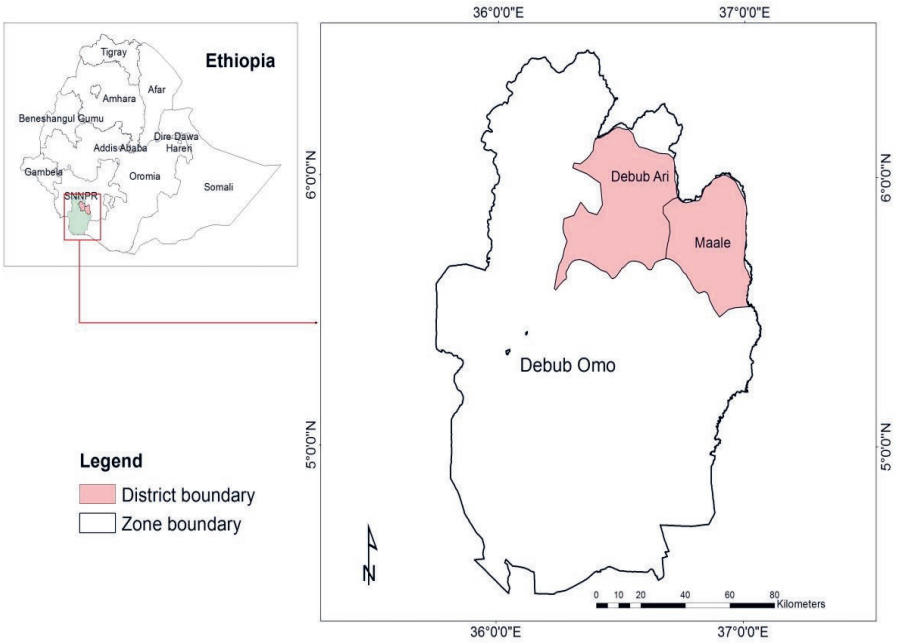

Figure 1.1. Location of Debub Ari and Maale districts in southern Ethiopia

1.6.2 Research approach, method of data collection and analysis

The research approach followed was part of the ethnobiological approach that mainly use methods and approaches from a wide array of sciences. Ethnobotanical research methods from botany, ecology and anthropology (Bridges and Lau, 2006) were used for this thesis research.

Data were collected through reconnaissance surveys, field observations, focus group discussions, semi-structured interviews with individuals and key informants, preference ranking and paired comparisons as described by Martin (1995), Alexiades (1996) and Cotton (1996) were employed.

Plant specimens were collected with traditional medicinal and ethnoveterinary use and also included those wild and semi-wild edible plant species found in the study area. Specimens were identified using taxonomic keys and Floras (Hedberg and Edwards, 1989; Edwards, 1991; Edwards et al., 1995; Edwards et al., 1997; Edwards et al., 2000; Hedberg et al., 2003; Hedberg et al., 2004; Hedberg et al., 2006). All plant names and authors were checked for accuracy by means of the Plant List (www.the plant list.org, 2013).

Market surveys were also carried out for one year in the study area. Markets were visited every fifteen days in market days considering limitations in logistics. All wild and semi-wild edible fruits and medicinal plants that were sold at two markets were documented including their price, source of collection and additional trade information.

Data were analyzed using the statistics program SPSS. Descriptive statistics were used to illustrate frequencies, percentages, means, etc. Moreover, analysis of variance (ANOVA), multiple regression, familiarity index (FI), Jaccard similarity index and use value were also used to analyze the data. Details of data collection and methods of analysis are described in each chapter of the thesis.

1.7 Relevance of this research

The study of people and plant interactions is very important throughout human history because livelihoods and cultures are largely dependent on plant resources for their subsistence (Cruz-Garcia, 2012). Through people-plant interaction and dependency different communities in different habitats acquire knowledge that is important for sustainable management and utilization of resources. This research, which is focused on ethnobotanical information on valuable plants that considers knowledge variation and transfer among/ within social groups, helps decision makers and development practitioners to make informed decisions. Moreover, ethnobotanical research is believed to be a cost-effective means of locating new and useful plant compounds and reduce the costs of new drug development. Gurib-Fakim (2006) discussed the importance of ethnobotanical research and concluded that in most cases the secondary plant compounds employed in modern medicine were first discovered through ethnobotanical investigation. Dar et

al. (2017) also indicated the dynamic role played by medicinal plant for the development of drug discovery.

Many advances have also been made in the discovery of drugs from medicinal plants and are the outcomes of traditional knowledge (Nechal et al., 2004; Ghorbani, 2006). If we screen plant drugs from known natural sources with claimed therapeutic efficacy, the percentage of hits will be increased, thus saving time and money. Otherwise developing a single new drug from unknown source needs screening of 10,000 molecules and requires 10-15 years at an expenditure of more than $ 900 million (Khajuria and Agarwal, 2006). Therefore, this research will contribute to the development of drugs by providing new information from previously unstudied ethnic groups.

Furthermore, the results of this study would also contribute directly or indirectly to the goals set in the "Convention of Biological Diversity (CBD) and Sustainable Development" through generating relevant information and conclusions. The CBD was endorsed by several countries including Ethiopia and also accepted by many countries (SCBD, 2005). Article 8(j) of the CBD states that "Each contracting party shall, as far as possible and as appropriate and subject to national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote the wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices."

1.8 Outline of the thesis

The thesis is organized in six parts including this general introduction. Following this introduction, the second chapter discusses and analyses ethnobotanical information of wild and semi-wild leafy vegetable species used by the Maale and Ari ethnic groups, and the third chapter discuss about ethnobotany of wild and semi-wild edible fruit bearing species. Chapter four presents and analyzes the use and management of human medicinal plants by Maale and Ari ethnic groups. Chapter five analyses and provides insight on the ethnoveterinary medicinal plants used by the Maale and Ari. Chapter six discusses and concludes the major findings of the thesis, and also presents the major development, policy and research recommendation.

In this thesis, I used the term "ethnic communities" at the beginning of my study to describe a group of people with shared language, common culture and tradition etc. Later in the thesis, I transitioned to the use of alternative and more current term "ethnic groups".

2

Wild and semi-wild leafy vegetables used by the Maale and Ari ethnic communities in southern Ethiopia

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Abstract

We studied wild and semi-wild leafy vegetables used by the Maale and Ari ethnic groups in southern Ethiopia. Quantitative and qualitative ethnobotanical methods, including individual and focus group (n = 18) discussions, field observations, and individual interviews (n = 144), were used in three rural kebeles (lowest administrative unit). The two ethnic groups consume 30 leafy vegetable species grouped into 22 genera and 15 families. The study participants underlined that wild and semi-wild leafy vegetables are important components in traditional dishes, more frequently during periods of food shortage. The communities showed high preference for *Balanites aegyptiaca* and *Solanum dasyphyllum* in the Maale and Ari study sites, respectively. Taste, marketability and above ground edible biomass were farmers' main selection criteria suitable for leafy vegetables cultivation. The transfer of local knowledge within the community on wild and semi-wild leafy vegetables is not differentiated by gender or age and thus enables knowledge continuity, although harvesting and cooking activities are considered as women's tasks by the communities. Major threats to wild and semi-wild leafy vegetables need to be minimized and complementary in-situ and ex situ conservation strategies scaled up.

Keywords Food shortage. Leafy vegetables. Social group differentiation. Traditional botanical knowledge

Introduction

Ethiopia, with its diverse agroecological zones, is endowed with a rich botanical diversity (Friis et al. 2005; IBC 2007). The country is well-known for its diversity of indigenous food plants, including species used as vegetables (Asfaw 1997; Gelmesa 2010). Wild and semi-wild leafy vegetables contribute to the diet of both rural and urban communities (Mathenge 1997; Andreas et al. 2008). It is not always clear which plants fall within the category of ‘‘vegetable’’. There have also been attempts to define vegetables (Schippers 2000; Van Rensburg et al. 2007). Here, we consider leafy vegetables as plants whose leaves are eaten raw, cooked, boiled or roasted, and sometimes prepared together with their flowers, succulent stems or shoots. There have been also attempts to define the term ‘‘wild’’ (FAO 1999; Mengistu 2008; Friis 2010). For example, Mengistu (2008) defined ‘‘wild’’ as those plant species dwelling in the agricultural landscape - natural environment continuum and not recognized by the community exclusively as domesticates. The term ‘‘wild’’ in this thesis refers to those plants that are growing in natural environments without human interference, while the term ‘‘semi-wild’’ is applied to those plants that are indigenous or introduced and naturalized to the environment while being nurtured through encouragement and tolerance by humans in their crop fields, home gardens or borders.

Wild and semi-wild leafy vegetables have nutritional importance as sources of vitamins, minerals, trace elements and essential amino acids (Vorster 2007; Kwenin et al. 2011) and thus comprise a valuable component of the local diet. According to Modi et al. (2006), wild and semi-wild vegetables such as amaranth (*Amaranthus* spp.) and black jack (*Bidens pilosa* L.) are more valuable sources of vitamin C, vitamins A and E, and iron and zinc than cabbage (*Brassica oleracea* var. capitata L.) and Swiss chard (*Beta vulgaris* subsp. cicla (L.) W.D.J. Koch). By supplementing important micronutrients to the diet, they play a very important role in preventing diseases caused by nutrient deficiency, which affect millions of people worldwide. (Orech et al. (2005), Rashid and Anand (2009) and Gelmesa (2010) have discussed the specific importance of such plants in periods of food crises. The absence of micronutrients usually leads to poor health, low work productivity and high rates of mortality and morbidity (Shackleton 2003; Addis 2009).

In many societies, including rural farming households of southern Ethiopia, wild and semi-wild leafy vegetables are regularly used and essential components of traditional dishes (Asfaw, 2009). However, they have been relatively neglected in research (Asfaw, 1997; Gelmesa, 2010). It is believed that traditional food represents the regional identity of people, ethnic groups and communities. The use of the wild food plants is associated with traditional ecological and ethnobotanical knowledge (Andreas et al., 2008; Chantita and Price, 2007).

Despite their importance for large numbers of rural populations, the availability of wild and semi-wild leafy vegetables in the landscape is threatened by factors that depend on local socio-economic, cultural and ecological circumstances. Generally, the extensive collection of wild and semi-wild leafy vegetables may have negative consequences for their natural populations and their survival. A study conducted in South Africa showed that the extensive use of herbs contributed to well-being of rural populations through direct consumption and income generation (Shackleton, 2003). However, this practice threatened local populations of the species involved through unsustainable extraction, which lead to genetic erosion and/or biodiversity loss. In turn, dwindling plant resources gradually lead to loss of indigenous knowledge on the use and management of these resources, especially in areas where local knowledge is transferred orally in the presence of the resource (practice based).

Hens and Boon (2003) associated biodiversity loss with habitat loss, the introduction of exotic species, over-harvesting of biodiversity resources, and homogenization of species in agriculture. Tabuti et al. (2004) associated the decline of wild food plants with habitat destruction, which was followed by a loss of knowledge on cultivation and food preparation in Bulamogi County in Uganda. They also associated knowledge loss with the limited opportunity for youngsters to learn about wild food plants from elders because they spend more time at school. Ladio and Lozada (2003) noted the decline in wild plant knowledge among the young informants of Cayluf community (Argentina) and Benz et al. (2000) explained the abandoning of aboriginal ancestral practices by indigenous people in Mexico because they looked for economic and social gain. A study in Spain, on the other hand, showed that the decline in wild food gathering was due to negative connotations and associations with times of scarcity (Pardo-De-Santyana and Tardi´,

2005). Generally, the loss of indigenous knowledge and biodiversity worldwide, including Ethiopia, has diverse reasons and has been explained under local, ecological, socio-economic and cultural contexts. Studying the major reasons for the decline of resources and loss of associated knowledge under given cultural, socio-economic and ecological conditions will help decision makers in their formulation and analysis of their policy (Andreas et al., 2008). Despite their importance, such important studies are almost absent for Ethiopia (Addis, 2009).

It is also crucial to understand importance of wild and semi-wild leafy vegetables for different social groups. Thapa (2005) explained the importance of gender analysis for the purpose of maintaining and improving the management of resources. Idowu et al. (2012) stressed the importance of gender studies for a sound conservation policy analysis and for designing effective development options.

The objective of this paper is to identify the species and analyse the knowledge and use of wild and semi-wild leafy vegetables by Maale and Ari communities in southern Ethiopia and aim at answering the following five main questions: (1) What species of wild and semi-wild leafy vegetables are used by Maale and Ari communities? (2) Which species are important for nutrition during annual food shortages and/or are important component of traditional dishes? (3) How is knowledge about them distributed among different gender and age groups? (4) What are the farmers' motivations to cultivate leafy vegetables? (5) What are the major threats that affect leafy vegetable resource availability?

By providing scientific explanations to the research questions, our study pledges to provide input to the national development of plans concerning the sustainable use, conservation and management of these valuable plant and knowledge resource.

Materials and methods

Study area

The study areas fall within the Maale and Debub Ari districts, where the Maale and Ari communities reside and are located in the Debub Omo Zone of the Southern Nations, Nationalities and Peoples Region (SNNPR) of Ethiopia (Fig. 2.1). Both study districts are located about 750 km South-West of the national capital, Addis Ababa.

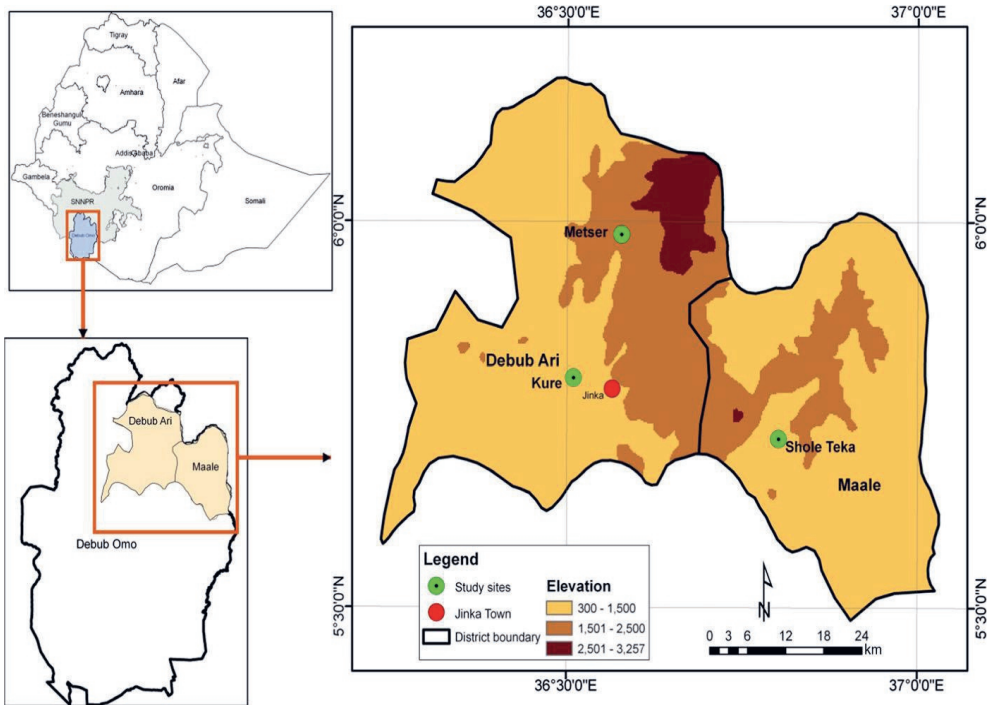

Fig. 2.1 Map of Ethiopia showing the location of the study area

The SNNPR, where the study was conducted, comprises about 55 ethnic communities, among which are found the Maale and Ari. The language of the Maale people is called *Mallo´ mucci* (Amha, 2001) where as the Ari speak *Araf* (Yintiso, 1995; Kebede, 2009). The vegetation of the Maale site is characterized by *Acacia-Commiphora* and *Combretum–Terminalia* woodland.

Moist evergreen Afromontane forest and *Combretum–Terminalia* woodland characterize the vegetation of Kure in Debub Ari (Friis et al., 2010). In the Metser study site the forest area has been converted to agricultural land and dominated by scattered trees in the fields and home gardens. Based on the census report of 2007, the population of Maale was 84,657 and that of Debub Ari was 212,389 (CSA, 2008).

Data collection

Data were collected through reconnaissance surveys, field observations, discussions with individual farmers, focus group discussions, key informant interviews, informal interviews, semi-structured interviews, preference ranking and paired comparisons, photographing and voice recording as described by Martin (1995), Alexiades (1996), and Cotton (1996). In ranking exercises, the lowest value was given for the most-preferred species and the highest value for the least-preferred one. In July and August 2010, a reconnaissance survey was conducted in both districts. It encompassed transect drives, field observations and walks and discussions with administrative officials from the zonal, districts and *kebele* offices in the two districts. *Kebele* is the lowest administrative unit in Ethiopia. Individual discussions were carried out to compile lists of leafy vegetables and to understand their importance for other uses. Key informants were approached for discussions held with them. Focus group (n = 18) discussions were carried out in selected kebeles of the two districts. Free listing was also used to identify the major local dishes in the study area.

Based on the results of the reconnaissance surveys and discussions, three kebeles were randomly selected for detailed, formal survey. Two kebeles (Kure and Metser) were selected in the Debub Ari District located in the lowland (500–1,500 m a.s.l.) and midland (1,500–2,500 m a.s.l.) areas respectively. Shole Teka kebele was selected from the Maale District which is located in the lowland (500–1,500 m a.s.l.) (Fig.2.1). A list of all individuals in the households of the three studied kebeles was obtained from the respective *kebele* offices. In total, 144 individuals from different households (72 male and 72 female) belonging to different age groups were selected, using stratified random sampling methods (Alexiades 1996). We used two age groups because local people regarded an individual above 40 as a mature adult and this classification was used earlier by Mengistu (2008). Field research was carried out from August 2010 to February 2012

with multiple travels to the research site. Whenever necessary, translators were used while collecting the data. The study prticipants were differentiated by their socio-demographic characteristics as shown in Table 2.1.

Table 2.1. Socio-demographic characteristics of the study participants for the formal survey in the Maale (Shole Teka) and Ari (Kure and Metser) study sites.

Characteristics	Number of study participants				
	Shole Teka	Kure	Metser	Total	(%)
Ethnic group	Maale	Ari	Ari		
Religion					
Christian / Protestant	29	34	9	72	50.0
Christian / Orthodox	0	13	32	45	31.3
Traditional	19	0	7	26	18.1
Muslim	0	1	0	1	0.7
Gender					
Male	24	24	24	72	50.0
Female	24	24	24	72	50.0
Age group					
≤40	24	24	24	72	50.0
>40	24	24	24	72	50.0
Educational status					
Illiterate	36	32	20	88	61.1
Read and write	1	2	7	10	6.9
Grade 1-6	9	6	9	24	16.7
Grade 7-8	2	5	5	12	8.3
Grade 9-12	0	3	7	10	6.9

Voucher specimens of all leafy vegetables were collected for all reported species. These were identified at the National Herbarium (ETH) of Addis Ababa University by using the Flora of Ethiopia and Eritrea for determination and nomenclature. Species, family and authority names were also checked and standardized by means of the Plant List (www. theplantlist.org, 2013).

Data analysis

Data were analysed by using statistics program SPSS 16.0. Descriptive statistics were used to illustrate averages and percentages. Similarities and differences in wild and semi-wild edible vegetable plant species occurrences between sites, respondents and ethnic communities were evaluated and compared by means of the Jaccard similarity index (Höft et al., 1999). The index (JI) is expressed as:

$$JI = \frac{c}{a+b+c}$$,

where JI is the Jaccard similarity index, 'c' is the number of species shared by the two sites, 'a' is the number of species present in site A only and 'b' is the number of species present only in site B (Höft et al.,1999).

We calculated a familiarity index (FI) as a relative indicator of the popularity of a leafy vegetable species within a given community (Tabuti et al., 2004):

$$FI = \frac{Frequency\ of\ a\ given\ leafy\ vegetable\ species\ mentioned\ as\ food}{Total\ number\ of\ respondents}$$.

We considered the use value (UV) applied by Albuquerque et al. (2006) and Rossato et al. (1999), modified from Phillips and Gentry (1993), to estimate the total cultural significance of

each species. Species with higher use value are believed to have a higher cultural significance. The use value was calculated using the following formula:

$$UV = \sum Ui / n$$

Where U_i is the number of uses mentioned for a given species by the i^{th} informant divided by the number of informants in the survey (n). The value for each specific use category was also considered and computed by adding the number of informants that mentioned a given species for a specific use divided by the total number of informants (Tardio and Pardo- De-Santayana 2008). Analysis of variance (ANOVA) was also performed to test whether familiarity and average numbers of leafy vegetable species listed differed among gender and age groups.

Results and discussion

Diversity and knowledge of wild and semi-wild leafy vegetables

The Maale and Ari ethnic study participants listed a total of 30 wild and semi-wild leafy vegetable species, belonging to 22 genera and 15 plant families used as wild and semi-wild leafy vegetable (Table 2.2). Of all vegetables documented, 25 were found in Maale and 09 in Ari. Four species were shared by the two communities: *Solanum nigrum, S. dasyphyllum, Portulaca quadrifida* and *Vigna membranacea* subsp. caesia.

Table 2.2. Wild and semi-wild leafy vegetables in Maale (Shole Teka) and Ari (Kure and Metser).

Nº	Maale (M) and Araf (A) names	Scientific name	Family	Maale (Shole Teka)	Ari (Kure)	Ari (Metser)
1	Kolaybuchi (M)	*Justicia calyculata* Deflers	Acanthaceae	yes	no	no
2	D'ia (A)	*Justicia ladanoides* Lam.	Acanthaceae	no	yes	no

Nº	Maale (M) and Araf (A) names	Scientific name	Family	Maale (Shole Teka)	Ari (Kure)	Ari (Metser)
3	Maytse (A)	*Amaranthus dubius* Thell.	Amaranthaceae	no	yes	yes
4	Chomachi (M)	*Amaranthus graecizans* L.	Amaranthaceae	yes	no	no
5	Sermo (M)	*Digera muricata* (L.) Mart.	Amaranthaceae	yes	no	no
6	Pijee (M)	*Pergularia daemia* (*Forss*k.) Chiov.	Apocynaceae	yes	no	no
7	Metsee (M)	*Leptadenia hastata* (Pers.) Decne.	Apocynaceae	yes	no	no
8	Woppa (A)	*Crambe hispanica* L.	Brassicaceae	no	yes	yes
9	Irraiso (M)	*Cleome gynandra* L.	Cleomaceae	yes	no	no
10	Shinburbucha (A)	*Cleome monophylla* L.	Cleomaceae	no	yes	yes
11	Kelkelo (M)	*Maerua angolensis* DC.	Capparaceae	yes	no	no
12	Mutalako (M)	*Boscia salicifolia Oliv.*	Capparaceae	yes	no	no
13	Korioo (M)	*Commelina foliacea* Chiov.	Commelinaceae	yes	no	no
14	Alfeso (M)	*Commelina imberbis* Ehrenb. ex Hassk.	Commelinaceae	yes	no	no
15	Kunchindo (M)	*Commelina diffusa* Burm.f.	Commelinaceae	yes	no	no
16	Gisha (A)	*Commelina latifolia* Hochst. ex A.Rich.	Commelinaceae	no	yes	no
17	Najiee (M)	*Momordica pterocarpa* Hochst. ex A.Rich.	Cucurbitaceae	yes	no	no
18	Shuntee (M)	*Kedrostis foetidissima*	Cucurbitaceae	yes	no	no

Nº	Maale (M) and Araf (A) names	Scientific name	Family	Maale (Shole Teka)	Ari (Kure)	Ari (Metser)
		(Jacq.) Cogn.				
19	Hachirindo (M)	*Cucumis dipsaceus* Ehrenb. ex Spach	Cucurbitaceae	yes	no	no
20	Durinbo (M)	*Kedrostis leloja* (Forssk. ex J.F. Gmel.) C. Jeffrey	Cucurbitaceae	yes	no	no
21	Etsemalko (M) Zegulaa (A)	*Vigna membranacea* A.Rich. subsp. *caesia* (Chiov.) Verdc.	Leguminosae	yes	yes	no
22	Toro (M)	*Crotalaria incana* L.	Leguminosae	yes	no	no
23	Danfurindo (M)	*Senna obtusifolia* (L.) H.S.Irwin & Barneby	Leguminosae	yes	no	no
24	Kilankozolo(M)	*Corchorus olitorius* L.	Malvaceae	yes	no	no
25	Alfakunso (M)	*Adenia gummifera* (Harvey) Harms	Passifloracea	yes	no	no
26	Tsoralle (M) Mulkosa (A)	*Portulaca quadrifida* L.	Portulacaceae	yes	yes	no
27	Ziambee (M)	*Caylusea abyssinica* (Fresen.) Fisch. & C.A. Mey.	Resedaceae	yes	no	no
28	Achikolpo (M) Garenti (A)	*Solanum dasyphyllum* Schumach. & Thonn.	Solanaceae	yes	yes	yes
29	Tsepoo (M) Tsepa (A)	*Solanum nigrum* L.	Solanaceae	yes	yes	yes
30	Donkey (M) Total number of species per site	*Balanites aegyptiaca* (L.) Delile	Zygophyllaceae	yes	no	no

Nº	Maale (M) and Araf (A) names	Scientific name	Family	Maale (Shole Teka)	Ari (Kure)	Ari (Metser)
				25	09	05

"Yes" indicates listed in the study site; " No" indicates not listed

Similarity in leafy vegetable species use across the study sites is shown in Table 2.3. High similarity was found between Ari sites (Kure and Metser), but less between Ari and Maale sites. This indicates that vegetable use considerably vary among ethnic communities, which may be attributed to local species availability and traditional experience and preference.

Table 2.3. Jaccard's similarity index between study sites

Study kebeles (Communities)	Jaccard's Index (JI)	
	Shole Teka (Maale)	Kure (Ari)
Kure (Ari)	0.1333	-
Metser (Ari)	0.0714	0.5556

"JI values ranges from 0-1; higher values indicate greater similarity"

The familiarity (popularity) of vegetable species among the different social groups within each community is shown in Tables 2.4 and 2.5. While *Balanites aegyptiaca* and *Momordica pterocarpa* have a high familiarity index in Maale, *Solanum dasyphyllum* and *Solanum nigrum* took the lead in Ari and attributed to their availability, use and preference. The results of the one-way ANOVA showed that there is no significant difference in familiarity between male and female groups as all p values > 0.05. Similarly, there was no significant difference in familiarity with vegetables among age groups.

Table 2.4. Familiarity indices (%) of selected leafy vegetables in Maale (Shole Teka)

Nº	Species name	Familiarity indices (in %)			
		Male > 40	Male ≤ 40	Female > 40	Female ≤ 40
1	*Balanites aegyptiaca*	100.0	91.7	83.3	100.0
2	*Momordica pterocarpa*	83.3	75.0	83.3	75.0
3	*Kedrostis foetidissima*	66.7	75.0	66.7	33.3
4	*Portulaca quadrifida*	33.3	41.7	66.7	50.0
5	*Cleome gynandra*	41.7	75.0	25.0	33.3

"Species with high familiarity index are selected and displayed here; otherwise total numbers of species found in Maale are listed in Table 2.2."

Table 2.5. Familiarity indices (%) of leafy vegetables in Debub Ari (Metser and Kure)

		Familiarity indiices (in %)							
		Kure				Metser			
	Gender /Age Group/	Male > 40	Male ≤ 40	Female > 40	Female ≤ 40	Male > 40	Male ≤ 40	Female > 40	Female ≤ 40
Nº	Species name								
1	*Solanum dasyphyllum*	91.7	50.0	91.7	66.7	50.0	58.3	91.7	91.7
2	*Solanum nigrum*	91.7	91.7	75.0	50.0	83.3	75.0	66.7	41.7
3	*Cleome monophylla*	33.3	41.7	58.3	41.7	33.3	41.7	58.3	50.0
4	*Crambe hispanica*	41.7	41.7	33.3	0.0	58.3	41.7	41.7	58.3
5	*Amaranthus dubius*	50.0	91.7	66.7	83.3	0.0	8.3	0.0	0.0
6	*Justicia ladanoides*	66.7	83.3	75.0	91.7	*	*	*	*

The average numbers of wild and semi-wild leafy vegetables listed by different age and gender groups in the study sites are summarized in Table 2.6. The results of one-way ANOVA also showed no significant difference in average number of edible leafy vegetable species listed by the different gender and age groups (all values $p > 0.05$), indicating an open knowledge transfer within the communities, which is important for knowledge continuity and future development and conservation plans.

Table 2.6. Average number of wild and semi-wild leafy vegetables listed by males and females in each study site

Age	Shole Teka		Kure		Metser	
	Male	Female	Male	Female	Male	Female
>40	5.00	6.67	4.42	4.42	2.25	2.58
≤40	6.83	6.00	4.25	3.67	2.25	2.42

Farmers' preference criteria for future cultivation and ranking of leafy vegetables

Seven preference criteria were identified through participant interviews. Participants indicated that taste was the most important criterion for preference in the case of leafy vegetables (Table 2.7), which was also found by Dansi et al. (2008) in Benin. Usually, the tastiest species scored high in marketability and were sought by customers, although less tasty species may also have medicinal importance or double as spices.

Marketability was the second in rank, high above-ground edible leaf production was the third best criterion for possible future cultivation of wild and semi-wild leafy vegetables. These criteria influence future cultivation of these species, and are associated with obtaining higher yields per area in a region where land shortage is a problem.

Table 2.7. Ranking (mean rank) of criteria by participants for the cultivation of wild and semi-wild leafy vegetables

Nº	Ranking criterion	Mean rank by site and gender					
		Shole Teka		Kure		Metser	
		Male	Female	Male	Female	Male	Female
1	Marketability (income generation)	2	2	2	1	2	2
2	Taste (flavor in the mouth)	1	1	1	2	1	1
3	Biomass production	3	3	3	3	3	3
4	Ease of collection	5	6	5	4	5	5
5	Ease of processing	4	5	4	5	4	4
6	Specific cultural application	7	7	6	6	6	6
7	Low effect on undergrowth	6	4	n.m	n.m	n.m	n.m

In all three study sites, participants identified the most important wild and semi-wild leafy vegetable species according to their taste. Selected species were then ranked by the respondents drawn from different age and gender groups in all study kebeles. *Balanites aegyptiaca* ranked first in Maale and *Solanum dasyphyllum* in the two Debub Ari study sites (Tables 2.8 and 2.9).

Table 2.8. Pair-wise mean score and coresponding rank of wild and semi-wild leafy vegetables based on taste in Shole Teka (Maale).

Nº	Species	Mean score	Rank
1	*Balanites aegyptiaca*	4.79	1

2	*Cleome gynandra*	2.77	2
3	*Momordica pterocarpa*	2.69	3
4	*Kedrostis foetidissima*	2.42	4
5	*Portulaca quadrifida*	1.96	5

"Maximum mean score value is 5 here in pair wise ranking"

Table 2.9. Pair wise mean score and corresponding rank of wild and semi-wild leafy vegetables based on taste in Kure and Metser (Ari).

Nº	Species	Kure		Metser	
		Mean score	Rank	Mean score	Rank
1	*Solanum dasyphyllum*	4.98	1	4.58	1
2	*Amaranthus dubius*	3.94	2	0.48	5
3	*Solanum nigrum*	3.42	3	2.60	3
4	*Crambe hispanica*	2.38	4	2.85	2
5	*Cleome monophylla*	1.61	5	0.79	4
6	*Justicia ladanoides*	1.40	6	n.a.	

"Maximum mean score values are 6 in kure and 5 in Metser here for pair wise ranking"

The role of leafy vegetables as ingredients in traditional dishes

The use of wild and semi-wild leafy vegetables to prepare traditional dishes is a common practice in both Maale and Ari communities. Dietary diversity, expressed as diversity of food in a diet, increase the likelihood that all nutrients are included and thus contribute to a balanced diet. The major reasons why farmers still used leafy vegetables was to prepare their local dish, to fill the stomach and to lengthen somehow the period of food availability during food shortage periods. Our communities did not eat them for the sake of pleasure of eating something special

or different, as was observed by Ladio (2001) in Argentina. Participants listed the major traditional dishes that were cooked with or eaten alongside leafy vegetables. Preferences of the wild and semi-wild leafy vegetables for the preparation of traditional dishes in Maale and Ari are shown in Table 2.10.

Table 2.10. Major traditional dishes of Maale and Ari (Ari name between brackets) with leafy vegetables as ingredients

Nº	Dish Types : Maale name (Ari name)	Description of dish types	Wild and semi-wild leafy vegetables used to prepare the dish
1	Fosese (fosese)	Porridge made from sorghum or maize flour	All listed species in table 2.2
2	Tirbo (durko)	Porridge made from sorghum or maize flour in Maale (cooked with vegetables only in Maale)	*Amaranthus graecizans*, *Commelina imberbis* and *C. foliacea*
3	Lada (kita)	Bread, usually prepared from sorghum or maize flour, eaten with boiled vegetables	*Amaranthus dubius* , *Solanum dasyphyllum*
4	Kenchela (kurkufa)	Dish in which first leafy vegetables are cooked, then maize or sorghum flour is mixed with water, small clods are prepared and then cooked after mixing with the cooked vegetables	*Cleome gynandra, Amaranthus dubius, Solanum dasyphyllum, Crambe hispanica*
5	Solo (belsh)	Traditional Ethiopian flat thin spongy bread (*Injera*) usually made of teff, sorghum, or maize flour. Eaten with different cooked vegetables	*Amaranthus dubius, Solanum dasyphyllum,*
6	Koko (tima)	Boiled sorghum, maize or sometimes wheat grain and prepared with different leafy vegetables	*Amaranthus dubius, Solanum dasyphyllum Crambe hispanica, Cleome gynandra, Justicia ladanoides*

Nº	Dish Types : Maale name (Ari name)	Description of dish types	Wild and semi-wild leafy vegetables used to prepare the dish
7	Ougusi (mossa)	Prepared from leafy vegetables and processed enset (*Ensete ventricosum*)	*Balanites aegyptiaca, Solanum dasyphyllum*
8	Kolo (kolo)	Roasted sorghum, maize and wheat, sometimes roasted with vegetables in Ari.	*Solanum dasyphyllum , Solanum nigrum*

Cooking of leafy vegetables to prepare the traditional dish called Fosese is used by both ethnic groups and involves all leafy vegetable species, except the cultivated *Colocasia esculenta* L. in Ari. *C. esculenta* is not used for the preparation because farmers say it contains too much water. Almost all vegetables in Maale and Ari were eaten cooked. A few species such as *Solanum dasyphyllum* and *Solanum nigrum* were consumed roasted with grains of sorghum, maize and wheat in Ari, but not encountered in Maale. In contrast, Vaninio-Mattila (2000) reported that in northeastern Tanzania these vegetables are eaten in stew.

Leafy vegetables that are cooked and eaten with *INJERA* appear to be also eaten with *KITA* (Table 2.10) and include species like *Amaranthus dubius* and *Solanum dasyphyllum*. The use of these species with *KITA* and *INJERA* is associated with relatively high above-ground edible leafy biomass as compared to other species in Ari. Most farmers considered leafy vegetable species such as *Justicia ladanoides* as having low above-ground edible biomass yield and harvesting of this species was considered as time consuming. Moreover, farmers usually did not use relatively low edible biomass-yielding species such as *Justicia ladanoides* to cook alone as they did not fill the stomach with the low biomass. Farmers ate these species in some cases because they have good taste or because they are important in times of food shortage. However, in this study we did not quantify the above-ground biomass yields of each species for comparison.

Leafy vegetables can be prepared fresh or dried, depending on cultural preferences and the characteristics of the leaves. Results of our focus group discussions showed that almost all leafy

vegetables were consumed fresh, directly after collecting, except short time drying of the leaves of *S. dasyphyllum* practiced by the Ari. Studies conducted in Kenya, Benin and South Africa by Ngugi (2000), Dansi et al. (2008) and Vorster et al. (2007) respectively also described the practice and culture of consuming leafy vegetables either fresh or dried, species for example amaranth,. The practice of drying vegetables helps to store food for shortage periods.

Other uses of leafy vegetables

While direct use values of vegetables are explained by consumption and income earned by commercialization, indirect value of the plants is related to their social and cultural values (Price and Britta, 2008). Most farmers in our study area gave more emphasis to the direct use values of wild and semi-wild edible vegetables. Here, the use value index reflects the relative cultural significance of the species. Table 2.11 lists uses (medicinal, construction, fencing, agricultural tools, fuel wood, animal feed, bee forage, furniture, marketability and edibility) of each wild and semi-wild vegetable.

Table 2.11. The use value of wild and semi-wild leafy vegetables in the study sites.

Species	Study sites/uses	Medicine	Construction	Fencing	Agri. tools	Fuel wood	Animal feed	Bee forage	Furniture	Market	Edibility	Sum (Use value)
Balanites aegyptiaca	Shole Teka	0.00	1.00	1.00	0.91	1.00	1.00	0.73	0.82	0.55	1.00	8.01
Portulaca quadrifida	Shole Teka	0.55	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	1.00	3.55
Kedrostis foetidissima	Shole Teka	0.82	0.00	0.00	0.00	0.00	0.45	0.64	0.00	0.00	1.00	2.91
Momordica peterocarpa	Shole Teka	0.55	0.00	0.00	0.00	0.00	0.55	0.45	0.00	0.00	1.00	2.55
Cleome gynandra	Shole Teka	0.00	0.00	0.00	0.00	0.00	0.64	0.73	0.00	0.00	1.00	2.36
Solanum dasyphyllum	Kure	1.00	0.00	0.00	0.00	0.88	0.50	0.00	0.00	0.00	1.00	3.38
Solanum dasyphyllum	Metser	0.80	0.00	0.40	0.00	0.90	0.10	0.10	0.00	0.40	1.00	3.70

Justicia ladanoides	Kure	0.00	0.00	0.00	0.00	0.00	0.63	0.50	0.00	0.00	1.00	2.13
Amaranthus dubius	Kure	0.00	0.00	0.00	0.00	0.13	0.75	0.00	0.00	0.00	1.00	1.88
Solanum nigrum	Kure	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	1.00	1.25
Solanum nigrum	Metser	0.00	0.00	0.00	0.00	0.80	0.70	0.10	0.00	0.10	1.00	2.70
Cleome monophylla	Kure	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	1.00	1.13
Cleome monophylla	Metser	0.00	0.00	0.00	0.00	0.70	0.70	0.30	0.00	0.00	1.00	2.70
Crambe hispanica	Kure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
Crambe hispanica	Metser	0.00	0.00	0.00	0.00	0.70	0.70	0.30	0.00	0.10	1.00	2.80
Amaranthus dubius	Metser	0.00	0.00	0.00	0.00	0.70	0.90	0.20	0.00	0.00	1.00	2.80

" Maximum value depends on the number of uses and here it is 10"

Balanites aegyptiaca had the highest use value index in Maale study site, because this tree is used for many other purposes other than vegetable. In Debub Ari study sites, however, *Solanum dasyphyllum* had the highest use value. Male and female participants did not differ in evaluating the use value of leafy vegetable species, which agrees with the results of Andreas et al. (2008), who found no difference in use values reported by males and females, due to the fact that knowledge transfer was open in the community. Species themselves differed substantially in use values (Table 2.11). Species with high use value also have a high cultural significance for the communities (Albuquerque et al. 2006) and are important for food security.

Leafy vegetables used during food shortage periods

The major causes of food shortages in the study area are uneven distribution of rainfall, drought, unexpected occurrences of pests, population pressure and the associated shortage of agricultural land. In all study sites, shortages of cereal food started in February and became serious in April and May. Generally the food shortage lasted from the end of dry period to the beginning of the rainy season. Food shortage can appear throughout the year till the next harvest if there is a crop failure in the preceding cropping season. In our focus group discussion with the participants and

administrative officials, such serious food shortage was said to occur occasionally in the study area.

One of the strategies adopted by the farmers during food shortage is increased consumption of leafy vegetables. Ari study participants in Debub Ari district mentioned *Solanum dasyphyllum, S. nigrum* and *Justicia ladanoides* as important species in these periods. Maale study participants in Maale considered *Balanites aegyptiaca, Leptadenia hastata*, *Momordica pterocarpa, Maerua angolensis, Adenia gummifera* and *Portulaca quadrifida* as the major wild and semi- wild vegetables during shortage seasons (Table 2.12). Gelmesa (2010) and Addis (2009) also indicated the importance of the wild and semi-wild leafy vegetables in preventing hunger and to serve as a bridge in times of grain shortage. Similarly, Guinand and Lemessaa (2000) indicated and argued how some wild leafy vegetables rescued thousands of hungry Ethiopians during such periods.

Table 2.12 Leafy vegetables used during food shortages in Maale (Shole Teka) and Ari (Kure and Metser) (n=144), with the percentage of participants mentioning this species

Nº	Species	% citation by study participants		
		Shole Teka	Kure	Metser
1	*Balanites aegyptiaca*	93.8		
2	*Leptadenia hastate*	72.9		
3	*Momordica pterocarpa*	66.7		
4	*Maerua angolensis*	33.3		
5	*Adenia gummifera*	29.2		
6	*Portulaca quadrifida*	20.8	2.1	
7	*Senna obtusifolia*	12.5		
8	*Cleome gynandra*	10.4		

Nº	Species	% citation by study participants		
		Shole Teka	Kure	Metser
9	*Kedrostis foetidissima*	10.4		
10	*Commelina diffusa*	8.3		
11	*Vigna membranacea* subsp. *caesia*	4.2		
12	*Cucumis dipsaceus*	4.2		
13	*Boscia salicifolia*	4.2		
14	*Justicia ladanoides*		31.3	
15	*Amaranthus dubius*		29.2	
16	*Solanum nigrum*	4.2	29.2	8.3
17	*Cleome monophylla*		18.8	
18	*Vigna membranacea* subsp. *caesia*		6.3	
19	*Solanum dasyphyllum*	2.1	39.6	58.3
20	*Crotalaria incana*	2.1		

Major threats to leafy vegetable resources and associated knowledge

Participants in all study sites mentioned a decline in the availability of the wild and semi-wild leafy vegetable and that no effort was made to reverse or to minimize the rate of this decline. The major factors that threatened the vegetable according to the informants are indicated in Table 2.13. Balemie and Kebebew (2006) reported the same trend in Derashe and Kucha in southern Ethiopia. Wild and semi-wild plants are usually self-seeded and severely affected by harvesting before maturity and seed formation (Vorster, 2007). Minimizing and if possible alleviating such threatening factors is a viable strategy for wild vegetable protection and should be supported by complementary *in situ* and *ex situ* conservation strategies to conserve and sustainably utilize the remaining resource and the associated knowledge. The same understanding and ranking of the

major treats of leafy vegetables by male and female respondents is a good opportunity in future conservation and development works. Storage of seeds, protection of wild stands, distribution of seedlings for home gardens and further stimulations for cultivations could help to reverse the decline in wild vegetable resources.

Table 2.13. Average (mean) ranking by gender for factors that threaten leafy vegetable plants by the study site.

Nº	Threats	Shole Teka		Kure		Metser	
		Male	Female	Male	Female	Male	Female
1	Agricultural land expansion	1	1	2	1	1	1
2	Lack of culture of planting	2	2	5	5	3	3
3	Selective harvesting for other use (house construction, farm implements, household utensils)	5	4	n.m	n.m	n.m	n.m
4	Drought/shortage of rainfall	6	6	1	2	4	4
5	Fuel wood collection	3	3	n.m	n.m	n.m	n.m
6	Grazing pressure	4	5	4	3	2	2
7	Wildfire	7	7	3	4	5	5

"n.m: not mentioned in the study site"

During our focus group discussions local people said that nowadays they focused more on planting marketable (domesticated) leafy vegetables than wild and semi-wild vegetable species. Moreover, younger people preferred and focus more on the cultivated and marketable species and considered wild species as low-value vegetables. This trend may seriously threaten future conservation and sustainable management of these wild and semi-wild resources. Engle (2000) also argued that the rapid introduction and adoption of highly improved cultivars of vegetables could also threaten the tradition of using indigenous vegetables.

Future potential niches for the promotion of wild and semi-wild leafy vegetables

In the past, the majority of wild and semi-wild leafy vegetables were collected freely. Nowadays, the practice of free collecting from any field is becoming a challenge as the resource became gradually scarce and currently most land is demarcated and used by entitled individuals for agriculture. Harvesting leafy wild vegetables from someone's land now requires permission from individuals who entitled the land, which indicates how the resource has become scarce in the landscape in the study area. Most farmers, especially in Debub Ari, had the perception that wild and semi-wild leafy vegetables growing by their own as weeds in their cultivated fields did not require intensive management. Thus, there were no specific management practices that facilitated better growth and yield of these vegetables in the study area, except intensive field management for their crops that directly favored growth of wild vegetables. Apart from sustainably collecting from their natural habitat, farmers in the study area showed interest in the future promotion and managing of leafy vegetables only in their own home gardens and crop fields. This is also attributed to ownership rights, ease of collection, management and supervision. Future promotion in home gardens and crop field requires increasing productivity of the preferred species as land shortage is a major problem in the study area. Therefore, species-based research on cultural practices, to enhance growth and development of wild and semi-wild leafy vegetables are crucial as underlined by Modi et al. (2006).

Conclusions

Ethiopian Maale and Ari ethnic communities consume 30 species of wild and semi-wild leafy vegetables, which are crucial ingredients in the preparation of traditional dishes and especially important during food shortage periods. These plants also serve as animal fodder, bee forage, fuel wood and medicine. Their various uses and importance during food shortage periods are good arguments for the design and implementation of future participatory conservation projects. Ethnic communities showed a high preference for *Balanites aegyptiaca* and *Solanum dasyphyllum* in the Maale and Ari study sites, respectively.

Wild and semi-wild leafy vegetable resources in the study sites were threatened by agricultural land expansion, the decline or natural habitats, limited traditions of planting and nurturing, harvesting for other uses, drought, fuel wood collection, overgrazing and wildfire. Thus, all concerned actors should work towards alleviating or minimizing factors to halt the loss of these valuable resources. There is a need for *in situ* and *ex situ* conservation projects and the preservation of the associated knowledge.

This study revealed that knowledge on wild and semi-wild leafy vegetable species is open to everybody, which helps to secure knowledge continuity and future development and conservation plans. However, the loss of indigenous knowledge on wild and semi-wild leafy vegetables may occur if the resources disappear from the landscape. Thus, documentation of traditional knowledge is important besides working towards minimizing the threatening factors for these species.

Conservation of wild and semi-wild leafy vegetables in natural habitats is crucial. Nevertheless, it is important to focus on home gardens and crop fields for the promotion and cultivation of prioritized leafy vegetables, because of ease of management, ownership, supervision and also due to intensive cultural practices in cultivated land. For immediate action we should focus on those species that have good market value, taste and high above-ground edible biomass, as these are important farmers' criteria. Special attention should also be given to leafy vegetables that are important during food shortage periods of the year. Moreover, it is crucial to work towards developing technologies that increase the productivity of the leafy vegetables considering farmers prioritized criteria.

3

Ethnobotany of wild and semi-wild edible fruit species used by Maale and Ari ethnic communities in Southern Ethiopia

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Abstract

Wild and semi-wild tree fruit species are important resources in combating food insecurity and providing supplementary diet to rural people. We studied wild and semi-wild fruit species used by the Maale and Ari communities in southern Ethiopia and the conservation status of these resources. We used focus group discussions (n=18) and individual interviews (n=144) in three rural kebeles. In total, the two communities used 52 species of wild and semi-wild fruit species which were especially important for their diet in times of food shortage. The most important species were, for the Maale community, *Balanites rotundifolia* (Tiegh.) Blatt. and *Dobera glabra* (Forssk.) Juss. ex Poir. and, for the Ari community, *Carissa spinarum* L. and *Vitex doniana* Sweet. No significant variation in ethnobotanical knowledge regarding fruit species existed among gender and age groups. The main traded fruit species were *B. rotundifolia*, *Ximenia caffra* Sond., and *Vangueria madagascariensis* J.F.Gmel. The major threats reported by informants to the availability of wild and semi-wild fruit species were tree felling and conversion of forest to agricultural land. In addition to preserving the local knowledge and implementing conservation strategies that protect the remaining fruit trees, maintenance and enrichment planting of the most important species are plausible management interventions.

Introduction

Ethiopia is an ecologically diverse country that not only harbours an exceptionally rich botanical diversity (Friis et al., 2005), but is also known for it's extraordinarily agro-biodiversity resulting from varied geography and climate, and ethnic diversity and strong food culture (Edwards, 1991; Kahsay 2004 and Rolien & de Jager 2009). In Ethiopia, a large number of fruit species are used for human consumption and most of them come under the broad category of wild or semi-wild edible plants (Asfaw & Tadesse, 2001). Edible fruit species refer to a subset of this broad category to pinpoint the plants in which the fleshy parts of the fruits (and sometimes seeds) are eaten raw, boiled or roasted. There have been several attempts to define the term "wild" (for e.g., FAO, 1999; Fentahun, 2008). The term 'wild' in this paper, however, refers to indigenous plants that are growing only in natural environments, while 'semi-wild' applies to those plants that are indigenous or introduced and naturalized to the region while nurtured also through encouragement or tolerance by people in their crop fields, home gardens, or borders.

Millions of rural people in developing countries, including Ethiopia, are unable to obtain or produce enough food through currently conventional means. Thus, they often depend on wild and semi-wild fruits to complement and enrich their diet, especially in periods of food shortage (Akinnifesi, 2006; Balemie & Kebebew, 2006; Campbell, 1987; CTA, 2007; Effiong & Udo 2010). These fruit species play a crucial role in combating food insecurity, especially the so-called "hidden hunger" caused by deficiencies of micronutrients, vitamins and minerals (Deshmukh & Waghmod, 2007; Motlhanka & Makhabu 2011). They also serve as a safety net for filling the gaps when cultivated fruits are scarce (CTA, 2007; Valvi & Rathod, 2011).

Wild and semi-wild fruit species are not only consumed directly, but also serve to make beverages (Falconer & Arnold, 1991) or are used for other specific purposes, such as to detoxify poisonous yams (*Dioscorea* spp.) during cooking, like in the case of tamarind pods in Ghana (CTA, 2007). Furthermore, by collecting and marketing them, fruits provide an additional source of income, especially for rural women and children (Effiong & Udo, 2010; Kalaba, 2009). Although in sub-Saharan Africa the benefits of wild and semi-wild fruits are acknowledged by rural communities, their importance remains understudied and undervalued by outsiders (CTA,

2007). Some of these edible fruit resources, however, may also have harmful effects if consumed in large amounts (Samson, 2003). Thus, understanding which wild fruits have adverse health effects will help to design future research on anti-nutritional factors and to devise solutions for possible consequences of long term consumption (Mengistu & Hager, 2009).

Wild and semi-wild fruit resources are not only important as food but may also have several other functions and services (Motlhanka et al., 2008; Tabuti et al., 2004), such as medicinal applications or bee forage, although their relative importance depends on local circumstances. Due to their diverse functions, these resources may be exposed to overexploitation or otherwise threatened, especially in periods of food scarcity. These threatening factors may vary from region to region, depending up on the local socio-economic and ecological circumstances.

Thapa (2005) stressed the important role of women in natural resource utilization and suggested that any study on natural resource utilization should begin with a gender analysis for the purpose of maintaining and improving the resource's management. Moreover, Idowu et al. (2012) highlighted the importance of gender studies for a sound conservation policy analysis and for designing effective development options.

Ethiopia is sometimes called a museum of diverse ethnic communities (Yintiso, 1995), as it is home to about 70 ethnic groups. Although many of these communities regularly consume wild and semi-wild fruits and consider them part of their diet, little research has been undertaken on this valuable resource (Addis, 2009; Balemie & Kebebew, 2006; Mengistu & Hager 2008). A recent review by Lulekal et al. (2011) indicated that only a small number of communities were addressed and most studies poorly dealt with issues surrounding the different gender and age groups (Balemie & Kebebew, 2006). Information on seasonal fruit availability in different parts of the country is largely lacking (Feyissa et al., 2011). To fill part of this knowledge gap, we present evidence on wild and semi-wild fruit consumption by two ethnic groups (Maale and Ari) for whom no previous information exists.

The objectives of this study are to describe and analyse the consumption, preference and marketing of wild and semi-wild edible fruits in the Maale and Ari communities. We expect that wild and semi-wild fruit species play an important role in the local diet and contribute to the

nutrient intake of Maale and Ari people. Our null hypothesis is that all gender and age groups have a similar knowledge and familiarity on wild and semi-wild fruits. If differences exist in traditional knowledge among these groups, this will have an impact on the long-term availability of this food source, which should be addressed separately in any conservation strategy.

To test our hypothesis, we need to answer the following major research questions: 1) which wild and semi-wild edible fruit species are harvested by Maale and Ari communities, in which quantities, and what is their seasonal availability? 2) Are there differences in familiarity, preference and trade of these fruit species among age and gender groups? 3) Which criteria are important to farmers for the possible transition of wild fruits to semi-wild or even cultivated conditions? 4) Which elements affect wild and semi-wild fruit availability and trade?

Materials and Methods

Study area

The study was conducted in two ethnic groups (Maale and Ari) in the Maale and Debub Ari districts of southern Ethiopia, some 750 km from the capital Addis Ababa (Fig. 2.1).

Among the other nine regions and two city administrations in the country, the Southern Nations, Nationalities and Peoples Regional State (SNNPR) comprises the highest number of ethnic groups (ca. 55), among which are the Maale and Ari. The language of the Maale people is called *Malló mucci* (Amha, 2001), while the Ari speak the *Araf* (Kebede, 2009; Yintiso, 1995).

Field work

We used combined reconnaissance surveys, field observations, discussions with individual farmers and focus groups, semi-structured key informant interviews and preference ranking comparisons as described by Martin (1995), Alexiades (1996), and Cotton (1996). In ranking exercises, usually the highest value is given for the most preferred species and the lowest value is given for the least preferred ones. However, as this was difficult for our informants, we modified the procedure and used rank one for the most preferred ones and higher values (six or seven) for less preferred items to enable respondents to express their preference more easily.

Reconnaissance surveys were conducted in July and August 2010 in the two districts. They encompassed transect drives, walks and discussions with administrative officials from the zone, district and kebeles (the lowest formal administrative unit in rural Ethiopia) in the two districts. Field observations were made in the same period during village walks with key informants and local community members. Individual formal and informal discussions were carried out to compile lists of wild and semi-wild fruit species and to understand their general importance. Focus group discussions (n=18) were also carried out. At each study site about 10-12 informants from different socio-demographic groups were involved in the focus group discussions.

Generally, stratified simple random sampling procedure was used in selection of study sites and study participants (Alexiades, 1996). Based on altitude and ethnicity, the study areas were divided into three strata. Finally, three study kebeles (one from each stratum) were randomly selected for a more detailed, formal survey. Two *kebeles* (Metser and Kure) were selected in Debub Ari district, which represent the midland *(*1500-2500 m a.s.l*.)* and lowland (500–1500 m a.s.l.) climatic zones respectively. One *kebele* (Shole Teka) was selected from the Maale district, which is located in the lowland climatic zone. The respective *kebele* offices supplied us with lists of households and household members of the study areas from which males and females were randomly selected. We used two age groups because in both communities an individual above forty was considered matured adult. Similar groupings were used by Mengistu & Hager (2008) in their study in northern Ethiopia.

Voucher specimens were collected for wild and semi-wild fruit species used by the two ethnic communities in the presence of study participants and key informants. Preliminary identification is carried out in the field. Further, specimens were identified using taxonomic keys and Floras (Edwards et al., 1997; Edwards et al., 2000; Edwards et al., 1995; Hedberg & Edwards, 1989; Hedberg et al, 2003; Hedberg et al., 2006) and compared with earlier identified specimens. Finally the specimens are deposited at the National Herbarium (ETH) of Addis Ababa University. Plant names were also checked for accuracy by means of the Plant List (www.theplantlist.org).

Market surveys were carried out from February 2011 up to February 2012 at Beneta market in the Maale area and Jinka market for Debub Ari. Markets were visited every fifteen days. All wild and semi-wild edible fruit species that were sold at these two markets were documented with their price, source and additional trade information.

Data analysis

Data were analysed with the statistical program SPSS 16.0 (SPSS, 2007). Descriptive statistics were used to illustrate averages, percentages and market survey results. Similarities and differences in fruit consumption between sites and ethnic communities were compared by means of the Jaccard similarity index (Höft *et al*., 1999). This index uses positive reply (plant used as edible fruit) and negative reply (plant not used) data sets and is expressed as:

$$JI = \frac{c}{a+b+c},$$

Where JI is the Jaccard similarity index, 'c' is the number of species used by the two sites, 'a' is the number of species used by the ethnic groups in site A only, and 'b' is the number of species by the ethnic groups in site B only (Höft *et al*., 1999).

We used a familiarity index (FI) as a relative indicator of the popularity of the wild and semi-wild fruits within the communities (Tabuti *et al*., 2004), which was computed using:

$$FI = \frac{Frequency\ of\ a\ given\ fruit\ species\ mentioned as\ food}{Total\ number\ of\ respondents}.$$

The total figure of use value (UV) and the cultural importance index is the same, although defined in different ways (Tardio & Pardo-De-Santayana 2008). We considered the use value applied by Albuquerque *et al*. (2006) and Rossato *et al*. (1999), modified from Phillips and

Gentry (1993), to estimate the total cultural significance of each species. Use value was calculated using:

$$UV = \sum Ui / n$$

Species use values (UV) were obtained by adding the number of uses mentioned by each informant for a given species (Ui) and dividing them by the number of informants in the survey (n). The value for each specific use category was also considered and obtained by adding the number of informants mentioning a given species for a specific use and dividing this by the total number of informants (Tardio & Pardo-De-Santayana, 2008).

One-way analysis of variance (ANOVA) was performed to compare responses among different age and gender groups with regard to the familiarity and numbers of wild and semi- wild edible fruit species listed.

Results

Informants

The field study was carried out by multiple trips to the study sites from July 2010- November 2012. We randomly selected a total of 144 individuals (72 males, 72 females) from households in three kebeles. Socio-demographic characteristics of the participants are listed in Table 3.1.

Table 3.1. Site and socio-demographic characteristics of the participants in the formal surveys in Maale (Shole Teka) and Debub Ari (Kure and Metser) study areas

Characteristics	Site characteristics and number of individuals				
Study sites	Shole Teka	Kure	Metser	Total	(%)
District	Maale	Debub Ari	Debub Ari		
Ethnicity	Maale	Ari	Ari		

Vegetation	*Acacia-commiphora and Combretum – Terminanlia* wood land	Moist evergreen Afromontane forest and *Combretum – Terminalia* woodland	Forest converted to agricultural land; scattered trees in fields and home gardens		
Rainfall	Bimodal	Bimodal	Bimodal		
Gender : Male	24	24	24	72	50.0
Female	24	24	24	72	50.0
Age group :					
≤ 40	24	24	24	72	50.0
>40	24	24	24	72	50.0
Educational status					
Illiterate	36	32	20	88	61.1
Read and write	1	2	7	10	6.9
Grade 1-6	9	6	9	24	16.7
Grade 7-8	2	5	5	12	8.3
Grade 9-12	0	3	7	10	6.9

Diversity of wild and semi-wild fruits used

A total of 52 wild and semi-wild fruit-bearing species from 37 genera and 22 families were recorded among Maale and Ari communities (Appendix 3.1). The family Moraceae was most important (8 species), followed by the Rubiaceae (6 spp.), Fabaceae and Malvaceae (4 spp. each) and Anacardiaceae (3 spp.). Ten wild and semi-wild edible fruit species were common to both ethnic communities, while 36 species were used exclusively by the Maale and six species were consumed only by the Ari. The Jaccard's similarity indices for fruit use among the two study sites are given in Table 3.2. The two Ari kebeles (Kure, Metser) were more similar to each other

than to the Maale kebele (Shole Teka), which could be attributed to geographical proximity and shared cultural preferences for fruit species.

Table 3.2. Similarity in wild and semi-wild fruit knowledge among the three study sites in Debub Ari and Maale, Debub Omo Zone, Ethiopia.

Study site (ethnic group)	Jaccard Index (JI) *	
	Shole Teka (Maale)	Kure (Ari)
Kure (Ari)	0.1923	-
Metser (Ari)	0.0588	0.5000

*JI values ranges from 0-1; higher values indicate greater similarity.

In all three study sites, knowledge on wild and semi-wild fruits was primarily acquired or transferred from parents, followed by friends, neighbors, and accidentally encountered individuals (Table 3.3).

Table 3.3. Knowledge transfer means and ranking in Debub Ari and Maale, Debub Omo Zone, Ethiopia.

Transfer means (Source)	Sum of ranking per study site			Mean rank			Mean ranks sum for all study sites	Overall rank
	Shole Teka	Kure	Metser	Shole Teka	Kure	Metser		
Parents	53	48	49	1.1	1.0	1.0	3.1	1
Friends	103	117	130	2.2	2.4	2.7	7.3	2
Neighbors	133	123	112	2.8	2. 6	2.3	7. 7	3
Accidental	191	192	189	4.0	4.00	3.9	12	4

The average numbers of wild and semi-wild fruit species listed by different age and gender groups and the result of the one way ANOVA test are summarized in Table 3.4. The ANOVA results showed no significant difference in knowledge among different age and gender groups as all p-values were greater than 0.05.

Table 3.4. Average number of fruits listed by males and females in study sites in Debub Ari and Maale, Debub Omo Zone, Ethiopia.

	Study sites					
Age	Shole Teka		Kure		Metser	
	Male	Female	Male	Female	Male	Female
> 40	11.67	11.42	4.08	3.50	2.17	2.25
≤ 40	12.75	12.17	3.17	3.42	2.08	2.83
ANOVAs (p-value) for gender & age groups for each site	0.524		0.506		0.635	
ANOVA (p-value) for gender & age groups in all sites	0.991					

The results of familiarity index for preferred species based on taste at each site are also shown in Table 3.5. *Balanites rotundifolia* (Tiegh.) Blatt. , *Vitex doniana* Sweet and *Garcinia livingstonei* T.Anderson were the most familiar species in Shole Teka, Kure and Metser study sites, respectively. Our ANOVA test showed no significant differences in familiarity among the gender and age groups for all sites at $P > 0.05$ ($P = 0.953$ in Shole Teka, $P = 0.895$ in Kure and $P = 0.847$ in Metser).

Table 3.5. Selected wild and semi-wild fruits and their familiarity indices (in % -age) in Shole Teka, Kure and Metser study sites, in Debub Ari and Maale, Debub Omo Zone, Ethiopia. n=48 in each site.

Fruit species	% in each study site											
	Shole Teka				Kure				Metser			
	Male		Female		Male		Female		Male		Female	
Age	>40	≤40	>40	≤40	>40	≤ 40	>40	≤40	>40	≤40	>40	≤40
Balanites rotundifolia (Tiegh.) Blatt.	67	83	92	92								
Diospyros mespiliformis Hochst. ex A.DC.	67	67	58	92								
Uvaria leptocladon Oliv.	42	50	50	75								
Canthium pseudosetiflorum Bridson	50	25	50	58								
Carissa spinarum L.	75	8	50	50					33	25	83	50
Meyna tetraphylla (Schweinf. ex Hiern) Robyns	42	25	42	67								
Flacourtia indica (Burm.f.) Merr.	58	42	25	25								
Vitex doniana Sweet	33	33	42	33	67	100	92	92				
Grewia schweinfurthii Burret	25	42	33	25.0								
Vangueria madagascariensis J.F.Gmel.	0.0	0.0	33	0.0								
Ximenia americana L.					67	42	75	50				
Garcinia livingstonei T.Anderson					75	17	50	58	58	67	83	83
Manilkara butugi Chiov.					67	25	25	50	58	67	83	75
Ficus vasta Forssk.					33	25	25	33				
Ficus sycomorus L. subspecies *sycomorus*					17	17	42	25				
Rubus steudneri Schweinf.					25	17	8.3	17	50	42	50	67
Syzygium guineense (Willd.) DC.					25	25	17	0				
Rubus apetalus Poir.									17	8.3	0.0	8.3

Seasonal fruit availability

Wild and semi-wild fruit species appear to be important food resources in the dry season and at the beginning of the rainy season, when there is a shortage in cultivated food in the study areas. The critical food scarcity starts in February and extends up to April or May. Food is generally in short supply during the dry period and at the beginning of the rainy season, but shortages can also occur throughout the year if there was no crop harvest in the preceding seasons. The most commonly cited fruits harvested during food shortage periods were *B. rotundifolia* and *Dobera glabra* (Forssk.) Juss. ex Poir. in Shole Teka, *Carissa spinarum* L.*, V. doniana, and Ximenia Americana* L. in Kure and *Manilkara butugi* Chiov. and *Garcinia livingstonei* in Metser (Table 3.6).

Table 3.6. Most important fruit species harvested during food shortage periods in Shole Teka, Kure and Metser study sites in Debub Ari and Maale, Debub Omo Zone, Ethiopia. n=48 in each site.

Fruit species	**% citation**		
	Shole Teka (Maale)	Kure (Ari)	Metser (Ari)
Balanites rotundifolia (Tiegh.) Blatt.	35.4		
Dobera glabra (Forssk.) Juss. ex Poir.	20.8		
Diospyros mespiliformis Hochst. ex A.DC.	14.6		
Tamarindus indica L.	8.3		
Vangueria apiculata K.Schum.	6.3		
Uvaria leptocladon Oliv.	6.3		
Ficus vasta Forssk.	6.3	8.3	
Ficus platyphylla Delile	6.3		
Ficus sycomorus L.	4.2	8.3	2.1
Vangueria madagascariensis J.F.Gmel.	4.2		
Carissa spinarum L.		43.8	
Vitex doniana Sweet		37.5	
Ximenia americana L.		33.3	
Mussaenda arcuata Poir.		14.6	
Garcinia livingstonei T.Anderson		14.6	31.3
Manilkara butugi Chiov.		12.5	33.3

Fruit species	% citation		
	Shole Teka (Maale)	Kure (Ari)	Metser (Ari)
Syzygium guineense (Willd.) DC.		8.3	
Rubus steudneri Schweinf.		4.2	12.5
Meyna tetraphylla (Schweinf. ex Hiern) Robyns	2.1		

The seasonal availability of selected fruit-bearing species, especially important during food shortage periods, is indicated in Table 3.7. Wild and semi-wild fruit species are not only important to fill the stomach during different seasons but they also contribute essential nutrients to the local diet. Mengistu and Hager (2009) studied the nutrient contents of *Ziziphus spina-christi* (L.) Desf. and *Diospyros mespiliformis* Hochst. ex A.DC. and showed that these wild species contained higher quantities of important nutrients than cultivated ones. Thus, wild and semi-wild fruits can play an important role in the local nutrient intake, provided their availability is guaranteed.

During group discussions, farmers mentioned several trees that bore fruit even in periods of severe drought: *D. mespiliformis, Tamarindus indica* L.*, B. rotundifolia, Ximenia caffra* Sond.*, Sterculia Africana* (Lour.) Fiori*, Ficus sur* Forssk. (Figure 3.1)*, Grewia schweinfurthii* Burret *and Ficus vasta* Forssk.

Figure 3.1 Fruits of *Ficus sur* Forssk, an important wild fruit resource during drought periods in Debub Omo Zone, Ethiopia.

Table 3.7. Seasonal availability of selected wild and semi wild fruits over the year as reported by informants in Shole Teka, Kure and Metser in Debub Ari and Maale, Debub Omo Zone, Ethiopia. Seasons: Dry season (D), Rainy season (R).

Months of the year	January	February	March	April	May	June	July	August	September	October	November	December
Season	D	R	R	R	D	D	R	R	D	D	D	D
Species												
Balanites rotundifolia (Tiegh.) Blatt.			√	√			√	√				
Carissa spinarum L.						√	√	√	√			
Diospyros mespiliformis Hochst. ex A.DC.	√	√										√
Dobera glabra (Forssk.) Juss. ex Poir.		√	√	√								
F. platyphylla Delile	√	√										√
Ficus sur Forssk.	√	√										√
F. vasta Forssk.	√	√										√
Garcinia livingstonei T.Anderson	√									√	√	√
Manilkara butugi Chiov.			√	√	√							
Mussaenda arcuata Poir.			√	√								
Tamarindus indica L.	√	√				√	√					√
Vitex doniana Sweet	√	√										
Ximenia Americana Sond.				√	√							

"√" in this table represents the availability of the specified fruit species in the corresponding season/month"

Farmers' criteria and preferences for future cultivation of fruits

Participants from both cultures distinguished seven preference criteria for the (future) cultivation of wild fruits. The most important were taste and marketability, followed by fast growth and high yield of the species (Table 3.8).

Table 3.8. Preference criteria for wild and semi-wild species as reported by informants in Shole Teka, Kure and Metser in Debub Ari and Maale, Debub Omo Zone, Ethiopia. Rank value 1 is given for the most preferred and rank value 7 is given for the least preferred criteria. n=48 in each site.

Study sites	Shole Teka (Maale)		Kure (Debub Ari)		Metser (Debub Ari)			Overall
Criteria	Mean rank	Rank	Mean rank	Rank	Mean rank	Rank	Sum of rank	Overall rank
Taste (flavour in the mouth)	1.77	1	2.08	2	1.29	1	4	1
Marketability (income generatio through selling)	2.23	2	1.46	1	2.10	2	5	2
Fast growth and high yield	2.83	3	3.52	3	3.02	3	9	3
Ease of collection	5.04	6	3.83	4	4.83	4	14	4
Low shade effect on undergrowth	4.54	4	5.27	5	5.65	6	15	5
Ease of preparation	4.88	5	5.35	6	5.02	5	16	6
Specific cultural application	6.63	7	6.48	7	6.13	7	21	7

Maale and Ari farmers did not plant wild and semi-wild fruit trees as actively as they did with exotic domesticated fruit species, due to the better price and higher market demand of the latter. In Maale, *B. rotundifolia* was the only species actively grown for its fruit. *Cordia Africana* Lam. (in Maale), *F vasta* and *Ficus sycomorus* L. (in Ari) were also cultivated, but mainly as shade tree in coffee plantations. Spontaneously growing fruit trees or shrubs in farms and home gardens were managed and protected to a certain extent. However, the increased demand for agricultural land made it difficult for farmers to save the remaining wild fruit species. Respondents of all three groups did not suggest enrichment planting of wild fruits in the

remaining forest, but they did protect trees that already grew there as these were highly appreciated. The lack of motivation for enrichment planting was associated with the problem of ownership rights, individual benefit sharing and difficulty of close supervision. The taste preference ranking of fruit species depended on availability of resource and knowledge based on practices. The most preferred species with regard to taste are listed in Table 3.9.

Table 3.9. Pair-wise mean value and rank of wild and semi-wild fruits based on taste in Shole Teka , Kure and Metser in Debub Ari and Maale, Debub Omo Zone, Ethiopia.

Study sites	**Shole Teka (Maale**		**Kure (Debub Ari)**		**Metser (Debub Ari)**	
Species	Mean value	Rank	Mean value	Rank	Mean value	Rank
Balanites rotundifolia (Tiegh.) Blatt.	7.90	1	-	-	-	-
Meyna tetraphylla (Schweinf. ex Hiern) Robyns	5.75	2	-	-	-	-
Diospyros mespiliformis Hochst. ex A.DC.	5.19	3	-	-	-	-
Uvaria leptocladon Oliv.	4.67	4	-	-	-	-
Canthium pseudosetiflorum Bridson	4.21	5	-	-	-	-
Grewia schweinfurthii Burret	3.96	6	-	-	-	-
Vangueria madagascariensis J.F.Gmel.	3.48	8	-	-	-	-
Flacourtia indica (Burm.f.) Merr.	3.21	9	-	-	-	-
Manilkara butugi Chiov.	-	-	8.17	1	6.19	1
Vitex doniana Sweet	3.81	7	6.13	2	-	-
Carissa spinarum L.	2.83	10	5.50	3	2.92	5
Garcinia livingstonei T.Anderson	-	-	4.88	4	4.10	2

Study sites	Shole Teka (Maale		Kure (Debub Ari)		Metser (Debub Ari)	
Species	Mean value	Rank	Mean value	Rank	Mean value	Rank
Rubus steudneri Schweinf.	-	-	4.65	5	3.90	3
Ximenia americana Sond.	-	-	3.77	6	-	-
Ficus vasta Forssk.	-	-	3.40	7	-	-
Syzygium guineense (Willd.) DC.	-	-	2.08	8	-	-
Ficus sycomorus L. subspecies *sycomorus*	-	-	1.52	9	0.27	6
Rubus apetalus Poir.	-	-	-	-	3.85	4

"The maximum value for pair wise ranking depends on the number of plants (n) used in the pair-wise ranking exercise; Higher values shows highest rank"

Wild and semi-wild fruit harvesting and consumption

Harvesting of wild fruits was done either by shaking the plant, loosening the fruits with long sticks or by climbing the tree. Harvesting for household consumption was usually done by all groups of people. Most fruits were consumed raw and fresh (Figure 3.2), but some were cooked with maize and sorghum (*B. rotundifolia* and *D. mespiliformis*), roasted *(S. africana* and *T. indica)* or boiled (*Vangueria apiculata* K.Schum. and *D. glabra)***.** Few species were processed into juice. Table 3.10 lists the farmer's preference of species used to prepare juice.

Figure 3.2 A young Maale girl in Shole Teka (Maale) eating fresh fruits of *Uvaria leptocladon* Oliv.

Table 3.10. Farmer's preference rank order based on the taste of fruit juice in Shole Teka, Maale, "Debub Omo Zone", Ethiopia.

Botanical name	**Mean Rank**	**Rank**
Senna singueana (Delile) Lock	1.3	1
Rhus natalensis Bernh. ex C. Krauss	1.7	2
Rhus ruspolii Engl.	3.3	3
Tamarindus indica L.	3.7	4
Grewia villosa Willd.	5.,1	5
Carissa spinarum. L.	6.1	6
Bridelia micrantha (Hochst.) Baill.	6.8	7

Making juice from wild fruits was not a regular practice by the Ari ethnic group, but they occasionally did this with *X. americana*, *G. livingstonei***,** *C. spinarum* and *M. butugi*. Moreover, the Ari boiled unripe fruits of *Carissa spinarum* to prepare soup during critical periods of the year. In some cases, the Maale also stored *B. rotundifolia* and *D. glabra* seeds for later use in traditional dishes. *Balanites rotundifolia* seeds can be stored for a year under dry conditions.

Long storability was considered as one of the important characteristics of the fruits that were used during food shortage.

Side effects of wild fruit consumption and farmers' control strategies

Knowledge of wild fruit characteristics and farmers' control strategy is crucial, not only for dietary purposes, but also to prevent or treat the side effects of overconsumption. Experiences from Maale and Ari farmers and their remedies are indicated in Table 3.11. Excessive consumption of certain fruit species was mentioned to cause stomach and bowel problems. The use of wood ash as possible remedy should be studied further to understand possible health effects. Moreover, the reported side effects caused by eating meat immediately after consuming certain fruits require also further research attention.

Table 3.11. Fruit with undesirable effects and farmers control strategy in Shoe Teka, Kure and Metser in Debub Ari and Maale, Debub Omo Zone, Ethiopia.

Species	**Undesirable effect**	**Causes**	**Farmers control strategy**
Balanites rotundifolia (Blatt Tiegh.)	Diarrhea, stomach ache	Eating meat after fruit	Avoid eating of meat after fruit consumption
Carissa spinarum L.,			
Flacourtia indica (Burm.f.) Merr.			
Ximenia caffra Sond.			
Cordia Africana Lam.	Diarrhea, stomach ache	Excessive consumption	Drinking lime juice
F. platyphylla Delile	Diarrhea, stomach ache, vomiting	Excessive consumption	Drinking hot coffee
F. sur Forssk			
F. *sycomorus* L.			
F. vallis-choudae Delile			
Ficus vasta Forssk. ,			
Manilkara butugi Chiov.	Aggravate and widen wounds	Eating the fruit or drinking the juice	Avoid drinking if one has wounds
Tamarindus indica L.	Diarrhea, stomach ache, vomiting	Excessive consumption	Drinking ash mixed with water
		Eating meat after fruit	Drinking the decoction of *Rhus natalensis* leaves

Other uses of wild and semi-wild fruits

Several wild and semi-wild fruit species with important cultural meaning are listed in Table 3.12. *Balanites rotundifolia, V. doniana and G.livingstonei* had the highest use value or cultural significance in Shole Teka, Kure and Metser sites respectively.

Table 3.12. Use value (UV) of species in Shole Teka (S), Kure (K) and Metser (M) in Debub Ari and Maale, Debub Omo Zone, Ethiopia.

Species	Study sites	Medicine	Construction	Fencing	Agri. tools	Fuel wood	Fodder	Bee forage	Furniture	Market	Edibility	Sum (UV)
Balanites rotundifolia (Tiegh.) Blatt.	S	1.0	0.3	1.0	0.5	0.9	0.6	0.8	0.1	1.0	1.0	7.2
Meyna tetraphylla (Schweinf. ex Hiern) Robyns	S	1.0	0.2	1.0	0.0	1.0	1.0	0.8	0.0	0.0	1.0	6.0
Diospyros mespiliformis Hochst. ex A.DC.	S	0.0	0.9	0.9	0.9	1.0	0.1	0.6	0.6	0.0	1.0	6.0
Vitex doniana Sweet	S	0.0	0.5	0.5	0.1	1.0	0.2	0.7	0.8	0.2	1.0	5.0
Carissa spinarum L.	S	0.2	0.1	1.0	0.0	0.8	0.8	0.8	0.0	0.0	1.0	4.7
Flacourtia indica (Burm.f.) Merr.	S	0.0	0.1	1.0	0.2	1.0	0.6	0.5	0.1	0.0	1.0	4.5
Grewia schweinfurthii Burret	S	0.0	0.1	0.6	0.0	1.0	0.8	0.8	0.1	0.0	1.0	4.4
Uvaria leptocladon Oliv.	S	0.1	0.3	0.8	0.0	0.7	0.1	0.9	0.1	0.0	1.0	4.0
Vangueria madagascariensis J.F.Gmel.	S	0.0	0.0	0.7	0.0	0.8	0.0	0.7	0.0	0.0	1.0	3.2
Canthium pseudosetiflorum Bridson	S	0.0	0.0	0.3	0.0	0.4	0.7	0.1	0.0	0.0	1.0	2.5
Vitex doniana Sweet	K	0.0	0.2	0.8	0.2	1.0	0.0	0.9	0.8	0.9	1.0	5.8
Syzygium guineense (Willd.) DC	K	0.0	0.1	1.0	0.1	1.0	0.0	0.3	1.0	0.3	1.0	4.8
Manilkara butugi Chiov.	K	0.0	0.6	0.8	0.3	1.0	0.0	0.3	0.4	0.2	1.0	4.6
Ficus vasta Forssk.	K	0.0	0.1	0.8	0.1	1.0	0.2	0.1	0.9	0.0	1.0	4.2
Ficus sycomorus L.	K	0.0	0.0	0.9	0.0	1.0	0.3	0.2	0.6	0.0	1.0	4.0
Garcinia livingstonei T.Anderson	K	0.1	0.2	0.9	0.2	1.0	0.0	0.1	0.0	0.3	1.0	3.8
Carissa spinarum L.	K	0.1	0.0	0.0	0.0	0.9	0.0	0.8	0.0	0.8	1.0	3.6
Ximenia americana L.	K	0.9	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.2	1.0	3.0
Rubus steudneri Schweinf.	K	0.0	0.0	0.2	0.0	1.0	0.1	0.0	0.0	0.4	1.0	2.7
Garcinia livingstonei T.Anderson	M	0.3	1.0	1.0	1.0	1.0	0.0	1.0	1.0	0.9	1.0	8.2
Manilkara butugi Chiov.	M	0.0	0.8	1.0	1.0	1.0	0.0	1.0	0.8	1.0	1.0	7.6
Ficus sycomorus L.	M	0.0	1.0	1.0	0.6	1.0	0.0	0.4	0.9	0.4	1.0	6.3

Species	Study sites	Medicine	Construction	Fencing	Agri. tools	Fuel wood	Fodder	Bee forage	Furniture	Market	Edibility	Sum (UV)
Rubus steudneri Schweinf.	M	0.1	0.0	0.9	0.0	0.9	0.1	0.2	0.0	0.8	1.0	4.0
Rubus apetalus Poir.	M	0.0	0.2	0.8	0.0	0.8	0.0	0.5	0.0	0.2	1.0	3.5
Carissa spinarum L.	M	0.0	0.0	0.5	0.0	0.7	0.1	0.0	0.0	0.0	1.0	2.3

Major threats to wild and semi- wild fruits

According to the Maale and Ari participants, agricultural expansion was the main threat to wild fruit availability (Table 3.13). Population pressure, combined with declining productivity of agricultural land, forced farmers to expand their fields to the remaining patches of forest, resulting in increased deforestation and a decline in wild fruit trees. The recent increased value of land contributed to further expansion to the remaining forested patches. The threats were similar in all study sites, but respondents ranked it differently. In Kure selective harvesting for other uses was ranked as a major threat next to agricultural expansion.

Table 3.13. Major threats to fruit species according to respondents (n = 144) in Shoe Teka, Kure and Metser, Debub Ari and Maale, Debub Omo Zone, Ethiopia. 0 - not mentioned as threat.

Threats	Shole Teka		Kure		Metser	
	Mean	Rank	Mean	Rank	Mean	Rank
Agricultural land expansion	1.7	1	2.8	1	1.5	1
Fuel wood collection	3.3	3	3.0	3	2.7	2
Selective harvesting for construction, farm tools, etc.	4.6	5	2.9	2	4.1	4
No enrichment planting in crop fields and home gardens	2.8	2	4.7	6	2.9	3
Wild fire	5.5	6	3.02	4	5.7	6
Drought/ shortage of rainfall	5.7	7	4.7	5	4.2	5

Threats	Shole Teka		Kure		Metser	
	Mean	Rank	Mean	Rank	Mean	Rank
Grazing pressure	4.6	4	0	0	0	0

Trade in wild and semi-wild fruits

Collecting wild and semi-wild fruit to sell in the market was said to be a common practice by the rural communities during different seasons. Unlike cultivated species, which were sold along road sides, marketing of wild and semi-wild fruits only took place at the main markets. The fruits were mainly harvested from the remaining forest patches, although farmers mentioned they were occasionally harvested from home gardens and crop fields. The main actors in wild and semi-wild fruit market chain were farmers (collectors) and customers (buyers). The market chain was very short; no middlemen were involved. During our survey at Jinka market, we only noticed *Vangueria madagascariensis* J.F.Gmel for sale, but according to consumers, fruits of *M. butugi, Syzygium guineense (*Willd) DC.*, V. doniana and C. spinarum* were also marketed. At Beneta market, we only saw the seeds of *B. rotundifolia* and *X. caffra* being offered for sale.

Prices of wild and semi-wild fruit species were very low compared to cultivated species such as mango (*Mangifera indica* L.*),* avocado *(Persea Americana* Mill.*)* or banana *(Musa acuminata x balbisiana Colla).* Study results showed that on average 1 kg of banana was sold for ca. 4 Birr (0.2 USD), whereas 1 kg of *V. madagascariensis* fruits was sold for ca. 1 Birr (0.05 USD). Traders purchased cultivated fruits either from the farmers' field or bought them at the local market and sold them again. However, we did not encounter any trader that was involved in the marketing of wild and semi-wild fruits in the area during our fieldwork. The major reasons why traders were not buying and selling wild and semi-wild fruits were the lack of supply and low prices. Lack of fruit stalls, short shelf life, and lack of storage facilities were also mentioned by traders as the major constraints in the marketing of cultivated species. Value additions by partial processing or packaging were practices with which our informants were not familiar.

Discussion

The higher consumption of wild and semi-wild fruit species by the Maale can be explained by the presence of higher numbers of fruit trees in the local vegetation and good experiences with their use by the community. Mengistu and Hager (2008) also argued that the various Ethiopian communities may utilize different species, and species importance depends on local practices. Jin et al. (1999) reported similar observations for Yunnan (China). These authors also emphasized that the extent of wild and semi-wild fruit use depended on the level of agricultural productivity and the environment.

No significant variation in the knowledge of wild and semi-wild fruits was found for the different age and gender groups. This indicates an open knowledge transfer in the communities, which is important for knowledge continuity and future participatory development and conservation plans. Our results differed from those reported by Mengistu & Hager (2008), who found that Amhara youngsters were more knowledgeable on edible fruits than elders, because some species that were not considered edible in earlier days were discovered as edible by a younger generation during times of (extreme) food scarcity**.**

The wild and semi-wild fruit species in our study sites were available throughout the seasons, including during food shortages, which indicates that they play a supplementary role during nutrition crises. In this regard, our results are in line with those of Mengistu & Hager (2009) and Pinstrub-Andersen (2009), who emphasized the importance of wild fruits in periods of food shortage to assure a healthy and nutritionally balanced diet. However, when wild fruits are consumed in low amounts, they have little influence on dietary intake and nutritional security, as Termote et al. (2012) recorded for Congo. Just as in Central Africa, the consumption of wild fruits in Ethiopia should be stimulated to increase their role in the balanced diet of rural people while giving due attention to sustainable management of resources. Feyissa et al. (2011) reported that many people in the Boosat and Fantalle districts of east Shewa, Ethiopia survived by partly eating *D. glabra* fruit during severe hunger periods some 50 years ago. The tree requires little rain to bear fruit. *Dobera. glabra* was also listed by the Maale as an important species during food shortage periods.

Just as in South Africa (Shackleton et al., 2010), taste was an important criterion for wild fruit preference. Such preferences, however, may vary from one study site to the other (Mengistu & Hager 2008). Preference criteria set by the communities should be taken into consideration in any research development programm in order to optimize community acceptance or adoption of wild fruit species.

According to our data, the availability of fruits was mainly affected by agricultural land expansion, which is a common phenomenon in different parts of Ethiopia, such as Derashe and Kucha in southern Ethiopia (Balemie & Kebebew 2006). Agricultural expansion affects the resource availability in the rural areas thereby decreasing the volume of fruits harvestable for private consumption and sale.

The low price and inadequate market supply of wild and semi-wild fruit species discouraged traders' from marketing this resource and also hampered the promotion of trade. Thus, it is important to work towards the maintenance or improvement of this resource to increase its supply. Moreover, market opportunities for rural farmers and traders should be improved to increase the current revenues obtained from wild and semi-wild fruit species.

Conclusions

Rural Ethiopian communities such as the Maale and Ari consume a wide variety of wild and semi-wild fruit species. Their availability during food shortage periods makes them important dietary supplements in rural areas. Moreover, the consumption of species with a relatively high level of essential nutrients showed their role in food security. Both communities have a broad knowledge on wild and semi-wild edible fruit species, which offers opportunities for future conservation of plant resources, as it will be relatively easy to implement conservation strategies compared to ethnic groups with limited knowledge. No significant variation on wild and semi-wild edible fruits knowledge was found between gender and age groups.

Agricultural expansion was mentioned as the major threat for the survival of wild fruit species. Beside alternative conservation strategies (*in-* and *ex-situ*) to protect the remaining forests, cultivation aims at gradual domestication, hence maintenance and enrichment planting of the

most preferred species such as *Balanites rotundifolia, Vitex doniana* and *Garcinia livingstonei* is recommended. The focus should be on enrichment planting in home gardens and nearby crop fields because these are easily supervised and do not involve ownership disputes. Moreover, it is important to take away the pressure from the natural forest.

Species with a high market value, good taste, fast growth and high yield should be considered for promotion, but species that bear fruit during food shortage periods should not be overlooked. Consideration of local farmers' preferences is crucial for development programs. Low prices, poor market and outlet opportunities hamper the trade in wild fruits. Creating demand and facilitating better market outlets will encourage communities to cultivate wild and semi-wild fruit species. For example, for fruits that are harvested in bulk, value addition by making jams, jellies or canned juice, as is done with *Opuntia ficus-indica* (L.) Mill. in northern Ethiopia, could be an option.

Appendix 3.1. Wild and semi-wild tree fruit species in Shole Teka, Kure and, Metser kebeles in Debub Omo Zone, Ethiopia. Local language: *Mallo mucci* (M), *Araf* (A).

Plant names			**Study sites**		
Scientific name		**Local names**	**Shole Teka**	**Kure**	**Metser**
Anacardiaceae	*Rhus natalensis* Bernh. ex C. Krauss	kubri (M)	Yes	no	no
	Rhus ruspolii Engl.	shawshini (M)	Yes	no	no
	Sclerocarya birrea (A.Rich.) Hochst.	tunkelo (M)	Yes	no	no
Annonaceae	*Annona senegalensis* Pers.	dangarasho (M)	Yes	no	no
	Uvaria leptocladon Oliv.	muralatse (M)	Yes	no	no
Apocynaceae	*Carissa spinarum* L.	ambelto (M), almi (A)	Yes	yes	yes

Plant names			Study sites		
Scientific name		Local names	Shole Teka	Kure	Metser
	Saba comorensis (Bojer. ex A.DC.) Pichon	kalikedo (M)	Yes	no	no
Arecaceae	Phoenix reclinata Jacq.	zembaba (A)	No	yes	yes
Boraginaceae	*Cordia africana* Lam.	galmi (M)	yes	no	no
	Cordia sinensis Lam.	shengolochi (M)	yes	no	no
Clusiaceae	*Garcinia livingstonei* T.Anderson	chedi (A)	no	yes	yes
Ebenaceae	*Diospyros mespiliformis* Hochst. ex A.DC.	goroki (M)	yes	no	no
	Euclea divinorum Hiern	ounsi (M)	yes	no	no
Fabaceae	*Bauhinia thonningii* Schumach.	dawrake (M), lol (A)	yes	yes	no
	Senna singueana (Delile) Lock	karahaleko (M)	yes	no	no
	Tamarindus indica L.	rokee (M)	yes	no	no
	Tylosema fassoglensis (Schweinf.) Torre & Hillc.	dankilo (M)	yes	no	no
Lamiaceae	*Hoslundia opposita* Vahl	lisho (M)	yes	no	no
	Vitex doniana Sweet	woro goroki (M), gorka (A)	yes	yes	no
Loganiaceae	*Strychnos innocua* Delile	jalijecho (M)	yes	no	no
Malvaceae	*Grewia damine* Gaertn.	beriaa (M)	yes	no	no
	Grewia schweinfurthii Burret	damage (M)	yes	no	no
	Grewia villosa Willd.	bonkako (M)	yes	no	no
	Sterculia africana (Lour.) Fiori	kautsee (M)	yes	no	no
Moraceae	*Ficus glumosa* Delile	kunstee (M)	yes	no	no

Plant names			Study sites		
Scientific name		Local names	Shole Teka	Kure	Metser
	Ficus ingens (Miq.) Miq.	laze (M)	yes	no	no
	Ficus platyphylla Delile	titee (M)	yes	no	no
	Ficus sur Forssk.	semo (M), sema (A)	yes	yes	yes
	Ficus sycomorus L.	bobi (M), shafa (A)	yes	yes	yes
	Ficus sycomorus subspecies gnaphalocarpa (Miq.) C.C. Berg	dawitchi (M), tomiri (A)	yes	yes	no
	Ficus vallis-choudae Delile	obori (M)	yes	no	no
	Ficus vasta Forssk.	shabi (M), wompa (A)	yes	yes	no
Myrtaceae	*Syzygium guineense* (Willd.) DC.	ochi (M), shiringi (A)	yes	yes	no
Olacaceae	*Ximenia americana* L.	mukla (A)	no	yes	no
	Ximenia caffra Sond.	muklee (M)	yes	no	no
Phyllanthaceae	*Bridelia micrantha* (Hochst.) Baill.	aericho (M)	yes	no	no
Rhamnaceae	*Ziziphus spina-christi* (L.) Desf.	gaudi (M)	yes	no	no
Rosaceae	*Rubus steudneri* Schweinf.	Sak " a" (A)	no	yes	yes
	Rubus apetalus Poir.	Sak " b" (A)	no	yes	yes
Rubiaceae	*Bullockia pseudosetiflorum* Bridson	Meddale (M)	yes	no	no
	Meyna tetraphylla (Schweinf. ex Hiern) Robyns	Onaki	yes	no	no
	Vangueria apiculata K.Schum.	garo (M)	yes	no	no
	Vangueria madagascariensis J.F.Gmel.	surangaro (M), gara (A)	yes	yes	no
	Mussaenda arcuata Poir.	murtsetse (M), Sertsegela (A)	yes	yes	no
	Psydrax schimperiana (A.Rich.)	gali (M)	yes	no	no

Plant names			Study sites		
Scientific name		Local names	Shole Teka	Kure	Metser
	Bridson				
Salicaceae	*Flacourtia indica* (Burm.f.) Merr.	gurchinchi (M)	yes	no	no
	Oncoba spinosa Forssk.	sewewbulko (M)	yes	no	no
Salvadoraceae	*Dobera glabra* (Forssk.) Juss. ex Poir.	bekee (M)	yes	no	no
Sapotaceae	*Manilkara butugi* Chiov.	koshimi (A)	no	yes	yes
	Mimusops kummel Bruce ex A. DC.	gosho (M)	yes	no	no
Zygophyllaceae	*Balanites aegyptiaca* (L.) Delile	donkey (M)	yes	no	no
	Balanites rotundifolia (Tiegh.) Blatt.	kuze (M)	yes	no	no

"Yes" indicates the specified species is listed in the study site; " No" indicates not listed

4

Use and management of traditional medicinal plants by Maale and Ari ethnic communities in southern Ethiopia

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Abstract

Around 80% of the people of Ethiopia are estimated to be relying on medicinal plants for the treatment of different types of human health problems. The purpose of this study was to describe and analyse the use and management of medicinal plants used for the treatment of human health problems by the Maale and Ari communities in southern Ethiopia.

Quantitative and qualitative ethnobotanical field inquiries and analytical methods including individual and focus group discussions (18), observations, individual interviews (n = 74), preference ranking and paired comparison were used. Data were collected in three study sites and from two markets; the latter surveyed every 15 days from February 2011 to February 2012.

A total of 128 medicinal plant species, belonging to 111 genera and 49 families, used as herbal medicine by Maale and Ari communities were documented. Predominantly harvested plant parts were leaves, which are known to have relatively low impact on medicinal plant resources. Species with high familiarity indices included *Solanum dasyphyllum, Indigofera spicata, Ruta chalepensis, Plumbago zeylanica* and *Meyna tetraphylla*. Low Jaccards similarity indices (≤ 0.33) indicated little correspondence in medicinal plant use among sites and between ethnic communities. The dominant ways of medicinal plant knowledge acquisition and transfer is vertical: from parents to children through oral means. Gender and site significantly influenced the number of human medicinal plants known currently in the study sites. Age was only a factor of significance in Maale. Marketing of medicinal plants harvested from wild and semi-wild stands is not common. Expansion of agricultural land and lack of cultivation efforts by local communities are mentioned by locals to affect the availability of medicinal plant resources.

S. dasyphyllum, I. spicata, P. zeylanica, M. tetraphylla, and *Oxalis radicosa* need to be considered for phytochemical and pharmacological testing to verify their efficacy and determine their dosages. Land use planning and development initiatives in the area and beyond need to sharply focus on strategies that could alleviate the major threats affecting medicinal plant resources in the landscape and encourage their cultivation to enhance their availability and complement ex-and in-situ conservation.

Background

Ethiopia is a country with regional differences in access to health services (Chaya, 2007). It is estimated that traditional medicine (about 95% herbal) is used by 80% of the Ethiopian population for the treatment of different types of human health problems (IBC, 2005). Medicinal plants are used as a major source for health promotion, prevention and cure (Flatie et.al., 2009; Gedif and Hahn, 2003). The traditional use of medicinal plants by most Ethiopians in health care system is generally ascribed to the incomplete coverage of the modern medical system, unaffordable and not always available prescription drugs (Yirga and Zeraburk, 2011; Joy et.al., 2001; Bekele, 2007) and the widespread belief in the effectiveness of herbal medicine (Fasil, 2003; Fasil, 2005). Medicinal plant knowledge is also shaped by the ecological diversity of the country (Giday, 2007), known to be site-specific (Awas, 2007) and also varies across peoples with different religious, linguistic and cultural backgrounds (Bekele, 2007). In Ethiopia, there are over 70 ethnic groups, residing in different ecological regions (Regassa, 2004) and the studies so far have shown extensive medicinal plant knowledge, acquired through centuries of experience. Although several studies have been conducted on medicinal plants throughout the country e.g. (Hunde et al., 2006; Teklehaymanot and Giday, 2007; Yinger et al., 2008; Giday et al., 2008; Teklehaymanot, 2009; Ashagre, 2011), the full wealth of this knowledge has not yet been sufficiently studied. We therefore document medicinal plants used by less studied the Maale and Ari ethnic groups and evaluate similarities and differences among sites and between the two communities.

Ethiopian farmers' knowledge on medicinal plants may be influenced by certain demographic characteristics. Awas (2007) and Giday et al. (2009) have also shown that gender and age significantly affected farmers' knowledge on traditional medicine. However, in other farming communities, Dalle et. al. (2005) found that gender and age had no significant effect on useful plant knowledge. In order to effectively preserve indigenous knowledge, we also need to find out whether socio- demographic factors (age, gender, religion, educational level, family size) or locality affect the level of medicinal plant knowledge among the Maale and Ari communities.

Traditionally used medicinal plants and associated knowledge are disappearing at an alarming rate (Yirga, 2010). Natural and anthropogenic factors contribute to these losses but threatening factors may

vary from one region to the other (Teklehaymanot, 2009). Therefore, we also want to understand factors that threaten local traditional medicinal plant resources and knowledge, which are important for decision makers for their policy formulation and analysis. Mechanisms of medicinal plant knowledge acquisition and transfer affect knowledge continuity within a community. Most studies conducted in Ethiopia so far have shown that the major mechanism for transfer of ethnomedicinal knowledge is oral (Yirga, 2010), although Fassil (2003) indicated existence of pharmacopias (ancient written medicinal plant knowledge) in monasteries in the northern highlands of Ethiopia. In order to preserve herbal medicine traditions, we need to reveal the local mechanisms of knowledge transfer.

Marketing of medicinal plants may have implications on natural resources, depending on the species marketed, the type of plant part harvested, volumes sold and cultivation efforts of commercial species. A few of the ethnobotanical studies in Ethiopia attempted to highlight the issue of marketing of medicinal plants (Tolasa, 2007; Giday et al., 2009). However, the studies were of cross-sectional nature and did not conduct systematic repeated visits and data collection, and also elements that affect marketing of traditional medicinal plants were hardly addressed. In this paper, we describe and analyze the use and management of medicinal plants by Maale and Ari communities by answering the following research questions:

1) Which plant species are used as medicines at different sites by the two communities ps and for what purposes?
2) What are the mechanisms of herbal medicinal plant knowledge transfer among different social groups?
3) Which demographic factors significantly influence medicinal plant knowledge?
4) How do the two communities differ in their use and handling of medicinal plants?
5) What factors threaten medicinal plant resources in the study area?
6) Which medicinal plants are commercialized and what elements affect their marketing?

Materials and methods

Study area and selection of informants

The study was conducted in the Maale and Debub Ari districts of southern Ethiopia, where the Maale and Ari communities reside. The study area is located at about 750 km south of the Ethiopian capital, Addis Ababa.

A reconnaissance survey was conducted from July to August 2010 in the two study districts. Well settled areas by the two ethnic groups within the two districts were studied. Detailed fieldwork was conducted from August 2010 to October 2012. Prior to detailed data collection, individual and focus group discussions (18) with informants were conducted. At each kebele (the lowest formal administrative unit in rural Ethiopia), 10 to 12 informants from different socio-demographic groups were involved in the focus group discussions. In general we used stratified simple random sampling for the selection of the study sites, study kebeles and study participants. The stratifying variables were ethnic communities and altitude. The three study sites selected for detailed formal survey were Maale, Ari 1 and Ari 2 (Figure 4.1). For each site, two kebeles (Shole teka and Beneta in Maale, Kure and Geza in Ari 1 and Pilla and Metser in Ari 2) were randomly selected (Figure 4.1). The Ari 1 and Maale study kebeles were selected from the area with altitude of 500-1500 m.a.s.l. However, the Ari 2 study site is located within altitude ranging from 1500-2500 with mean altitude of 1700 m. Despite the presence of areas with altitude ranging from 1500-2500 in Maale district, the area was not included in the study because there are no substantial settlements.

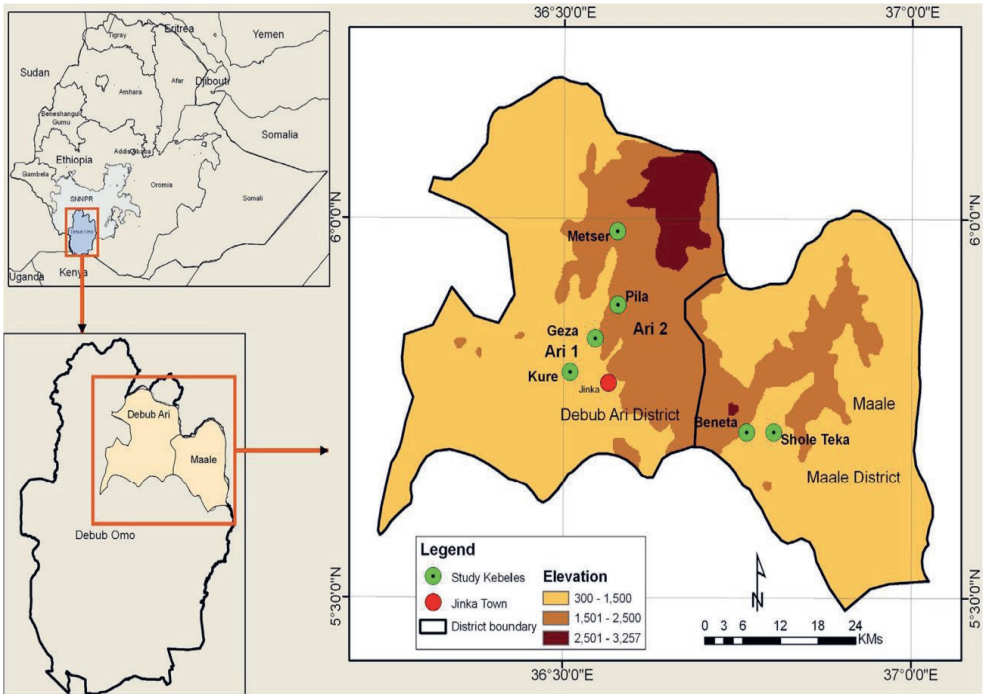

Figure 4.1. Location map of the study area in southern Ethiopia.

Acacia - *Commiphora* and *Combretum* – *Terminalia* woodland is characterized the remnant vegetation of Maale study site; the mean altitude of the selected study site is 1350 m.a.s.l. The remnant vegetation of Ari 1 is characterized by moist evergreen Afromontane forest and *Combretum* – *Terminalia* woodland (Friis et.al., 2010) with a mean altitude of 1330 m.a.s.l. The forest area is converted to agricultural land, with scattered trees in the fields and home gardens of Ari 2. The language of Ari is *Araf*, while the language of Maale is *Mallo´ mucci*. The 2007 population census shows that there were 84657 in Maale and 212 389 in Debub Ari (CSA, 2008).

A total of 74 study participants (24 from Ari 1, 24 from Ari 2 and 26 from Maale), belonging to the two ethnic groups were considered for the interviews. The age range of randomly selected study participants lied between 20 and 60 except a single participant who was older: 70 years. Oral informed consent was obtained from each participant prior to conducting the interviews.

Ethical approval

Written permission (approval) was obtained from South Omo "zonal" council and also from the Maale and Debub Ari district council offices before the start of the study.

Consent

Oral and also signed informed consents were obtained from the study participants for the publication of this report and any accompanying images.

Data collection

We used semi-structured interviews, field observations, preference ranking and paired comparison following the standard ethnobotanical methods and procedures as given by various authors (Martin, 1995; Alexiades, 1996; Cotton, 1996) to collect information on various aspects of medicinal plants in the two districts. The semi-structured interviews contained questions on common health issues, medicinal plants, plant parts used, preparation and application methods, dosage, and possible threats to medicinal plant resources. Moreover, study participants were asked how they acquired medicinal plant knowledge and whether they were willing to transfer this knowledge. Each informant was visited at least two times during the study period in order to validate the information provided. Following the recommended procedures by Alexiades (1996), responses of the study participants that contradicted with each other were not considered for analysis.

Voucher specimens of medicinal plants were collected with the assistance of key informants following standard botanical procedures. Preliminary plant identification was done in the field while collecting and further identification and confirmation was done at the National Herbarium (ETH) of Addis Ababa University (AAU) using taxonomic keys provided in the relevant volumes of the Flora of Ethiopia and Eritrea (Edwards et.al., 1995; Edwards et.al., 1997; Edwards et.al., 2000; Hedberg and Edwards, 1989; Hedberg et.al., 2003; Hedberg et.al., 2004; Hedberg et.al., 2006). Finally, the identified specimens were deposited at the National Herbarium of AAU. Scientific names were checked for accuracy by means of the Plant List (2013, accessed date). Between February 2011 and February 2012, surveys were carried out at Beneta market (Maale area) and Jinka market (Debub Ari). Markets were visited every fifteen

days and all medicinal plants sold were documented with their price, source and additional trade information.

Data analysis

Descriptive statistics were used to calculate average numbers of medicinal plants and illness types listed by the study participants, and to quantify acquisition and transfer of traditional knowledge. In Maale, ten key informants were selected to participate in a preference ranking exercise following Martin (1995) for eight plants used to treat the most frequently cited health problem (in this case ascariasis). Key informants ranked plant species according to their perceived efficacy: the most effective being given a value of one, and the least effective a value of eight. Priority ranking was used to classify major issues that affected the availability of medicinal plants in the study sites.

The calculated Jaccard's similarity indices (Höft et.al., 1999) were used to compare similarity of medicinal plant knowledge among the studied ethnic groups. This index uses plant presence/ positive reply or absence/negative reply data sets and is expressed as:

$$JI = \frac{c}{a+b+c},$$

Where JI is the Jaccard similarity index, 'c' is the number of species shared by the study sites, 'a' is the number of species in study site A only and 'b' is the number of species in study site B only. The JI values range between 0 and 1, whereby a value of 1 indicates complete similarity.

Familiarity index (FI) was used as an indicator of the popularity of a species (Tabuti et. al., 2004). FI was defined as the number of respondents that mentioned a species for a specific use, divided by the total number of respondents. The value of FI varies between 0 and 1, whereby a value of 1 represents the highest familiarity of a medicinal plant in the study site.

$$FI = \frac{Frequency\ of\ a\ given\ medicinal\ plant\ species\ mentioned as medicine}{Total\ number\ of\ respondents}.$$

Multiple regression analysis was employed to reveal demographic factors that predicted traditional knowledge (Pallant, 2007). We used the number of plants known as dependent variable and considered age, gender, religion, education level, family size and geographic location as explanatory variables. Variables that were highly correlated ($r \geq 0.9$) were not included in the model (Pallant, 2007). Independent t-tests were employed to compare the differences between gender and age groups. All statistical methods were carried out in the program SPSS 20.0.

Results and discussion

Medicinal plants reported

A total of 128 medicinal plant species, belonging to 111 genera and 49 families were reported by Maale and Ari ethnic groups for the treatment of 48 different types of health problems (see Table 4.1). The family Lamiaceae was represented by the highest number of species (19) followed by Leguminosae (10 species), Acanthaceae, Solanaceae, Cucurbitaceae, and Malvaceae (each 8 spp.) and Rubiaceae and Compositae (6 spp. each). The highest number (92 spp.) was reported in Maale, while 54 species were jointly documented in Ari 1 and Ari 2, of which 18 species were shared. Medicinal plants were used as the first line of treatment by 96%, 83%, and 88% of the respondents of Maale1, Ari 1 and Ari 2 respectively. This indicates that traditional medicine plays a significant role in the primary health care system of the Maale and Ari ethnic groups.

Table 4.1. Medicinal plants used in Maale and Ari with plant parts used, growth form and applications.

Nº	Vernacular names: Maale (M), Ari (A)	Ailments	Scientific name	Family Name	Voucher Nº	Parts used	Growth form	Application route	Study sites
1	Tsinkaso (M)	Eye disease (infection), Headache	*Barleria ventricosa* Hochst. ex Nees	Acanthaceae	210 , 356	Leaves	Herb	Topical	M
2	Moro Golodo (M)	Gastritis	*Blepharis maderaspatensis* (L.) Roth.	Acanthaceae	234, 637	Whole	Herb	Oral	M
3	Golodo (M)	Oral trash, Gastritis, Malnutrition	*Justicia bizunehiae* Ensermu	Acanthaceae	357	Leaves	Herb	Oral	M
4	Busino (M)	Amoebiasis, Stomach ache, Diarrhea	*Hypoestes forsskaolii (*Vahl) R. Br.	Acanthaceae	30	Root	Herb	Oral	M
5	Kati Murso (M)	Constipation, Ascariasis	*Thunbergia alata* Boj. ex Sims	Acanthaceae	232,366, 391	Whole	Climber	Oral	M
6	Majimaylo (M)	Tape worm	*Celosia trigyna* L.	Amaranthaceae	679	Leaves	Herb	Oral	M
7	Tsami shinkurt (A)	Stomach ache	*Allium sativum* L.	Amaryllidaceae	-	Bulb	Herb	Oral	A1, A2
8	Salvano (M)	Ascariasis	*Ozoroa insignis* Delile	Anacardiaceae	177, 224 289 ,302	Stem bark	Tree	Oral	M
9	Kubri (M)	Diarrhea, Toothache, Food poisoning, Vomiting	*Rhus natalensis* Krauss	Anacardiaceae	28	Leaves	Shrub	Oral	M
10	Muralatse (M)	Food poisoning, vomiting	*Uvaria leptocladon* Oliv.	Annonaceae	24	Leaves	Shrub	Oral	M
11	Afi Deshe (A)	Evil eye	*Agrocharis melanantha* Hochst.	Apiaceae	309	Leaves	Herb		A 2
12	Etsewayo (M), Ountinkam (A)	Gastritis, Headache, Evil eye	*Centella asiatica (*L.) Urban	Apiaceae	36,128	whole	Herb	Oral	M, A1, A2
		Swelling	*Centella asiatica* (L.) Urban			Whole	Herb	Topical	
13	Ambelto (M), Almi (A)	Tonsilites	*Carissa spinarum* L.	Apocynaceae	33,119	Leaves	Tree	Oral	M, A1
		Snake protection	*Carissa spinarum* L.			Root	Tree	Smoke	
		Stomach ache	*Carissa spinarum* L.			Root	Tree	Oral	
		Evil eye	*Carissa spinarum* L.			Root	Tree	Inhale	

Nº	Vernacular names: Maale (M), Ari (A)	Ailments	Scientific name	Family Name	Voucher Nº	Parts used	Growth form	Application route	Study sites
14	Pijie (M)	Ascariasis	*Pergularia daemia (*Forssk.) Chiov.	Apocynaceae	304	Root	Climber	Oral	M
		Malnutrition (Child)	*Pergularia daemia* (Forssk.) Chiov.			Leaves		Oral	M
15	Metse (M)	Retained placenta	*Leptadenia hastata* (Pel's.) Decne.	Apocynaceae	101	Leaves	Shrub	Oral	M
		Liver disease(Ara)	*Leptadenia hastata* (Pel's.) Decne.			Leaves		Inhale	
16	Zolpe (M)	Liver disease (Ara)	*Stereospermum kunthianum* Cham.	Bignoniaceae	282,402	Leaves	Tree	Inhale	M
17	Achenti (A)	Stomach ache	*Cynoglossum lanceolatum* Forssk.	Boraginaceae	2	Root	Herb	Oral	A2
18	Kolpo (M)	Common cold	*Brassica carinata* A. Braun	Brassicaceae	-	Leaves	Herb	Oral	M
19	Feto	Common cold	*Lepidium sativum* L.	Brassicaceae	-	Seed	Herb	Oral	A2
20	Afi Deshe (A)	Evil eye	*Monopsis stellarioides (*Presl) Urb.	Campanulaceae	246	Leaves	Herb	Oral	A2
	Guni deshe (A)	Snake bite	*Monopsis stellarioides* (Presl) Urb.						
21	Chedi (A)	Oral trash	*Garcinia livingstonei* T.Anders.	Clusiaceae	14	Fruit	Tree	Topical	A2
22	Yemdir Berbere (A)	Tooth ache, Tonsillitis	*Acmella caulirhiza* Delile	Compositae	89,313	Flower	Herb	Topical	A1
23	Dunko (M), Duno (A)	Stomach ache	*Artemisia absinthium* L.	Compositae	-	Leaves with stem	Herb	Oral	M, A1
		Evil eye, Sudden disease, Headache	*Artemisia absinthium* L.			Leaves with stem		Oral/ Inhale	
24	Hachenti (M)	Diarrhea	*Bidens pilosa* L.	Compositae	233	Root	Herb	Oral	M
25	Azi deshe (A)	Swelling(eti)	*Conyza gouanii* (L.) Willd.	Compositae	311	Leaves	Herb	Topical	A2
26	Rebasho (M) Haro mato (M)	Rheumatism	*Tagetes minuta* L.	Compositae	203	Leaves	Herb	Topical	M
		Amoebiasis	*Tagetes minuta* L.			Leaves	Herb	Oral	
27	Gera (A)	Malaria	*Vernonia amygdalina* Delile	Compositae	-	leaves	shrub	Oral	M, A1

Nº	Vernacular names: Maale (M), Ari (A)	Ailments	Scientific name	Family Name	Voucher Nº	Parts used	Growth form	Application route	Study sites
28	Kwakuch deshe (A)	Skin disease (‘Kwakucha)	*Cuscuta campestris* Yuncker	Convolvulaceae	259	Leaves with succulent stem	Herb	Topical	A1
29	Lago (M)	Malnutrition (Child) Diarrhea, heart disease, Gastritis	*Ipomoea obscura* (L.) Ker-Gawl.	Convolvulaceae	211	Leaves	Herb/climber type	Oral	M
30	Welanke (M)	Liver disease	*Ipomoea spathulata* Hall.f.	Convolvulaceae	173,404	Leaves	Herb	Inhale	M
31	Kamakarsho (M)	Ascariasis	*Combretum aculeatum* Vent.	Combretaceae	287,504	Leaves	Shrub	Oral	M
32	Gaal (M)	Typoid	*Terminalia brownii* L.	Combretaceae		Leaves	Tree	Oral	M
		Snake bite	*Terminalia brownii* L.			Bark		Oral/ Topical	
33	Hachirindo (M)	Lower extremity weakness	*Cucumis dipsaceus* Ehrenb. ex Spach	Cucurbitaceae	15	Leaves	Herb	Topical	M
		Amoebiasis	*Cucumis dipsaceus* Ehrenb. ex Spach			Whole		Oral	
34	Botayilashe (M), Bota (A)	Tape worm	*Cucurbita pepo* L.	Cucurbitaceae	-	Seed	Herb	Oral	M, A1
35	Shuntee (M)	Mouth wound	*Kedrostis foetidissima* (Jacq.) Cogn	Cucurbitaceae	84	Leaves	Herb	Topical	M
36	Choko (M)	Amoebiasis	*Momordica foetida* Schumach.	Cucurbitaceae	204, 242	Whole	Herb	Oral	M
37	Najie (M)	Evil eye	*Momordica pterocarpa* Hochst. ex A. Rich.	Cucurbitaceae	20	Leaves	Climber	Topical	M
		Amoebiasis	*Momordica pterocarpa* Hochst. ex A. Rich.			Leaves	Climber	Oral	
38	Ounsi (M)	Stomach ache	*Euclea divinorum* Hiern	Ebenaceae	26	Root	Shrub	Oral	M
39	Sauto zao (M)	Stomach bloating, food poisoning, Vomiting	*Acalypha fruticosa* Forssk.	Euphorbiaceae	98	Leaves	Shrub	Oral	M
		Stomach ache	*Acalypha fruticosa* Forssk.			Stem		Oral	M
40	Sauti (M)	Eye injury	*Acalypha volkensii Pax*	Euphorbiaceae	223	Leaves	Herb	Topical	M
41	No local name	Eye disease (Cataract)	*Euphorbia hirta L.*	Euphorbiaceae	496	Latex	Herb	Topical	M

Nº	Vernacular names: Maale (M), Ari (A)	Ailments	Scientific name	Family Name	Voucher Nº	Parts used	Growth form	Application route	Study sites
42	Tsedo (M)	Rabies	*Euphorbia tirucalli* L.	Euphorbiaceae	285	Root	Shrub	Oral	M
43	Tsamo desho (M)	Wound	*Ricinus communis* L.	Euphorbiaceae	350	Seed	Shrub	Topical	M,A2
44	Beto (M) Beta (A)	Gonorrhea ,Tape worm	*Croton macrostachyus* Hochst. ex Ferret & Galinier	Euphorbiaceae	-	Leaf bud	Tree	Oral	M, A1, A2
45	Gaina deshe/Azi deshe (A)	Stomach bloating	*Geranium arabicum* Forssk.	Geraniaceae	312,445	Leaves	Herb	Oral	A2
		Swelling	*Geranium arabicum* Forssk.			Leaves	Herb	Topical	
46	Bato ketero deshe (M)	Amoebiasis	*Pelargonium quinquelobatum* Hochst. ex A.Rich.,	Geraniaceae	227	Whole	Herb	Oral	M
47	Afi Deshe (A)	Evil eye	*Hypericum peplidifolium* A.Rich.	Hypericaceae	263	Leaves	Herb	Oral	A1, A2
48	Harsi deshe/ Gaina deshe/Shai Shar (A)	Diarrhea	*Ajuga leucantha* Lukhoba	Lamiaceae	274, 278, 441	Leaves	Herb	Oral	A1, A2
49	Baye Apo Desho (M)	Stomach ache, Heart , Rheumatism	*Becium filamentosum* (Forssk.) Chiov.	Lamiaceae	196,221,324	Whole	Herb	Oral	M
50	Bokolo (M), Dumfeken (A)	Stomach bloating, vomiting	*Clerodendrum myricoides* (Hochst.) Vatke	Lamiaceae	195,346	Leaves	Shrub	Oral	M, A1, A2
		Evil eye	Clerodendrum myricoides *(Hochst.) Vatke*	Lamiaceae	38	Root	Shrub	Oral ,Inhale	
51	Apo Desho (M)	Evil eye	*Endostemon tereticaulis* (Poir.) M.Ashby	Lamiaceae	99,165	Whole	Herb	Topical	M
52	Tsamo desho (M)	Cold	*Fuerstia africana* T.C.E. Fr.	Lamiaceae	230	Leaves	Herb	Topical	M
53	Pelo Tsala (M)	Stomach ache, Amoebiasis, Stomach bloating, Head ache, Food poisoning, Vomiting	*Leucas abyssinica* (Benth.) Briq.	Lamiaceae	167,321	Leaves	Shrub	Oral	M
		Rheumantism	*Leucas abyssinica* (Benth.) Briq.			Leaves		Topical	
54	Chergicola	Pus from Ear, nose, mouth; Eye disease (cataract), Rheumatism	*Leucas glabarata (*Vahl) Sm. in Rees	Lamiaceae	237, 281, 320, 365	Leaves	Herb	Topical	M

Nº	Vernacular names: Maale (M), Ari (A)	Ailments	Scientific name	Family Name	Voucher Nº	Parts used	Growth form	Application route	Study sites
		Headache				Leaves		Oral/ inhale	
55	Azi deshe	Swelling	*Leucas martinicensis* (Jacq.) R.Br.	Lamiaceae	315	Leaves	Herb	Topical	A2
56	Lamo (M)	Stomach ache	*Ocimum basilicum* L.	Lamiaceae	222 ,317	Leaves	Herb	Oral	M
57	Gurdarindo (M)	Headache, Diarrhea Stomach bloating, Stomach ache, Vomiting	*Ocimum forskolei* Benth.	Lamiaceae	214 , 235	Whole	Herb	Oral	M
58	Pasi kedo	Heart disease	*Ocimum lamiifolium* Hochst. ex Benth.	Lamiaceae	225,37	Leaves	Herb	Oral	M,
	Demakesse	Headache	*Ocimum lamiifolium* Hochst. ex Benth.		134	Leaves		Oral/ Inhale	A1, A2
59	Kuliti kup (M)	Herpes simplex (“Mich”)	*Ocimum urticifolium* Roth	Lamiaceae	133	Leaves	Shrub	Topical	A1, A2
		Stomach ache, Vomiting	*Ocimum urticifolium* Roth					Oral	
		Headache	*Ocimum urticifolium* Roth					Inhale	
60	Pero (M)	Amoebiasis, Stomach ache	*Plectranthus barbatus* Andrews	Lamiaceae	85	Root	Herb	Oral	M
61	Dumio (M)	Lower extremity weakness	*Plectranthus cylindraceus* Hochst. ex Benth.	Lamiaceae	229,503	Leaves	Herb	Topical	M
62	Ketero Desho Solelo (M)	Stomach ache, Amoebiasis, Diarrhea	*Plectranthus longipes* Baker	Lamiaceae	464	Whole	Herb	Oral	M
63	Banjirindo (M)	Ease of Birth	*Plectranthus punctatus* (L.f) L.'Hér.	Lamiaceae	207,318,369	Whole	Herb	Oral	M
64	Anchip (M)	Amoebiasis, Diarrhea, Stomach bloating, Stomach ache, Food poisoning	*Pycnostachys abyssinica* Fresen.	Lamiaceae	205, 319	Leaves	Herb	Oral	M
65	Sheto (M)	Constipation	*Satureja abyssinica* (Benth.) Briq.	Lamiaceae	292, 690	Leaves	Herb	Oral	M
66	Zene gaime Deshe	Stomach ache	*Satureja paradoxa*	Lamiaceae	310, 371	Leaves	Herb	Oral	A2

Nº	Vernacular names: Maale (M), Ari (A)	Ailments	Scientific name	Family Name	Voucher Nº	Parts used	Growth form	Application route	Study sites
	(A)		(Vatke) Engl. ex Seybold						
67	Kayneka/Digita (A)	Stomach ache	*Calpurnia aurea* (Ait.) Benth.	Leguminosae	247,272	Leaves	Shrub	Oral	A1, A2
		Diarrhea	*Calpurnia aurea* (Ait.) Benth.			Root	Herb	Oral	
68	Aro Dor deshe (M)	Malnutrition (Child)	*Chamaecrista mimosoides* (L.) Greene	Leguminosae	197,322	Whole	Herb	Oral	M
69	Dongordoso (M)	Tonsilites	*Indigofera spicata* Forssk.	Leguminosae	202, 251, 256,261, 345,388,467	Root	Herb	Oral	M, A1
	Afi Deshe/Gaina Deshe/Wesfat deshe (A)	Diarrhea, Evil eye Ascariasis, Stomach ache	*Indigofera spicata* Forssk.			Whole		Oral	
70	Birbira (A)	To close wound caused by Jiggers	*Millettia ferruginea* (Hochst.) Baker	Leguminosae	-	Seed	Tree	Topical	A2
71	Dawrake (M)	Liver disease	*Piliostigma thonningii* (Schumach.) Milne-Redh.	Leguminosae	117	Leaves	Tree	Inhale	M
72	Ara Deshe (A)	Liver disease (Ara)	*Senna petersiana* (Bolle) Lock	Leguminosae	260	Leaves	Shrub	Inhale	A1, A2
73	Karhaleko (M)	Stomach ache, Diarrhea , Food poisoning, Vomiting, Ascariasis	*Senna singueana (*Delile) Lock	Leguminosae	59,28	Root	Shrub	Oral	M
74	Dino desho (M)	Diarrhea (Children)	*Stylosanthes fruticosa* (Retz.) Alston	Leguminosae	-	Leaves	Herb	Oral	M
		Snake bite	*Stylosanthes fruticosa (*Retz.) Alston			Root		Oral	
75	Dolkoiso (M)	Stomach ache, Vomiting	*Tephrosia bracteolata* Guill. & Perr.	Leguminosae	291	Leaves	Shrub	Oral	M
76	Seringo demo golodo (M)	Gastritis	*Zornia pratensis* Milne-Redh.	Leguminosae	192, 328	Leaves	Herb	Oral	M
77	Polo Golodo (M)	Stomach ache, Diarrhea, Gastritis	*Abutilon longicuspe* Hochst. ex A.Rich	Malvaceae	193	Leaves	Herb	Oral	M
78	Puta (M)	Heart, food poisoning	*Gossypium herbaceum* L.	Malvaceae	621	Leaves	Shrub	Oral	M
		Ear ache	*Gossypium herbaceum* L.			Leaf bud		Topical	

Nº	Vernacular names: Maale (M), Ari (A)	Ailments	Scientific name	Family Name	Voucher Nº	Parts used	Growth form	Application route	Study sites
79	Wari Beshe (M) Civil deshe (A)	Oral trash, Diarrhea , Malnutrition (Child)	*Kosteletzkya adoensis* (Hochst. ex A.Rich.) Mast.	Malvaceae	209,368,465	Leaves	Herb	Oral	M,
		Fresh cut to stop bleeding	*Kosteletzkya adoensis* (Hochst. ex A.Rich.) Mast.			Leaves	Herb	Topical	A1
80	Chuksha (A)	Swelling	*Sida rhombifolia* L.	Malvaceae	93, 314	Leaves	Herb	Topical	A2
81	Kautso (M)	Vomiting, Food poisoning	*Sterculia africana* (Lour.) Fiori	Malvaceae	47	Leaves	Tree	Oral	M
82	Gontersa (M)	Snake bite, Liver disease	*Bersama abyssinica* Fresen.	Melianthaceae	436,475	Stem bark	Shrub	Oral/ Topical	A1, A2
83	Chorahe (M)	Amoebiasis	*Chasmanthera dependens* Hochst.	Menispermaceae	100	Stem	Herb	Oral	M
		Swelling	*Chasmanthera dependens* Hochst.					Topical	
84	Balari (M)	Amoebiasis, Diarrhea, Rabies, Stomach ache	*Cissampelos mucronata* A.Rich.	Menispermaceae	29,96	Root	Herb	Oral	M
85	Haleko, Kellengi (A)	Eye disease (cataract)	*Moringa stenopetala (*Bak.) Cuf.	Moringaceae	-	Stem bark	Tree	Topical	M,
		Malaria	*Moringa stenopetala* (Bak.) Cuf.			Leaves	Tree	Oral	A1
86	Musi (A)	Diarrhea	*Musa paradisiaca* L.	Musaceae	-	Fruit	Herb	Oral	A1
87	Enkoko (A)	Tape worm	Embelia schimperi Vatke	Myrsinaceae	-	Seeds	Shrub	Oral	A2
88	Diko (M)	Lower extremity weakness, Rheumatism	*Commicarpus grandiflorus (*A.Rich) Standley	Nyctaginaceae	-	Leaves	Herb	Topical	M
89	Mukalle (M)	Wound	*Ximenia caffra* Sond.	Olacaceae	22	Seed	Tree	Topical	M
90	Chamo (M)	Tape worm	*Jasminum grandiflorum* L subsp. floribundum (R.Br. ex Fresen.) P.S.Green:	Oleaceae	415,727		Climber	Oral	M
91	Rimiti (M)	Ascariasis, Gonorrhea	*Olea europaea* L. *subsp. cuspidata* (Wall.ex G.Don) Cif.	Oleaceae	108	Leaves	Tree	Oral	M
92	Afi deshe (Bere Keno) (A)	Evil eye	*Biophytum umbraculum* Welw.	Oxalidaceae	264	Leaves	Herb	Oral	A2
93	Solcarindo (M), Kinsa kins (A)	Malnutrition (children) Diarrhea ,	*Oxalis radicosa* A. Rich.	Oxalidaceae	212, 326	Leaves with	Herb	Oral	M, A1

Nº	Vernacular names: Maale (M), Ari (A)	Ailments	Scientific name	Family Name	Voucher Nº	Parts used	Growth form	Application route	Study sites
		Tooth ache, Stop fresh cut bleeding				succulent stem			
94	Azi (ite) deshe	Swelling	*Phyllanthus ovalifolius* Forssk.	Phyllanthaceae	200	Leaves	Shrub	Topical	A1,A2
95	Afi Deshe (A)	Evil eye	*Phyllanthus rotundifolius* Willd	Phyllanthaceae	244, 305	Leaves	Herb	Oral	A1
96	Tolsi (M), Andod (A)	Gonorrhea, Stomach bloating	*Phytolacca dodecandra* L 'Hérit.	Phytolaccaceae	97,241	Leaves	Climber	Oral	M,A1
97	Kurupe (M), Guni deshe (A)	Tooth ache	*Plumbago zeylanica* L.	Plumbaginaceae	90, 279, 284,306,367	Root bark	Climber	Topical	M, A1,A2
		Snake bite	*Plumbago zeylanica* L.			Whole		Oral	
98	Tsoralle (M)	Skin burns	*Portulaca quadrifida* L.	Portulacaceae		Leaves	Herb	Topical	M
99	Wuchanbe (M)	Tape worm	*Myrsine africana* L.	Primulaceae	178	Seed	Shrub	Oral	M
100	Gero (M)	Tooth ache	*Faurea speciosa* Welw.	Proteaceae	109,413	Leaves	Tree	Topical	M
101	Dishoo (M)	Ear ache	*Clematis hirsuta* Perr. & Guill.	Ranunculaceae	110,231	Leaves	Climber	Topical	M
		Headache	*Clematis hirsuta* Perr. & Guill.			Leaves		Oral	
102	Afi Deshe (M)	Evil eye	*Ranunculus multifidus* Forssk.	Ranunculaceae	381,111, 270	Leaves	Herb	Topical	A2
		Tonsillitis	*Ranunculus multifidus* Forssk.					Oral	
103	Ziambee	Ascariasis	*Caylusea abyssinica* (Fresen.) Fisch. & Mey	Resedaceae	16	Leaves	Herb	Oral	M
104	Kulmi (A)	Tonsilities	*Rhamnus prinoides* L.'Hérit.	Rhamnaceae	-	Leaves	Shrub	Oral	A1,A2
105	Kosso (A)	Tape worm	*Hagenia abyssinica (*Brace) J.F.Gmel.	Rosaceae	-	Flower	Tree	Oral	M, A2
106	Afi Deshe(b)	Evil eye	*Oldenlandia lancifolia (*Schumach.) DC.	Rubiaceae	245	Leaves	Herb	Oral	A1
107	Wari ampi (M)	Liver disease (Ara)	*Pavetta gardeniifolia* A.Rich.	Rubiaceae	325	Leaves	Shrub	Inhale	M

Nº	Vernacular names: Maale (M), Ari (A)	Ailments	Scientific name	Family Name	Voucher Nº	Parts used	Growth form	Application route	Study sites
		Common cold	*Pavetta gardeniifolia* A Rich.						
108	Afi deshe/ gaina deshe (A)	Diarrhea, Evil eye, Tooth ache, Stomach ache, Head wound	*Pentas lanceolata* (Forssk.) Deflers	Rubiaceae	277,243,250, 276, 249	Root	Herb	Oral	A1, A2
109	Garo (M)	Ascariasis	*Vangueria apiculata* K. Schum.	Rubiaceae	8,157	Leaves	Shrub	Oral	M
110	Gembala (M)	Malaria	*Gardenia ternifolia* Schumach. & Thonn.	Rubiaceae	352	Leaves	Tree	Oral	M
111	Onaki (M)	Ascariasis	*Meyna tetraphylla* (Schweinf. ex Hiern) Robyns	Rubiaceae	4	Leaves	Tree	Oral	M
112	Lomi (A)	Oral trash; Food poisoning	*Citrus aurantiifolia* (Christm.) Swingle	Rutaceae	-	Fruit	Tree	Oral	A1
113	Tselto (M)	Stomach ache, common cold	*Ruta chalepensis* var.tenuifolia D'Urville	Rutaceae	-	Leaves with succulent stem	Herb	Oral	M, A1.A2
114	Gedai (M)	Common cold	*Zanthoxylum chalybeum* Engl.	Rutaceae	31	Seed	Tree	Oral	M
115	Wulchi (M)	Scorpion bite	*Anemia schimperiana* Presl.	Schizaeaceae	290	Leaves	Herb	Oral	M
116	Mitmita (A)	Malaria	*Capsicum annuum* L.	Solanaceae	-	Fruit	Herb	Oral	A1
117	Guni deshe (A)	Snake bite	*Datura metel* L.	Solanaceae	103	Whole	Herb	Oral/ topical	A1
118	Atsefaris (M)	Toothache	*Datura stramonium* L.	Solanaceae	-	Leaf bud	Shrub	Topical	M
119	Ara Deshe (A)	Liver disease	*Discopodium penninervium* Hochst.	Solanaceae	339	Leaves	Tree	Inhale	A2
120	Tumbaho (M)	Leeches	*Nicotiana tabacum* L.	Solanaceae	-	Leaves	Herb	Topical/ Oral	A1, A2
121	Achi Kolpo (M), Garenti (A)	Amoebiasis, Stomach ache, Evil eye	*Solanum dasyphyllum* Schumach.	Solanaceae	9,94	Root	Herb	Oral	M, A1,A2

Nº	Vernacular names: Maale (M), Ari (A)	Ailments	Scientific name	Family Name	Voucher Nº	Parts used	Growth form	Application route	Study sites
122	Kotse Garenti (A) Bulabulo(M)	Ascariasis, stomach ache	*Solanum incanum* L.	Solanaceae	94	Root	Herb	Oral	M
123	Muto (M)	Cold	*Withania somnifera* (L.) Dunal	Solanaceae	176, 208	Root	Herb	Oral	M
124	Azi deshe/ masna (A)	Swelling	*Veronica abyssinica* Fres.	Scrophulariaceae	316, 334	Leaves	Herb	Topical	A2
125	Enaro (M)	Headache, Vomiting	*Lantana camara* L.	Verbenaceae	169	Leaves	Shrub	Oral	M
126	Dolo amede (M)	Headache	*Lantana trifolia* L.	Verbenaceae	190	Leaves	Shrub	Oral	M
127	Atuch	Stomach ache	*Verbena officinalis* subsp. *africana* R.Fernandes & Verdc.	Verbenaceae	268	Leaves	Herb	Oral	A2
128	Kuze (M)	Ascariasis, Food poisoning ,Vomiting	*Balanites rotundifolia (van Tieghem) Blatter*	Zygophyllaceae	41	Leaves	Tree	Oral	M

Study sites: M= Maale, A1= Ari 1 and A2= Ari 2; Plant names are checked based on www.theplantlist.org

Malaria, diarrhoea, ascariasis and amoebiasis were the most frequently cited health problems in Maale. Ascariasis is a helminthic human infection caused by Ascarias lumbricoides, a large roundworm. It is found worldwide with highest prevalence in tropical and subtropical regions, and in areas with inadequate sanitation (Ascariasis, 2013; WHO, 2013). Malaria, headache, stomach ache and diarrhoea were the main cited ailments in Ari 1 and Ari 2. Respondents said they identified and diagnosed the type of ailments by visual observation of the human body. Yellow, white of the eyes, for example, indicated liver health problem. Lulekal et al. (2008) reported similar ways of diagnosis among traditional healers in Mana Angetu, southeastern Ethiopia. On the other hand, tape worm and ascariasis were diagnosed by observation of the worms in human faeces by the patients themselves or elders in the case of young children.

The average number of medicinal plants cited by each study participant of different age and gender groups is displayed in Table 4.2. The highest numbers of species were mentioned by participants from the Maale ethnic community. Moreover, in all study sites the results revealed that male participants mentioned a higher number of medicinal plants than female ones (t-test, $p < 0.05$). Our results are in agreement with the study results reported for the Bench ethnic communities in south-western Ethiopia by Giday et al. (2009) that they found that the male study participants to have greater plant knowledge than females, because boys were favored for the transfer of medicinal plant knowledge.

Table 4.2. Average number of medicinal plants cited per respondent groups (age and gender groups).

Study sites	Gender		T-test	Age groups		T-test
	Male	Female	P-value	> 40	≤40	P-value
Maale (n= 26)	20.33	13.64	0.01*	19.67	12.73	0.01*
Ari 1(n= 24)	9.40	5.00	0.00*	8.06	7.22	0.65
Ari 2 (n= 24)	7.57	3.80	0.00*	6.77	5.09	0.13
Overall			0.01*			

People aged above 40 are considered matured adult by the community; P-values < 0, 05 are marked with *.

In all study sites more medicinal plants were reported by participants over 40 years of age than by younger ones but this difference was significant for the Maale site. Awas (2007) also found that older people knew more than the youngsters in his study of the Kefficho people, in south-western Ethiopia. This may be due to the fact that knowledge tends to be accumulated through time. The relative lack of knowledge in the young will further be aggravated in the future when many species become scarce in the landscape and this might have negative impact on knowledge continuity in the near future. On the other hand, the result from Ari showed that knowledge is not always disappearing, as there were no significant differences in plant knowledge between age groups.

Table 4.3 shows the familiarity indices of medicinal plants for the treatment of different types of health problems. *Meyna tetraphylla* in Maale and *Solanum dasyphyllum* in Ari 1 and 2 were most cited plants. There was little correspondence between the two sites with regard to frequently mentioned plant species, but health problems treated with medicinal plants were quite similar. Species with high familiarity indices should be considered for further phytochemical and pharmacological studies.

Table 4.3 Familiarity index (FI) of medicinal plants in Maale (M), Ari 1 (A1) and Ari 2 (A2).

Scientific name	Family name	Illness	Frequency	FI	Site
Meyna tetraphylla	Rubiaceae	Ascariasis	11	0.42	M
Plectranthus barbatus	Lamiaceae	Amoebiasis	11	0.42	M
Ozoroa insignis	Anacardiaceae	Ascariasis	11	0.42	M
Hypoestes forskaolii	Acanthaceae	Stomach ache	10	0.38	M
Ocimum basilicum	Lamiaceae	Stomach ache	10	0.38	M
Celosia trigyna	Amaranthaceae	Tapeworm	10	0.38	M
Plectranthus barbatus	Lamiaceae	Stomach ache	10	0.38	M
Solanum dasyphyllum	Solanaceae	Stomach ache	16	0.67	A1

Scientific name	Family name	Illness	Frequency	FI	Site
Indigofera spicata	Leguminosae	Ascariasis	12	0.50	A1
Ruta chalepensis	Rutaceae	Stomach ache	12	0.50	A1
Plumbago zeylanica	Plumbaginaceae	Snake bite	10	0.42	A1
Acmella caulirhiza	Compositae	Tonsillitis	9	0.38	A1
Kosteletzkya adoensis	Malvaceae	Fresh cut to stop bleeding	9	0.38	A1
Vernonia amygdalina	Compositae	Malaria	9	0.38	A1
Citrus aurantifolia	Rutaceae	Oral trash	9	0.38	A1
Acmella caulirhiza	Compositae	Tooth ache	8	0.33	A1
Oxalis radicosa	Oxalidaceae	Fresh cut to stop bleeding	8	0.33	A1
Rhamnus prinoides	Rhamnaceae	Tonsillitis	8	0.33	A1
Citrus aurantifolia	Rutaceae	Food poisoning	8	0.33	A1
Solanum dasyphyllum	Solanaceae	Stomachache	10	0.42	A2
Garcinia livingstonei	Clusiaceae	Oral trash	10	0.42	A2
Millettia ferruginea	Leguminosae	Close wound caused by Jiggers	9	0.38	A2
Nicotiana tabacum	Solanaceae	Leeches	8	0.33	A2
Hagenia abyssinica	Rosaceae	Tape worm	8	0.33	A2

Preference ranking among ten key informants for eight selected medicinal plants used for the treatment of ascariasis is shown in Table 4.4. From Table 4.4 it appears that people had certain preferences for medicinal plants based on their perceived efficacy for the treatment of the frequently cited health problem, ascariasis. Species with higher preference ranking may indicate effective healing properties, which suggests that they are interesting for further phytochemical and pharmacological research.

Table 4.4. Preference ranking of eight medicinal plants used for the treatment of ascariasis based on perceived efficacy by ten respondents in Maale**.**

Scientific name	Total sum of ranks (n=10)	Standard deviation	Mean ranking	Rank values
Ozoroa insignis	18	± 1.0	1.8	1
Meyna tetraphylla	22	± 1.4	2.2	2
Indigofera spicata	34	± 1.6	3.4	3
Vangueria apiculata	45	± 1.6	4.5	4
Balanites rotundifolia	54	*± 2.1*	*5.4*	*5*
Pergularia daemia	59	*± 1.7*	*5.9*	*6*
Senna singueana	61	*± 0.6*	*6.1*	*7*
Combretum aculeatum	67	*± 2.0*	*6.7*	*8*

Mechanisms of knowledge transfer among social groups

Most medicinal plant knowledge is transferred orally, as was reported by 71 study participants (96%) in the study sites (Table 4.5). Oral transmission is the dominant mechanism of traditional knowledge transfer system in Africa (Fasil, 2003), although this type of transfer cannot guarantee continuity under the current circumstances, where plant resource degradation and loss is severe. Most people (82%) obtained their knowledge from their parents (and or grand parents), which is similar to the percentage found by a study in Wonago district, Ethiopia (Mesfin et al., 2009). The great majority of the study participants preferred to transfer their medicinal plant knowledge to their children or grandchildren, which favours knowledge conservation and continuity mostly within the family line.

Table 4.5. Acquisition and willingness to transfer medicinal plant knowledge in the study sites.

	Maale Frequency (%)	Ari 1 Frequency (%)	Ari 2 Frequency (%)	Total Frequency (%)
Knowledge acquired				
Parents/grand parents	20 (76.9)	19 (79.1)	22 (91.7)	61(81.4)
Friends	1 (3.9)	1 (4.2)	0(0.0)	2 (2.7)
Neighbors	2 (7.7)	1 (4.2)	0(0.0)	3 (4.1)
Other (Given from God, accidentally encountered individuals)	3 (11.5)	3 (12.5)	2(8.3)	8 (10.8)
Knowledge willing to transfer to:				
Children and grand children	17 (65.4)	22 (91.6)	20 (87.5)	59 (79.7)
Any family member	4 (15.4)	1 (4.2)	1(4.2)	6 (8.1)
Neighbors	4 (15.4)	0 (0.0)	0 (0.0)	4 (5.4)
No one	1 (3.8)	1 (4.2)	3 (12.5)	5 (6.8)

The majority of study participants who showed interest to transfer their medicinal plant knowledge, preferred to transfer this to their first son. This preference was associated with the perception and fear that daughters would share the knowledge with their husbands' family when they get married. Knowledge transfer to the new family was not appreciated by respondents with the perception that their secret knowledge would be known by others. When the first son was not considered trustworthy to keep the knowledge secretly or not judged interested in the subject as assessed through what he says, what he does and his general attitudes, parents transferred it to their second son or grandson.

In most cases there existed a concern among ethnic groups and elder knowledgeable people on plant resource degradation around their village. Dwindling resources around settlements may have negative implications for the future transfer of medicinal plant knowledge, as elders are unable to walk long distances from their residence. If the plants are no longer available, it becomes difficult to show and teach others about their names, characteristics and uses.

Demographic factors influencing medicinal plant knowledge

Gender significantly predicted medicinal plant knowledge. Male study participants knew a higher number of medicinal plants than female ones. This is probably associated with the perception and culture of both ethnic groups to favour males in transferring medicinal plant knowledge. This must have implications for the cultivation of medicinal plant species in home gardens as women play a major role in managing these gardens. Moreover, site also strongly influenced the number of medicinal plants known and used (Table 4.6). Religion, family size and education did not influence plant knowledge.

Table 4.6 Socio-demographic and site factors prediction on the number of medicinal plants knoweldge

	Unstandardized		**Standardized**	
	Beta Coefficient	**Std.error**	**Beta Coefficient**	**p-value**
R^2=74.2				
Constant	3.831	0.443		
Age	0.016	0.006	0.198	0.014*
Gender	-0.819	0.149	-0.419	0.000*
Educational level	0.266	0.167	0.135	0.117
Family size	-0.041	0.025	-0.122	0.101
Site (Ari 1)	-1.485	0.185	-0.716	0.000*
Site (Ari 2)	-1.905	0.189	-0.918	0.000*

	Unstandardized		Standardized	
	Beta Coefficient	**Std.error**	**Beta Coefficient**	**p-value**
Religion (Protestant Christian)	0.136	0.178	0.068	0.449
Religion (Orthodox Christian)	0.190	0.199	0.093	0.343

Sites are compared against Maale site. Religion is compared against traditional religion; Variables with a significant influence (P<0. 05) are marked with *.

Older members of the community in Maale knew more medicinal plants than youngsters (Table 4.2), which may also reflect an ongoing gradual knowledge loss of knowledge in the study community. Hence, it is important to include traditional knowledge in the school curricula to raise awareness as recommended by Awas (2007).

Similarities in medicinal plant knowledge among sites

Generally we found little similarity among the three study sites. The calculated Jaccard similarity index was relatively higher between the two Ari sites (0.33), lower between Maale and Ari 1 (0.14) and lowest between Maale and Ari 2 (0.08). Our results showed that the Ari 1 and Ari 2 sites are more similar in medicinal plant knowledge than each of them compared to Maale. This can be explained by the geographical proximity between the two Ari sites and also supported by the fact that they belong to the same ethnic group and share their cultural background.

Medicinal plant collection, conservation efforts and major threats

Study participants mostly collected medicinal plants from crop fields, home gardens and nearby forest patches. The results of the growth form analysis revealed that herbs were the most common growth form and the dominant plant parts harvested were leaves. This was found by many researchers in different parts of East Africa (Togola et al., 2005). Harvesting of leaves may not have negative effects on resource availability, provided that the plant itself is not destroyed during harvesting, which is especially relevant for herbs.

A few study participants brought seedlings of medicinal herbs from fields and forest patches and started cultivating them in their home gardens. Their main reasons for doing so were to conserve

plants that were scarce in their surroundings, to keep herbs available that were unavailable during the dry season and to have the medicine at hand during emergency situations. The practice of nurturing of wild species in home gardens was limited to a very small area, because people suspected that their importance as medicine could be easily guessed by outsiders. This unwillingness to share resources with neighbors or other non-family members may negatively affect the conservation of medicinal plant knowledge and resources. Giday and Teklehaymanot (2013) did not encounter any cultivation of medicinal plants by Afar people in Ethiopian Ada'ar district. The main reason mentioned for this was easily availability of the medicinal plant in areas that are not far from the homesteads.

Agricultural expansion and lack of cultivation tradition were indicated by our study participants as major threats in all study sites (Table 4.7). The conversion of natural vegetation to agricultural fields is a serious issue in Eastern Africa, where the rural population is highly dependent on subsistence agriculture (NCAPD, 2008). Sustainable management of resources may not be an easy task, but it is crucial to guarantee future access to herbal medicine for rural communities (Cunningham, 1993). Other threats that were mentioned were lack of maintenance and the fact that people with little knowledge considered medicinal plants growing among their crops as weeds were likely to uproot them.

Most respondents (76% in Maale, 75% in Ari 1, 83% in Ari 2) collected plants at any time or day of the week. A few herbalists did not harvest plants on Sundays and some orthodox Christians did not harvest on Wednesdays and Fridays as these are fasting days. In emergency cases, they used stored herbal medicine on these days.

Commercialization of herbal medicine

Marketing of medicinal plants was not common at the studied markets, apart from the well-known *Hagenia abyssinica* flowers and *Embelia shimperi* seeds (both wild collected) and the cultivated *Allium sativum* and *Artemisia absinthium* that are also used as spices. The commercialization of other wild and semi-wild species is hampered by the fact that medicinal

knowledge is only held by few people. Tolasa (2007) also found only few species (*Thalictrum rhynchocarpum, Piper capense* and *Echinops kebericho*) at Gimibi and Gaba Senbeta markets, in western Ethiopia, while Giday et al. (2009) found that the few species sold by Bench communities in south-western, Ethiopia doubled as spices. In our study area, market chains were short and medicinal plants were directly sold by harvesters without further processing. The economic importance of the trade was limited: the price of *Embelia shimperii* seeds was only 2 Ethiopian Birr (0.10 $) per glass (about 250 ml). The product was not always available and marketed in small quantities.

Although herbalists' incomes obtained through giving treatments to local communities were not high, the most important aspect observed from traditional healers is local recognition and respect by the community. In our study sites, respondents mentioned that on average they were consulted by patients five times per month. The charges for a treatment depended on the type of health problem treated and on patient/healers' relationships. Payment per treatment ranged from 1-10 Ethiopian Birr (equivalent to 0.05 - 0.5 $) and sometimes were free of charge, especially in Maale area. However, in the Ari sites traditional healers believed that whatever relation existed, patients had to pay money for a consult; otherwise they underlined that the medicine would not be effective. Limited income obtained from marketing of medicinal plants or from treatments given to patients may have negative implications future cultivation, maintenance and conservation of medicinal plants in the landscape.

Conclusion

This study indicated that medicinal plants were important for the health care of the Maale and Ari ethnic groups, as they used at least 128 species and traditional medicine was considered as the first line of treatment by 89% of our respondents. Knowledge differed between and within ethnic groups and also among sites. The fact that knowledge transfer was predominantly to family members and in particular to first-born sons may negatively affect its continuity and may result in knowledge loss if medicinal plant resources become scarce in the future. Low income

obtained from marketing of medicinal plants and herbal treatments may have strong implications on the future conservation of medicinal plants in the landscape.

Agricultural land expansion and a lack of cultivation practices limit the availability of medicinal plant resources in the area. Urgent action is required towards conservation (both ex-situ and in-situ combined) of medicinal plants and traditional knowledge before we lose them in the near future. Moreover, land use planning and development plan should also consider strategies that stimulate medicinal plant availability in the landscape and work towards increasing their cultivation to complement ex-and in-situ conservation efforts.

Popular medicinal species such as *Solanum dasyphyllum, Indigofera spicata, Plumbago zeylanica, Meyna tetraphylla* and multi-use species like *Oxalis radicosa* are good candidates for consideration in further phytochemical and pharmacological research to verify their efficacy.

5

Ethnoveterinary medicinal plants used by the Maale and Ari ethnic communities in southern Ethiopia

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Abstract

Livestock production is an integral part of the agricultural system in Ethiopia. Medicinal plants are used and important rural communities for the treatment of livestock diseases. We studied and analysed the traditional medicinal plants used for the treatment of livestock diseases by the Maale and Ari ethnic communities in southern Ethiopia.

We used quantitative and qualitative ethobotanical methods, including individual and focus group discussions (n=18), field observations, and individual interviews (n=74) at three study sites.

In total, 46 plant species (28 families) were used for the treatment of livestock diseases. Leaves with succulent stems were the most used part of the plant. The most frequently cited cattle disease was blackleg, for which 21 plant species were used. Our study showed variation in ethnoveterinary plant species used among sites (Jaccard's similarity indices < 0.25).The number of medicinal plant species used was significantly influenced by gender and site. Knowledge on ethnoveterinary plants was predominantly held by males, who cited more plant uses than females. The most widely used species were *Lepidium sativum, Allium sativum, Clausena anisata, Croton macrostachyus, Ozoroa insignis, Sida rhombifolia, Centella asiatica, Cissampelos mucronata, Vernonia theophrastifolia* and *Vernonia amygdalina*.

The study indicated that ethnoveterinary medicinal plants are important for the Maale and Ari ethnic communities. Phytochemical and pharmacological studies should focus on widely used and multi-use species.

Introduction

Livestock production is of overwhelming importance for the livelihoods of many people, particularly in developing countries (Wanzala et al., 2005). It has diverse functions and roles, including the provision of food, income, employment and draft (muscle) power, and the dung being used as fuel and fertilizer (FAO, 2011; Pica-Ciamarra et al., 2011). Moreover, livestock helps to cope with adverse situations and food insecurity (PASDEP, 2006; Lai, 2007) and plays numerous socio-cultural roles (Moyo and Swanepoel, 2010). Livestock production is also an integral part of the agricultural systems in Ethiopia and plays a crucial role in the national economy: it contributed about 45% of the agricultural GDP in 2008–2009 (Behnke and Metaferia, 2011). Behnke and Metaferia (2011) reported the use animal traction by 80 % of Ethiopian farmers to plough their fields and showed the positive associations of the mean area cultivated by a farm household with cattle ownership and ploughing.

Despite its importance, livestock production and development in Ethiopia is constrained by many factors, such as frequently occurring diseases that affect their performance and the marketability of their products including hides and skins (Asfaw, 2003; Yineger et al., 2007; MOA, 2012). Livestock diseases negatively affect income and farming activities (oxen ploughing) of the rural poor, which in turn has implications on the livelihood of the farmers. In the period 2010–2011, hemorrhagic septicaemia, anthrax, blackleg, contagious caprine pleuropneumonia were the major livestock diseases that caused livestock mortality in Ethiopia (MOA, 2012). Available estimates in Ethiopia show that some 8–10 % of the cattle population, 14–16 % of the sheep and 11–13 % of the goat population are dying annually due to livestock diseases, a loss of about 36 million US$ (Behailu, 2011). Local medicinal plants are frequently used to treat different livestock diseases and are of particular importance in areas where modern veterinary services are absent, irregular and/or expensive (Toyang et al., 2007).

About 80–90% of the livestock population in Ethiopia is believed to rely on traditional medicine for the treatment and control of diseases (Regassa, 2004) and most of this is taken care of by herbal medicine. Generally, the dependency on medicinal plants is not only caused by a lack of

access to modern veterinary clinics and the high price of synthetic drugs (Eguale et al., 2011), but also by the belief that most traditional medicines are more efficacious than modern ones (Sori et al., 2004). As a result, rural communities rely on traditional knowledge and locally available medicinal plants. On the other hand, there are signs that indigenous knowledge is disappearing at an alarming rate in Ethiopia (Yirga, 2010) and also in many other parts of the world (Gradé et al., 2009).

Several studies have been done on traditional veterinary practices in Ethiopia, (e.g., Giday and Ameni, 2003; Sori et al., 2004; Yineger et al., 2007; Yirga et al., 2012a; 2012b; Gebrezgabiher et al., 2013; Shilema et al., 2013). Shilema et al. (2013) reported 14 medicinal plants for the treatment of trypanosomiasis and seven species to repel tsetse flies in Amaro district, southern Ethiopia. Yirga et al. (2012b) also found 22 plant species for treating 18 different livestock ailments and Sori et al. (2004) identified 77 different plants used by Borana pastoralists to treat or prevent a wide range of livestock diseases. However, more than 70 ethnic groups reside in Ethiopia, and only small part of the wealth of ethnoveterinary knowledge has been covered. Studies focused on ethnoveterniary plants and their uses that address the Maale and Ari ethnic groups are lacking. Moreover, ethnoveterinary knowledge was found to differ among and within communities (Matekaire and Bwakura, 2004) and also among sites (Awas, 2007), which was explained by cultural differences in plant use and variation in vegetation among sites.

The socio-economic and demographic characteristics are rapidly changing and also believed to affect ethnoveterinary knowledge (Selvaraju et al., 2011). The few studies in Ethiopia considered different demographic groups within communities (Yirga et al., 2012a; 2012b) and indicated the limited involvement of youth in the administration of herbal preparations. In order to effectively preserve traditional knowledge, we need to find out whether socio-economic and demographic factors or locality affect the knowledge and use of medicinal plants to treat livestock diseases. This study aims to document and analyse ethnoveterinary knowledge among the Maale and Ari ethnic groups in southern Ethiopia and identify socio-economic and demographic factors that may influence this knowledge. Our research questions are:

1) Which medicinal plants are used to treat different livestock diseases and most frequently mentioned by the two communities?

2) Which plant parts are most used and how does this affect their availability?

3) How do the two communities differ in their use of medicinal plants?

4) Do socio-economic and demographic factors (age, gender, educational level, religion, livestock number) influence ethnoveterinary plant knowledge and use?

By identifying how plant knowledge is distributed, what factors affect knowledge transmission and documenting medicinal plant use, we suggest measures to manage, sustainably use and conserve plants of ethnoveterinary importance and related traditional knowledge.

Materials and methods

Study area and selection of informants

The study was conducted in two districts of southern Ethiopia: Maale and Debub Ari, where the Maale and Ari communities reside, some 750 km south from the capital, Addis Ababa (Fig. 4.1). A reconnaissance survey was conducted from July to August 2010 in the two study districts. Detailed field work was conducted from August 2010 to October 2012. Prior to detailed data collection, individual and focus group discussions (n=18) with informants were conducted in rural kebeles (the lowest formal administrative unit in rural Ethiopia). At each kebele, ca. 10–12 informants from different socio-demographic groups were involved in the focus group discussions. Finally three study sites were selected for formal survey: Maale, Ari 1 and Ari 2. For each site, two kebeles were randomly selected: Sholeteka and Beneta in Maale, Kure and Geza in Ari 1 and Pilla and Metser in Ari 2 (Fig.4.1).

The study sites are characterized by mixed crop–livestock farming system, where crop and livestock are managed in an integrated way. Subsistence-oriented animal production is an important component of this farming system in the study area. The remnant vegetation of Maale is characterized by *Acacia–Commiphora* and *Combretum – Terminalia* woodland; the mean

altitude is 1350 m.a.s.l. The vegetation of Ari 1 is characterised by moist evergreen Afromontane forest and *Combretum–Terminalia* woodland (Friis et al., 2010), with a mean altitude of 1330m. In Ari 2 (ca 1700m), the forest is converted to agricultural land and scattered trees are found in fields and home gardens. The Ari communities speak the *Araf,* while the Maale speak the *Mallo mucci*. Rainfall is bimodal in all the study sites. Based on population census report, in 2007 the population of Maale was 84,657 and the population of Debub Ari is 212,389 (CSA, 2008).

A total of 74 respondents (26 from Maale, 24 each from Ari 1 and Ari 2) were interviewed using stratified random sampling procedures from the six randomly selected kebeles of the two districts. The respondents' group was composed of 41 males and 33 females. Oral informed consent was obtained from each participant prior to conducting the interview.

Data collection

We used semi-structured interviews, field observations, preference ranking and paired comparisons (Martin, 1995). The semi-structured interviews contained questions on socio-economic and demographic variables, common livestock health issues, medicinal plants and plant parts used, mode of preparation, application methods and dosage. Each informant was visited at least two times during the study period in order to validate the information provided. Following Alexiades (1996), responses of respondents that contradicted each other were not considered for analysis. Informants' description of livestock disease types was translated with the help of veterinarians. Ten key informants were selected to participate in a preference ranking exercise for eight plants used to treat the frequently cited blackleg disease in Maale. They were asked to rank plant species according to their perceived efficacy and the most effective was given the value one, and the least effective the value eight.

Plant voucher specimens were collected for identification with the assistance of informants following standard botanical collection procedures. Preliminary identification was done in the field and further identification took place at the National Herbarium (ETH) of Addis Ababa University (AAU) using taxonomic keys provided in the relevant volumes of the Flora of Ethiopia and Eritrea (Edwards et al., 1995; 1997; 2000; Hedberg and Edwards, 1989; Hedberg et

al., 2003; 2004; 2006; Phillips et al., 1995). At the end of this process, the identified specimens were deposited at the National Herbarium of AAU. Plant names were also checked for accuracy by means of the Plant List (www.the plant list.org).

Data analysis

Descriptive statistics were used to illustrate averages on the types of diseases listed, medicinal plants and parts used among the studied communities. Similarities and differences on plant uses between sites and ethnic groups were compared using the Jaccard's similarity index (Höft et al., 1999). This index uses plant presence/positive reply or absence/negative reply data sets and is expressed as:

$$JI = \frac{c}{a+b+c} \quad ,$$

Where JI is the Jaccard similarity index, 'c' is the number of species shared by the two study sites, 'a' is the number of species in site A only and 'b' is the number of species in site B only. A JI value of 1 (one) means plant use in site A and B is equal and a JI value of 0 (zero) means plant use in both sites is completely different.

We also used familiarity index (FI) as a relative indicator of the familiarity of a species, defined as the number of informants that mentioned the species for specific use divided by the total number of respondents (Tabuti et. al., 2004).

$$FI = \frac{Frequency\ of\ a\ given\ ethnoveterinary\ plant\ species\ mentioned\ as\ medicine}{Total\ number\ of\ respondents} \quad .$$

Multiple regression analysis was employed to understand which variables predicted medicinal plant knowledge (Pallant, 2007). We used the number of species known as dependent variable and considered age, gender, religion, educational level, tropical livestock unit (TLU) and

geographical site as explanatory variables. Tropical livestock unit (TLU) was used to quantify different livestock types and size to one standardized unit. TLU was calculated using the standard conversion factors for cattle (0.7), sheep and goats (0.1), donkeys (0.5), horses(0.8), mules (0.7) and chickens (0.01) (FAO, 1979 cited in Jahnke, 1982). Multi-collinearity among independent variables was checked and variables that were highly correlated ($r \geq 0.9$) were not included in the model (Pallant, 2007). Independent t-tests were also employed to compare the differences between gender and age groups. All statistical methods were carried out in the program SPSS 20.0.

Results

Livestock diseases in the study sites

Local communities usually describe ill health (disease) as a deviation observed in the livestock from what they assume as normal. For example, when an animal has diarrhea its faeces become liquid, whereas in the condition of constipation the faeces of the animal are too dry. In the case of leeches, blood will come out from its mouth. In some cases they also describe disease based on the appearance of new abnormal structure on the skin, like in the case of scabies. Communities sometimes also employ vernacular names for disease types that refer to their interpretation of the symptoms and the effects of the disease. The Maale ethnic communities, for example, called the disease Anthrax 'kedi kere'. This name is associated with an animal's sudden death by this disease. 'Kedi' means lifting up and 'kere' means falling. Anthrax-infected cattle suddenly lift up and fall down, after which they die immediately. In the case of CBPP and CCPP the disease is identified by difficulty in breathing and the Maale community named these diseases as 'kumpo'.

Trypnasomiasis disease is also described as 'fly disease' by our respondents, who considered that the disease was caused by a fly. This description is associated with a scientific explanation that the vector of this disease is tsetse fly. Sometimes, local communities diagnose the disease by visual observation of the cattle. For example, open-mouthed rapid breathing in the case of respiratory disease, by observation of ticks on the cattle or observation of white material in the

eye in the case of eye cataract. The disease ascariasis is diagnosed by the observation of worms in the faeces of the livestock and cattle bitten by dogs with rabies are usually recognised by restlessness and producing a lot of saliva.

Blackleg, anthrax, CBPP, trypanosomiasis, diarrhoea and amoebiasis are the most familiar diseases in the study area with average familiarity indices of 0.76, 0.49, 0.45, 0.24, 0.15 and 0.14, respectively. Anthrax showed more variation among study sites: 0.38, 0.33 and 0.75 for Maale, Ari 1 and Ari 2, respectively.

Of all cattle diseases, blackleg disease affects frequently the health and productivity of cattle in all three study sites. Blackleg was said to be more prevalent during the rainy season and informants believed that cattle fell ill while feeding on fresh maize stalks that were full of water. To prevent blackleg disease infection, the animals is given maize stalks that had been cut or uprooted and kept at least for one day to dry.

Next to blackleg, anthrax was a major cattle disease that kills cattle unexpectedly. Maale informants said that anthrax could be treated with the same plants used for blackleg, provided the disease was detected at early stage. If given in a later stadium no medicinal plant was believed to be effective. Leeches were also one of the common pests in Ari 1 and caused severe loss of blood (Fig. 5.1), affecting livestock health and productivity.

Fig. 5.1. Bleeding due to leeches in Kure *kebele* (Ari 1) (Picture taken by Berhane Kidane).

Medicinal plant species used to treat livestock diseases.

From all study sites, we found a total of 46 medicinal plants distributed in 28 families that were used to treat cattle and goat diseases (Appendix Table 5. 1), of which 39 species (85%) were wild/semi-wild and seven species (15%) were cultivated. Thus, wild and semi-wild species play an important role in maintaining the health of the livestock by the ethnic groups studied. The family Leguminosae was represented by seven species, followed by Compositae and Lamiaceae (4 spp. each). We found a total of 43 medicinal plants that were used to treat cattle diseases: 19 in Maale and 29 species in Ari 1 and Ari 2. Only five species were shared by the two ethnic groups and used for the same purpose (*Allium sativum, Lepidium sativum, Momordica foetida, Nicotiana tabacum* and *Sida rhombifolia*).

A total of 21 species were used to treat blackleg disease in the three study sites, of which 16 medicinal plant species were found at Ari 1 and Ari 2 and 9 species were from Maale. *Momordica foetida* was cited in all sites for the treatment of blackleg disease. *Lepidium sativum* was the most cited species in Maale, *Vernonia theophrastifolia* in Ari 1 and *Clausena anisata* in Ari 2 study sites, respectively. Details on citation frequencies for each study site are listed in Table 5.1. The preference ranking among ten key informants on the basis of their perceived efficacy against blackleg in Maale followed the same order as the citation frequency, with regard to the top eight medicinal species.

Table 5.1 Citation frequencies and preference ranking of ethnoveterinary plants used against blackleg disease

		Maale		Ari 1	Ari 2
		Citation frequency (percentage), n = 26	Preference ranking order	Citation frequency (percentage), n = 24	Citation frequency (percentage), n = 24
1	*Lepidium sativum**	11 (42.3)	1	2 (8.3)	
2	*Allium sativum*	8 (30.8)	2	3 (12.5)	1 (4.2)
3	*Chasmanthera dependens*	7 (26.9)	3		
4	*Tagetes minuta*	5 (19.2)	4		
5	*Commiphora sp.*	4 (15.4)	5		
6	*Momordica foetida*	3 (11.5)	6	3 (12.5)	1 (4.2)
7	*Momordica pterocarpa*	3 (11.5)	7		
8	*Rhynchosia elegans*	2 (7.7)	8		
9	*Croton macrostachys*				
10	*Centella asiatica*			2 (8.3)	6 (25)
11	*Clausena anisata*			2 (8.3)	1 (4.2)
12	*Cynoglossum coeruleum*				7 (29.2)
13	*Ajuga leucantha*			2(8.3)	1 (4.2)
14	*Ocimum lamifollium*				2 (8.3)
15	*Acmella caulirhiza*				2 (8.3)
16	*Caesalpinia volkensii*			1 (4.2)	
17	*Vernonia theophrastifolia*			4 (16.7)	
18	*Phytolacca dodecandra*			2 (8.3)	
19	*Capsicum annum**			2 (8.3)	
20	*Clerodendrum myricoides*			1 (4.2)	1 (4.2)
21	*Zingeber officinale**				2 (8.3)

* cultivated species; numbers in brackets are in %

Seven plant species were listed by Maale informants that are used for the treatment of goat diseases: *Dodonea angustifolia, Commiphora* sp., *Zanthoxylum chalybeum, Ximenia caffra, Hordeum vulgare, Olea europaea* subsp. cuspidata and O*zoroa insignis*. Three of these species were not used for any other livestock ailment (*Hordeum vulgare, Ximenia caffra* and *Dodonea angustifolia*). In Ari 1 and Ari 2, no medicinal plants were listed to treat goat diseases.

Plant parts and growth forms

The most widely used growth form of medicinal plants used for livestock diseases were herbs (43%) followed by trees (24%), shrubs (22%) and climbers (11%). The most frequently mentioned parts of the plant were leaves with succulent stems (11 species) followed by leaves (11 spp.), the whole plant (8 spp.), roots, bulbs or rhizomes (9 spp.), seeds (5 spp.), bark (3 spp.) and stem (1 spp.).

Familiarity of ethnoveterinary medicinal plants

The familiarity (the relative proportion of citation frequency) of the species in the three study sites is shown in Table 5.2. There are clear differences between sites, for example *Croton macrostachyus* is more frequently mentioned in Ari 2 than in Ari 1 but not mentioned in Maale, despite its existence of the species in the local vegetation.

Table 5.2. Familarity index of livestock medicinal plants in the study sites

Plant species	**Disease types**	**Study sites**		
		Maale	Ari 1	Ari 2
Lepidium sativum	Balckleg	0.42		
Allium sativum	Balckleg	0.31	0.25	0.08
Ozoria insignis	Ascariasis	0.31		
Sida rhombifolia	Calves constipation	0.31	0.33	0.00
Chasmanthera dependens	Anthrax/Blackleg/Amoebiasis	0.27		
Olea europaea subsp. Cuspidate	Ascariasis	0.23		
Tagetes minuta	Amoebiasis/ Blackleg	0.19		
Commiphora sp.	Amoebiasis/ Blackleg	0.15		
Zanthoxylum chalybeum	CBPP	0.15		
Nicotiana tabacum	Leeches	0.15	0.25	0.17
Momordica pterocarpa	Amoebiasis/ Anthrax	0.12		

Commiphora sp.	Anthrax	0.12		
Cissampelos mucronata	Amoebiasis	0.12		
Tagetes minuta	Anthrax	0.12		
Cissampelos mucronata	Rabies	0.12		
Clausena anisata	Blackleg		0.00	0.58
Croton macrostachys	Blackleg		0.17	0.50
Cynoglossum coeruleum	Blackleg		0.17	0.17
Momordica foetida	Blackleg	0.12	0.13	0.04
Vernonia amygdalina	Trypanosomiasis		0.33	0.00
Vernonia theophrastifolia	Blackleg		0.33	0.00
Croton machostachys	Constipation		0.25	0.00

Comparison of plant use among study sites and communities

The average number of ethnoveterinary plants known by Maale informants was significantly higher than that of informants in Ari 1 (P = 0.045) and Ari 2 (P = 0.01). The two Ari sites did not differ in the average number of medicinal plants known (P= 0.691). In all study sites, male respondents knew more plant species. The average number of plants known in Maale were (male: female) 6.7: 2.0, in Ari1 3.6: 0, and in Ari 2 1.6 : 1.1. This could be attributed to the favoring of sons in knowledge transfer and also the perception of the communities that dealing with livestock is the task of men. Female respondents in Ari 1 did not list a single livestock medicinal plant. Our study results also showed that only in Maale, people older than 40 years knew significantly more plants than those under 40. The results of our multiple regression (R^2 = 0.301) showed that among socio-economic and demographic factors only site and gender significantly influenced the number of medicinal plants known with p-value less than 0.05 (for gender 0.005; Ari 2 site with Maale 0.025 and Ari 1 site with Maale site 0.035). However, age, religion, TLU and education did not show significant influence on plant knowledge. The Jaccard's similarity indices for the use of veterinary plants among sites have shown little similarity (JI < 0.25), which may be caused by the differences in vegetation, people's experiences with plant species, or the occurrence and severity of diseases. Similarity indices for Ari 1 and Ari 2 sites were more similar to each other (0.24) than with Maale site (JI= 0.09 Maale with Ari 1 and JI= 0.13 Maale with Ari 2).

Discussion

The outbreak and prevalence of livestock diseases varied among sites, probably due to climatic differences. Blackleg was a major prevalent disease in our study area. This highly fatal infection in cattle is caused by the spore-forming bacteria *Clostridium chauvoei*. These soil-borne bacteria enter the animal by the ingestion of contaminated feed or pasture (www.access.edu, 2011). The first sign observed is usually lameness, loss of appetite, severe depression and rapid breathing. Localized swellings develop in the hip, shoulder, chest, back, neck or elsewhere. In agreement with our result Yineger et al. (2007) reported blackleg as one of the most reported livestock diseases in Bale Mountains National Park, Ethiopia. In contrast, Duguma et al. (2012) identified mastitis, internal parasites, lumpy skin disease and heart water as the most frequently occurring diseases in Jima Zone, Ethiopia. According to Powell (n.d.), blackleg is prevalent during the rainy season, just like our informants reported, due to the fact that the causative bacteria are frequently found in the soil and activated in anaerobic (oxygen deficient) environments. Hence, the severity of the blackleg out breaks in water-logged sites can be explained. The association of blackleg disease with the consumption of fresh maize stalks requires further attention.

Animal trypanosomiasis is a parasitic disease that is transmitted by the bite of a biological vector, tsetse fly (Palingand Dwinger, 1993). It causes serious economic losses in livestock from anaemia, loss of condition and emaciation. This disease was not mentioned in Ari 2, which may be associated with a lower prevalence at higher altitudes, as suggested by Majekodunmi et al. (2013) in their study at the Jos Plateau, Nigeria.

Wild and semi-wild plants play an important role in ethnoveterinary medicine for the Maale and Ari ethnic groups. We found the highest number of species that are used for the treatment of blackleg disease. This is in line with the findings of Yineger et al. (2007), who studied ethnoveterinary plant use at the Bale Mountains in Ethiopia. Just like the findings of Giday et al. (2009), most of the treatments were prepared from single species in Maale study sites, but people in Ari study sites in some cases used a mixture of different species. For example, they used

Allium sativum with *Lepidum sativum*, *Allium sativum* with *Centella asiatica*, or *Allium sativum* with *Zingiber officinale* for the treatment of blackleg disease.

The use of medicinal plants by a community depends on the availability of the species in the local vegetation, crop fields and home gardens. Cultural traditions or experiences and the prevalence of disease in the area also play a role in local use patterns. *Croton machrostachyus* was found in all three study sites, but only used for the treatment of blackleg and constipation in Ari 1 and 2, which might illustrate the limited exchange in ethnoveterinary knowledge among ethnic groups. The higher similarity in plant use between the two Ari sites compared to the Maale site could also suggest cultural preference for certain species.

Garlic (Allium sativum) is used for the treatment of blackleg disease by the Maale community. Yineger et al. (2007) also found the use of this species for the treatment of blackleg by traditional practitioners in Bale Mountains National Park, Ethiopia. Shilema et al. (2013), however, found its use for the treatment of trypanasomiasis and to repel tsetse fly in Amaro district in southern Ethiopia. *Lepidium sativum* is used for the treatment of blackleg disease in Maale and Ari 1 study sites. In agreement with our findings the use of this species is reported for the treatment of blackleg disease in Dabo Hana District in west Ethiopia (Tamiru et al., 2013). However, our results deviate from those of Shilema et al. (2013) who reported the use of the species for the treatment of trypanasomiasis and to repel tsetse flies.

Yineger et al. (2007) found *Nicotiana tabacum* used for blackleg by Oromo communities in the Bale Mountains, and Shilema et al. (2013), however, found its use to repel tsetse flies. Although tobacco was grown in homegardens in all three study sites, it was not known for the treatment of blackleg but used against leeches in Ari1 and 2 sites. Similar to our study, Tamiru et al. (2013) reported the use of tobacco for the treatment of leeches. Leaves of *Croton macrostachyus* are used for the treatment of blackleg and constipation in our study area. In the Tigray region of Ethiopia, a cooled decoction of the leaves is used to wash affected udders and leaf extracts are also used to treat dermatophilosis (Kalayou et al, 2012). Sori et al. (2004) reported its use for the treatment of stomach bloating by the Borana pastoralists in southern Ethiopia. Traditional healers

in the study area use *Vernonia amygdalina* to prevent trypanasomiasis. Similar results were demonstrated by Shilema et al. (2013) in southern Ethiopia Amaro district.

Phytolacca dodecandra roots were used for the treatment of blackleg in Ari 1, although Tamiru et al. (2013) reported its use for eye disease in the Dabo Hana District. *Ocimum lamiifolium* is used for the treatment of blackleg in Ari 2, while Yineger et al. (2007) reported this species for the treatment of diarrhea at Bale Mountains National Park. *Ximenia caffra* seeds were used for the treatment of foot rot in Maale. Gebrezgabiher et al. (2013) reported the use of the bark of this species for the treatment of wounds in the Tigray region. Giday and Teklehaymanot (2013) found the use of *Ziziphus spina-christi* to treat delayed placenta, orf and pneumonia in livestock of Afar people of the Ethiopian Ada'ar district. Despite the presence of this species in Maale, it was not mentioned as a treatment for livestock disease.

Our findings showed that most ethnoveterinary plants were herbs corroborates with those mentioned by Gebrezgabiher et al. (2013), who found a dominant use of herbaceous plants (60%) in the northern part of Ethiopia. They also found that leaves and succulent stems were frequently used. These findings differ from the results of Tabuti et al. (2003) who found that roots were mostly used in Bulamogi County, Uganda, and Yineger et al. (2007), who earlier found the same at Bale Mountains National Park, Ethiopia. The use of roots can have negative consequences for sustainability of plant resources (Cunningham and Mbenkum, 2003), as uprooting a plant often kills the individual.

Males were more knowledgeable on traditional veterinary treatments than females, which could be attributed to the fact that dealing with livestock is usually the task of men, except in the cases of milking, which involves both male and females in the studied ethnic groups. Moreover, medicinal plant knowledge is preferably transferred by most informants to their first son or grandson in the study area (Berhane et al., 2014).

Conclusion

A total of 46 plant species with ethnoveterinary important, predominantly wild and semi-wild species were used by the Maale and Ari ethnic groups. Low similarities among sites and ethnic groups may be caused by differences in the availability of plant species in the local vegetation, people's experiences with plants and the prevalence and severity of diseases.

Phytochemical and pharmacological studies should focus on well-known and multi-use species for future phytochemical studies and pharmacological testing, which include *Lepidium sativum, Allium sativum, Clausena anisata, Croton macrostachyus, Ozoroa insignis, Sida rhombifolia, Centella asiatica, Cissampelos mucronata, Vernonia theophrastifolia* and *Vernonia amygdalina*. The association of blackleg disease with the consumption of fresh maize stalks also requires further research attention.

Gender and site significantly influenced the ethnoveterinary plant knowledge of our respondents. Males appeared to be more knowledgeable on veterinary issues than females. This may affect the future conservation of these plants especially in home gardens, as women play a major role in tending gardens. Further degradation of the resource in the landscape may lead to a loss of ethnoveterinary plant knowledge. Therefore, it is important to involve all groups of people in the conservation of these resources.

Appendix: Table 5.1: Ethnoveterinary plants used in Maale and Debub Ari with plant parts used, ailments treated, mode of preparations and applications

N^{0}	Voucher N^{o}	Vernacular names: Maale (M) Araf(A)	Botanical name	Family	Growth form	Ailments treated (M= Maale; A=Araf)	Parts used, mode of preparation and application route	Study sites
1	-	Tsami shinkurt (A) *c	*Allium sativum* L.	Amaryllidaceae	Herb	Blackleg (*Abakorpa* (A), *Gorba* (M))	Bulb is pounded and mixed with cold water for nasal administration	A1, A2,M
2	177, 224, 289	Salvano (M)	*Ozoroa insignis* Delile	Anacardiaceae	Tree	Ascariasis (*Berinte* (M))	Stem bark is chopped and mixed with tepid water for oral administration	M
3	36, 128	Ountinkam (A)	*Centella asiatica (*L.) Urb.	Apiaceae	Herb	Blackleg (*Abakorpa* (A))	Leaves with succulent stem are pounded, mixed with water and inserted in nose	A1, A2
		Ountinkam	*Centella asiatica (*L.) Urb.	Apiaceae	Herb	Increase milk production (Ratse weyte (A))	Leaves with succulent stem are pounded and mixed with water for oral administration	A1, A2
4	33, 119	Almi (A)	*Carissa spinarum* L.	Apocynaceae	Shrub	Increase milk production (Ratse weyte (A))	Root is chopped and given orally with small amounts of salt	A1
5	253	Nech achenti (A)	*Cynoglossum coeruleum* Hochst. ex A.DC. subsp. *geometricum* (Baker & Wright) Edwards	Boraginaceae	Herb	Blackleg (*Abakorpa* (A))	Leaves with suculent stem is pounded in water for nasal administration	A1, A2
6	NC	Sibiki (M)*c	*Lepidium sativum* L.	Brassicaceae	Herb	Blackleg (*Abakorpa* (A); *Gorbo* (M))	Seeds are pounded, mixed with water and given orally	M, A1
7	410, 216	Dortse (M)	*Commiphora sp.*	Burseraceae	Tree	Anthrax, Blackleg, Amoebiasis	Leaves with suculent stem are chopped and given orally	M
8	121	Singla (A)	*Terminalia schimperiana* Hochst.	Combretaceae	Tree	Diarrhoea (*Arsi* (A))	Bark is chopped and mixed will tepid water and given orally	A1
	121	Singla	*Terminalia schimperiana* Hochst.	Combretaceae	Tree	Increase milk production (Ratse weyte (A))	Stem bark is chopped, mixed with salt and fed to the animal	A1

Nº	Voucher Nº	Vernacular names: Maale (M) Araf(A)	Botanical name	Family	Growth form	Ailments treated (M= Maale; A=Araf)	Parts used, mode of preparation and application route	Study sites
9	89, 313	Midir Berbere (A)	*Acmella caulirhiza* Delile	Compositae	Herb	Blackleg (*Abakorpa* (A)	Whole plant is pounded and mixed with cold water and inserted in nose	A2
10	203	Rebasho (M)	*Tagetes minuta* L.	Compositae	Herb	Anthrax, Blackleg, Amoebiasis (*Kedikere, Gorbo, Ketero* (M))	Leaves with succulent stem are chopped and mixed with water and given orally	M
11	-	Gera (A)	*Vernonia amygdalina* Delile	Compositae	Shrub	Trypanaso-miasis prevention (Sungla (A))	Leaves with succulent stems are ground and applied to the skin	A1
		Gera	*Vernonia amygdalina* Delile	Compositae	Shrub	Increase milk production (Ratse weyte (A))	Leaves with succulent stem are chopped, mixed with salt and fed to the animal	A1
12	35	Dofta (A)	*Vernonia theophrastifolia* Schweinf. ex Oliv. & Hiern	Compositae	Herb	Blackleg *Abakorpa* (A))	Root is pound, mixed with water and administered nasally	A1
13	204, 242	Choko (M)	*Momordica foetida* Schumach.	Cucurbitaceae	Herb	Anthrax Blackleg, Amoebiasis	Whole plant is pounded, mixed with water and given orally	M
		Sherna/ Chigshini (A)	*Momordica foetida* Schumach.	Cucurbitaceae	Herb	Blackleg (*Abakorpa* (A))	Whole plant is pounded, mixed with water and administered nasally	A1, A2
14	20	Najie (M)	*Momordica pterocarpa* Hochst. ex A. Rich.	Cucurbitaceae	Herb	Anthrax, Blackleg, Amoebiasis	Leaves are pounded, mixed with water and given orally	M
15	285	Tsedo (M)	*Euphorbia tirucalli* L.	Euphorbiaceae	Shrub	Rabies (Gissili (M))	Root is chopped, pounded, mixed with water and given orally	M
16	624	Beta(A)	*Croton macrostachyus* Hochst. ex Delile	Euphorbiaceae	Tree	Blackleg (*Abakorpa* (A))	Leaves are pounded, mixed with water and given orally	A1, A2

Nº	Voucher Nº	Vernacular names: Maale (M) Araf(A)	Botanical name	Family	Growth form	Ailments treated (M= Maale; A=Araf)	Parts used, mode of preparation and application route	Study sites
		Beta	*Croton macrostachyus* Hochst. ex Delile	Euphorbiaceae	Tree	Constipation (*Nokorti wechta* (A))	Leaves are pounded, mixed with tepid water and given orally	A1, A2
17	227	Bato ketero deshe (M)	*Pelargonium quinquelobatum* Hochst. ex A. Rich.	Geraniaceae	Herb	Amoebiasis (*Ketero* (M))	Whole plant is chopped, pounded, mixed with tepid water and given orally	M
18	332, 441	Shai shar (A)	*Ajuga leucantha* Lukhoba	Lamiaceae	Herb	Blackleg (*Abakorpa* (A))	Whole plant is pounded, mixed with water and applied nasally	A2
		Shai shar	*Ajuga leucantha* Lukhoba	Lamiaceae	Herb	Retained placenta (*Filki* (A))	Whole plant is pounded, mixed with water and given orally	A1
19	221, 324, 196	Baye afi Deshe(M)	*Becium filamentosum* (Forssk.) Chiov.	Lamiaceae	Herb	Better milk	Leaves with succulent stem are pounded, mixed with water and given orally	M
20	38, 382, 482	Dumfeken (A)	*Clerodendrum myricoides* R.Br.	Lamiaceae	Shrub	Blackleg (*Abakorpa* (A))	Roots are chopped, pounded and given orally	A1
21	-	Damakasse*[c]	*Ocimum lamiifolium* Hochst. ex Benth.	Lamiaceae	Shrub	Blackleg (*Abakorpa* (A))	Whole plant is pounded, mixed with water and given orally	A2
22	127, 300	Afi Deshe (A)	*Alysicarpus rugosus* (Willd.) DC.	Leguminosae	Herb	Evil eye (*Afi isake*)	Whole plant is pounded, mixed with water and given orally	A2
23	468	Tsanka(A)	*Caesalpinia volkensii* Harms	Leguminosae	Climber	Blackleg (*Abakorpa* (A))	Leaves are pounded, mixed with water and given orally	A1
		Tsanka	*Caesalpinia volkensii* Harms	Leguminosae	Climber	Leeches (*Oulet* (A))	Leaves are pounded, mixed with water and given orally	A1
24	150	Sibsen (A)	*Entada africana* Guill. & Perr.	Leguminosae	Tree	stomach worms (*Nokorti ketsa*(A))	Leaves are ground, mixed with water and given orally	A1
	150	Sibsen	*Entada africana* Guill. & Perr.	Leguminosae	Tree	Scabies (*Shai)*	Leaves are chopped, pounded, mixed with water, allowed to stay for a day and then orally administered	A1
25	131, 251, 256, 261, 378	Wesfat deshe (A)	*Indigofera spicata* Forssk.	Leguminosae	Herb	Scabies (*Shai)*	Leaves with succulent stem are pounded, mixed with water and smeared on the skin	A2

Nº	Voucher Nº	Vernacular names: Maale (M) Araf(A)	Botanical name	Family	Growth form	Ailments treated (M= Maale; A=Araf)	Parts used, mode of preparation and application route	Study sites
26	179	Merki (A)	*Mucuna melanocarpa* A. Rich.	Leguminosae	Climber	Tick (*Denga* (A))	Roots are chopped, pounded, mixed with water and brushed on the infested part	A1
27	293, 633	Moshto (M)	*Ormocarpum trichocarpum* (Taub.) Engl.	Leguminosae	Shrub	Diarrhoea	Leaves with succulent stems are chopped, pounded, mixed with tepid water and given orally	M
28	286,	Gafritro (M)	*Rhynchosia elegans* A. Rich.	Leguminosae	Climber	Anthrax, Blackleg, Amoebiasis	Roots are chopped, pounded, mixed with tepid water and given orally	M
29	93	Chuksha (A)	*Sida rhombifolia* L.	Malvaceae	Herb	Calves constipation (nokorti wechte(A))	Leaves with succulent stem are chopped, mixed with water and administered orally	M, A1
30	100	Chorah*e* (M)	*Chasmanthera dependens* Hochst.	Menispermaceae	Climber	Anthrax, Blackleg, Amoebiasis	Stems are chopped, pound, mixed with water and administered orally	M
31	29, 96	Balari (M)	*Cissampelos mucronata* A.Rich.	Menispermaceae	Climber	Amoebiasis (*Ketero* (M))	Leaves with succulent stem are pounded, mixed with water and administered orally	M
		Balari (M)	*Cissampelos mucronata* A.Rich.	Menispermaceae	Climber	Rabies (Gissili (M))	Leaves with succulent stem are pounded, mixed with water and given orally	M
32	113	Shafa (A)	*Ficus sycomorus* L.	Moraceae	Tree	Diarrhoea (*Arsi* (A))	Leaves are pounded, mixed with water for oral administeration or fresh leaves are chopped, mixed with salt and fed to cattle	A1
33	-	Bahirzaf*c (A)	*Eucalyptus globulus* Labill.	Myrtaceae	Tree	Leeches (*Oulet* ,(A))	Leaves are pounded, mixed with water for oral administration	A1
34	22	Mukale (M)	*Ximenia caffra* Sond.	Olacaceae	Shrub	Foot rot (*Shukmo* (M))	Seeds are ground and seed oil is brushed on the affected skin	M
35	108	Rimiti (M)	*Olea europaea L.* subsp. *cuspidata* (Wall.ex G.Don) Cif.	Oleaceae	Tree	Ascariasis (*diperta* (A))	Leaves are pounded, mixed with tepid water and given orally	M
36	238,	Tserpa (A)	*Schrebera alata* (Hochst.)	Oleaceae	Tree	Eye cataract (*Afi*	Leaves are pounded, mixed with water	A1

Nº	Voucher Nº	Vernacular names: Maale (M) Araf(A)	Botanical name	Family	Growth form	Ailments treated (M= Maale; A=Araf)	Parts used, mode of preparation and application route	Study sites
			Welw.			*more*(A))	and applied into the eye	
37	241	Andod (A)	*Phytolacca dodecandra* L 'Herit.	Phytolaccaceae	Shrub	Blackleg (*Abakorpa* (A))	Root are pounded, mixed with water and administered orally	A1
38	-	Gos (A) *[c]	*Hordeum vulgare* L	Poaceae	Herb	Respiratory disease in goats	Seed are ground, mixed with tepid water and brushed on nose and mouth	M
39	151, 438, 488	Kelewa (A)	*Maesa lanceolata* Forssk.	Primulaceae	Tree	Leeches (*Oulet* (A))	Seed are pounded, mixed with water and given orally	A2
40	125, 331, 530	Zumi (A)	*Clausena anisata* (Willd.) Hook.f. ex Benth.	Rutaceae	Shrub	Blackleg (*Abakorpa* (A))	Leaves are pounded, mixed with water and administered nasally	A2
		Zumi	*Clausena anisata* (Willd.) Hook.f. ex Benth.	Rutaceae	Shrub	Anthrax (*Abasenga* (A))	Leaves are pounded, mixed with water and given orally	A2
41	31	Gedai (M)	*Zanthoxylum chalybeum* Engl.	Rutaceae	Tree	Contagious caprine and bovine pleuropneumonia (CCPP/ CBPP) (*Kumpo* (M))	Stem bark is chopped, boiled and administered orally	M
42	363	Saringa (M)	*Dodonea angustifolia* L.f.	Sapindaceae	Shrub	Scabies (*Ketsa* (A))	Whole plant is chopped, pound, mixed with water and brushed on the affected skin	M
43	-	Mitmita *[c]	*Capsicum annuum* L.	Solanaceae	Herb	Blackleg (*Abakorpa* (A))	Seeds are mixed with water and administered nasally	A1
44	-	Dempha (A)	*Nicotiana tabacum* L.	Solanaceae	Herb	Leeches (*Oulet* (A))	Leaves with succulent stem are chopped, mixed with water and given orally	M,A1 A2
45	-	Jamla (A)*[c]	*Zingiber officinale* Roscoe	Zingiberaceae	Herb	Blackleg (*Abakorpa* (A))	Rhizomes are pounded, mixed with water and given orally	A2
46	218	Mugrumo (M)	*Tribulus terrestris* L.	Zygophyllaceae	Herb	Foot rot (*Shukmo* (M))	Whole plants are chopped, mixed with water and brushed on the affected part	M

*c: cultivatedspecies; studysites—M: Maale, A1:Ari1and A2:Ari2.

6

General discussion

6. General discussion

This chapter highlights the main conclusions of the thesis by taking in to account the major findings of the previous chapters. It also provides major extension and development implications of this study. Moreover, it provides recommendations for further research in this area. The research questions listed in chapter 1 are used here as a central discussion point for this thesis.

6.1 Discussion and Synthesis

Rsearch question 1:

Which wild and semi-wild edible leafy vegetables and fruits bearing species are harvested and used by Maale and Ari ethnic groups? Are there seasonal differences in use of these plants? (Chapter 2 and 3)

The use of wild and semi-wild leafy vegetables to prepare traditional dishes is a common practice in both Maale and Ari ethnic groups. In this thesis, a total of 30 species of wild and semi-wild leafy vegetables that are used by the Maale and Ari are identified (Chapter 2). Consuming a wide diversity of leafy vegetables increases dietary diversity and consequently also increases the likelihood that different nutrients are included in the diet and thus contribute to a balanced diet.

Farmers in the study area still use leafy vegetables to prepare their local dishes thereby also lengthening somehow the period of food availability during food shortage periods. The importance of leafy vegetables during food shortage periods, and farmer's strategy of increased consumption of these vegetables during this period is a good opportunity for design, promotion and implementation of future participatory conservation.

Edible plant species have different uses as evaluated by the local people based on specific uses. In this thesis species use value were used to evaluate the differences between edible plants. Species with high use value reveal the cultural significance of the species. For example, among leafy vegetables *Balanites aegyptiaca* had the highest use value in the Maale study site. This is

attributed to the fact that this species is a tree and used for several other purposes than other leafy vegetables by the Maale ethnic groups. *B. aegyptiaca* is the only species in the study area that bears edible fruit and has its leaves used as vegetable. It is important species to the Maale (Chapter 2 and chapter 3; high use value, familiarity and preference). *Solanum dasyphyllum* had also the highest use value among other leafy vegetables by the Ari. Species with high use value also serve as a model species or entry species in the development and conservation project of edible plant resources in the area.

In total 52 wild and semi-wild edible fruit-bearing species were identified among the Maale and Ari ethnic groups (Chapter 3). The presence and use of high diversity of wild and semi-wild edible fruits were important during critical food shortage periods and also important to diversify the types and increase amount of important nutrient intake for the healthy growth and development of the communities. For example species such as *Ziziphus spina-christi* and *Diospyros mespiliformis* contained higher quantities of important nutrients than some cultivated species (Mengistu and Hager, 2009). Therefore, identifying such species and increasing their availability in the landscape is crucial. Species such as *Diospyros mespiliformis, Tamarindus indica*, *Ximenia caffra, Sterculia africana, Ficus sur, Grewia schweinfurthii* and *Ficus vasta* trees bore fruit during periods of severe drought and play a vital role during such periods. Such species also contribute to lessen hunger, and good health and also well-being thereby strengthen the efforts to attain sustainable development goals.

Edible plants serve not only as food but also used for medicinal purpose. Twenty one edible plant species were found in this study that have both food and medicinal importance (Table 6.1.). The presence and use of species that have both food and medicinal importance have contribution in maintaining the health of the community.

Table 6.1. Wild and semi-wild leafy vegetables and fruits that have medicinal importance for human and livestock diseases (chapter 2, 3, 4 and 5).

Nº	Scientific name	Family	Edible Leafy	Edible fruits	Medicinal for humans	Medicinal plants
1	*Pergularia daemia* (Forssk.) Chiov.	Apocynaceae	yes	No	no	yes
2	*Leptadenia hastata* (Pers.) Decne.	Apocynaceae	yes	No	no	yes
3	*Cleome gynandra* L.	Cleomaceae	yes	No	no	yes
4	*Momordica pterocarpa* Hochst. ex A.Rich.	Cucurbitaceae	yes	No	no	yes
5	*Kedrostis foetidissima* (Jacq.) Cogn.	Cucurbitaceae	yes	No	no	yes
6	*Cucumis dipsaceus* Ehrenb. ex Spach	Cucurbitaceae	yes	No	no	yes
7	*Portulaca quadrifida* L.	Portulacaceae	yes	No	no	yes
8	*Caylusea abyssinica* (Fresen.) Fisch. et C.A. Mey.	Resedaceae	yes	No	no	yes
9	*Solanum dasyphyllum* Schumach. et Thonn.	Solanaceae	yes	No	no	yes
10	*Balanites aegyptiaca* (L.) Delile	Zygophyllaceae	yes	yes	no	no
11	*Uvaria leptocladon* Oliv.	Annonaceae	no	yes	no	yes
12	*Carissa spinarum* L.	Apocynaceae	no	yes	yes	yes
13	*Garcinia livingstonei* T.Anderson	Clusiaceae	no	yes	no	yes
14	*Euclea divinorum* Hiern	Ebenaceae	no	yes	no	yes
15	*Piliostigma thonningii* (Schumach.) Milne-Redh.	Leguminosae	no	yes	no	yes
16	*Senna singueana* (Delile) Lock	Leguminosae	no	yes	no	yes
17	*Ficus sycomorus* L. subsp. *sycomorus*	Moraceae	no	yes	no	yes
18	*Ximenia caffra* Sond.	Olacaceae	no	yes	no	yes

Nº	Scientific name	Family	Edible Leafy	Edible fruits	Medicinal for humans	Medicinal plants
19	*Meyna tetraphylla* (Schweinf. ex Hiern) Robyns	Rubiaceae	no	yes	yes	no
20	*Vangueria apiculata* K.Schum.	Rubiaceae	no	yes	no	yes
21	*Balanites rotundifolia* (Tiegh.) Blatt.	Zygophyllaceae	no	yes	no	yes

"Yes" shows the species are used for specific use; "no" indicates not used for specific purpose by the studied ethnic communities

Research question 2:

Which medicinal and ethnoveterinary plants are used by the two ethnic groups and for what purposes they are used for? (Chapter 4 and 5)

Plants are used for the treatment of different types of human and livestock diseases in the study area. The most familiar animal diseases in the study area were Blackleg, Anthrax, CBPP, Trypanosomiasis, Diarrhoea and Amoebiasis. With regard to human ailments Malaria, Diarrhoea, Ascariasis, Amoebiasis, Headache and Stomach Ache were the main cited health problems in the study area.

In this thesis we found a total of 128 plant species used for the treatment of different types of human health problems (Chapter 4) and 46 medicinal plant species that were used to treat livestock diseases (Chapter 5). We also found 24 medicinal plant species that were used both for the treatment of livestock and human health problems (Table 6.2). The use of plants for both human and livestock disease create a good opportunity for the maintenance of the species in the landscape by different healers.

Table 6.2 Medicinal plants that are used both for livestock and human health problems

	Species	Human health problems	Livestock health problems
1	*Ozoroa insignis* Delile [XX]	Ascariasis	Ascariasis
2	*Centella asiatica (*L.) Urban	Gastritis, Headache, Evil Eye, Swelling	Increase milk production (Ratse weyte (A)), Blackleg
3	*Carissa spinarum* L.	Tonsilites, Snake protection, Stomach ache, Evil eye	Increase milk production (Ratse weyte (A))
4	*Lepidium sativum* L.	Common cold	Blackleg
5	*Acmella caulirhiza* Delile	Tooth ache, Tonsillitis	Blackleg
6	*Tagetes minuta* L. [XX]	Rheumatism, Amoebiasis	Anthrax, Blackleg, Amoebiasis
7	*Vernonia amygdalina* Delile	Malaria	Trypanasomiasis prevention, Increase milk production
8	*Momordica foetida* Schumach. [XX]	Amoebiasis	Amoebiasis, Anthrax Blackleg,
9	*Momordica pterocarpa* Hochst. ex A.Rich. [XX]	Evil eye, Amoebiasis	Anthrax, Blackleg, Amoebiasis
10	*Croton macrostachyus* Hochst.ex Ferret & Galinier	Gonorrhea, Tape worm	Blackleg, Constipation
11	*Pelargonium quinquelobatum* Hochst. ex A.Rich., [XX]	Amoebiasis	Amoebiasis
12	*Ajuga leucantha* Lukhoba	Diarrhea	Blackleg, Retained placenta
13	*Becium filamentosum* (Forssk.) Chiov.	Stomach ache, Heart, Rheumatism	Better milk
14	*Clerodendrum myricoides (Hochst.) Vatke*	Stomach bloating, vomiting, Evil eye	Blackleg
15	*Ocimum lamiifolium*	Heart disease, Headache	Blackleg
16	*Indigofera spicata* Forssk.	Tonsillites, Diarrhea, Evil eye, Ascariasis, Stomach ache	Scabies

	Species	Human health problems	Livestock health problems
17	*Chasmanthera dependens* Hochst. [XX and X]	Amoebiasis, Swelling	Amoebiasis,Anthrax, Blackleg,
18	*Cissampelos mucronata* A.Rich [XX]	Amoebiasis, Rabies, Diarrhea, Stomach ache	Amoebiasis, Rabies
19	*Ximenia caffra* Sond. [X]	Wound	Foot rot
20	*Olea europaea* L. subsp. *cuspidata* (Wall. ex G.Don) Cif. [XX]	Ascariasis, Gonorrhea	Ascariasis
21	*Phytolacca dodecandra* L 'Hérit.	Gonorrhea, Stomach Bloating	Blackleg
22	*Zanthoxylum chalybeum* Engl. [X]	Common cold	Contagious caprine and bovine pleuropneumonia (CCPP/ CBPP)
23	*Nicotiana tabacum* L. [XX]	Leeches	Leeches
24	*Capsicum annuum* L.	Malaria	Blackleg

"XX" show medicinal plants used for the same type of disease in humans and livestock, "x" used for medicinal plants that are used for the diseases that have similarities

Species such as *Ozoroa insignis, Tagetes minuta, Momordica foetida, Momordica pterocarpa, Pelargonium quinquelobatum, Chasmanthera dependens*, *Cissampelos mucronata, Olea europaea, Nicotiana tabacum* (Table 6.2) are used for the treatment of similar type of human and livestock diseases in the area. They are considered as potential medicinal species and calls research attention to investigate their active compounds.

This thesis also showed that the most widely used growth form of medicinal plants and were herbs, and the dominant plant parts harvested were leaves. Harvesting of leaves may not have negative effects on resource availability, if the plant itself is not destroyed and provided seed setting is not affected. Therefore, it is important to educate traditional healers considering the

means of propagation of medicinal plants so as to ensure sustainable utilization. In some cases, roots of the plants are also used for medicinal purposes. Harvesting of roots from trees may have negative effect on the sustainability of the resources depending upon the species harvested and season of harvesting. In most cases root harvesting disturbs the soil environment and induces soil erosion. For example, around Kure area the roots of *Carissa spinarum* were harvested and soils around the roots of the plant was disturbed and exposed to erosion (Figure 6.1). This indicates that root harvesting not only affects the health of the plant but also induce soil erosion. Therefore, there is a need to create awareness on the possible consequences of root harvesting so that traditional healers are able to sustainably utilize and manage both plant and soil resources.

Figure 6.1 Harvesting of *Carissa spinarum* roots around Kure (Photo taken by Berhane Kidane)

Research question 3:

Do the two ethnic groups differ in their knowledge and use of wild and semi-wild edible and medicinal plants? What socio-economic and demographic factors significantly influence use of wild and semi-wild plants? (Chapter 2, 3, 4 and 5)

In this thesis Jaccard's similarity index (JI) was used to understand similarities/differences on the species used between sites. Jaccard's similarity index showed similar trends between studied sites for all studied domains of knowledge (Table 6.3). For example, for all domains of knowledge JI values between Ari 1 and Ari 2 study sites were 0.5556, 0.5000, 0.24, 0.33 and were higher values than values between other sites (Table 6.3). This is attributed to geographical proximity and similar cultural experience of the two Ari sites. Low similarity indices between Maale and Ari sites (< 0.2) reflects differences on the use of edible and medicinal plants between ethnic groups and attributed not only due to geographical proximity but also due to differences in cultural experience.

Table 6.3 Summary on Jaccard's similarity indices of plant use between study sites and ethinc groups

	Leafy vegetables		Wild fruits		Livestock medicine		Human medicinal plants	
Sites	Maale	Ari 2	Maale	Ari 2	Maale	Ari 2	Maale	Ari 2
Ari 1	0.1333	0.5556	0.1923	0.5000	0.13	0.24	0.14	0.33
Ari 2	0.0714	-	0.0583	-	0.09	-	0.08	-

The study also revealed that species popularity/familiarity varies between sites and is highly influenced by resource availability in the locality, by the long lasting culture of use and

preference. *Balanites aegyptiaca, Momordica pterocarpa, Solanum dasyphyllum* and *Solanum nigrum* have a high familiarity index (Chapter 2) from reported leafy vegetables and *Balanites rotundifolia, Vitex doniana* and *Garcinia livingstonei* were the most familiar species from the category of wild/semi-wild fruits (Chapter 3). With regard to variation between gender and age groups at each site no significant difference were obtained for both leafy vegetables and fruits. This is associated with ecology, cultural preference and open knowledge transfer. However, in the case of human and livestock medicinal plants, in all study sites Male respondents knew higher number of medicinal plants than women and associated with favouring of men in knowledge transfer.

Knowledge and use of wild plant evaluation could also contribute to understanding of any process within the community that erodes knowledge (Ladio and Lozada, 2004). In this thesis knowledge distribution frequencies were used in order to understand the degree how the knowledge is shared within the two ethnic groups, based on the studied knowledge domains. The study results showed that no variation exist between social groups with respect to edible plant knowledge. However, differences were obtained on medicinal plants knowledge for gender groups.

Male study participants knew a higher number of medicinal plants than females. This is attributed to favouring males in medicinal plant knowledge transfer by both ethnic groups . Similarly the average number of ethnoveterinary plants known by males was higher than by the females in all study sites and this was also attributed to the favouring of sons in knowledge transfer and the perception of the ethnic groups that dealing with livestock is the task of men. This type of perception and culture together with the unwillingness of healers to plant more herbaceous medicinal plants in home gardens may affect the future conservation of medicinal plants especially in home gardens, as women play a major role in managing these gardens (Chapter 3 and 4). Therefore, it is important to continuously train healers so as to increase their capacity and awareness especially on management and conservation of medicinal plants under existing local and cultural conditions.

Research question 4:

What are farmer's motives for the possible transition of wild leafy vegetables and fruits to semi-wild or even cultivated conditions? (Chapter 2 and 3)

The study identified farmers' important criteria for the possible transition of wild and semi-wild leafy vegetables and fruits to semi-wild or even cultivated conditions. Under the current rapid negative change of vegetation, understanding the major criterion for transition is important for policy makers for developing important strategies that help future maintenance and cultivation of wild and semi-wild species in the landscape. Taste, marketability and above-ground edible biomass were farmers' main selection criterion suitable for leafy vegetables cultivation. Taste is also considered as one of the important criteria to define culturally important food in Talle, Niger (Alexandra et al., 2013). Farmers' criteria influence future cultivation and promotion of edible plant species. Study participants in all three study sites identified the most important wild and semi-wild leafy vegetable species according to their taste. Among leafy vegetables *Balanites aegyptiaca* ranked first in Maale and *Solanum dasyphyllum* ranked highest in the two Ari study sites. From fruit trees *Balanites rotundifolia* ranked first in Maale (Chapter 2) whereas *Manilkara butugi* came first in Ari study sites (Chapter 3). Therefore, any development program related to wild edible and medicinal plants will be successful in the area provided it starts with the promotion and expansion of most preferred and ranked species. The criterion high above ground biomass for leafy vegetables is equally important with the criterion high fruit yield for fruit bearing trees.

Research question 5:

What are the mechanisms of edible and medicinal plant knowledge transfer among different social groups and how are these plants marketed? (Chapters 2, 3, 4 and 5)

Understanding the mechanisms of knowledge transfer is important in order to preserve knowledge. This study found differences in mechanisms of knowledge transmission for edible and medicinal plants. Knowledge transfer mechanism for edible wild and semi-wild leafy vegetable and fruit bearing species is open to everybody. However, knowledge transfer mechanism medicinal and ethnoveterinary plants is more secretive and was predominantly restricted to family members, in particular to first-born sons; this may negatively affect knowledge continuity. Open type of knowledge transfer contribute to knowledge continuity, and also resources development and conservation. But loss of knowledge on wild and semi-wild leafy vegetables may also occur if these resources gradually disappear from the landscape. Thus, what so ever the mechanism of transfer exists, I suggest systematically documentation of the existing traditional knowledge is crucial. Moreover, it is also necessary to work towards minimizing those factors (research question 8) that threaten these resources in the landscape because knowledge transfer is operated by showing the plant species in the field.

Marketability and price of the products also play an important role in the cultivation and conservation of the species concerned in the landscape. That was the reason why marketing ranked by the participated communities as the second most important criterion next to taste for the cultivation of wild and semi-wild leafy vegetables. Trade of cultivated leafy vegetables and fruits is common in the study area. Selection and prioritization of species based of the criterion is important for future development and research work.

The results of the study showed that collecting wild and semi-wild fruit to sell on the market was quoted as a common practice by the rural communities during different seasons. However, the prices of wild and semi-wild fruits were very low compared to those of cultivated species. The low price and inadequate market supply of wild and semi-wild fruits discouraged traders to market this resource and also hampered the promotion of trade. This in turn has an impact on the future cultivation and maintenance of these edible species in the landscape. Thus, it is important to work towards improving the supply chain that attracts more actors in the value chain, whicht indirectly encourages producers and also contribute to resource availability.

Marketing of medicinal and ethnoveterinary plants may have implications on the availability of the resources in the area depending up on the species marketed, the type of plant part harvested, volumes sold and cultivation efforts of marketed species. Marketing of medicinal plants is common only for a few well-known species such as *Hagenia abyssinica* flowers and *Embelia shimperi* seeds (both wild collected) and the cultivated *Allium sativum* and *Artemisia absinthium*. Low income obtained from marketing of medicinal plants and herbal treatments may also have negative implications in the future on the conservation of medicinal plants in the landscape by traditional healers. Therefore, understanding how to create marketing opportunity and improve the market chain for them is important but requires due attention as creating good market opportunity do not always lead to resource conservation and management but it may also lead to rapid resources degradation depending up on the productive biology and current resource availability of the species.

Research question 6:

What factors threaten wild and semi-wild leafy vegetables and fruit and medicinal plant resource availability in the study area? (Chapters 2, 3, 4 and 5)

Study participants mostly collected medicinal plants from crop fields, home gardens and nearby forest patches. However, there is a concern among communities and elder knowledgeable people on continued plant resource degradation around their village. In this thesis we found agricultural land expansion, limited or lack of enrichment planting, the decline of natural habitats, little tradition of planting and nurturing, harvesting for other uses, drought, fuel wood collection, overgrazing and wildfires as the major factors threatening the availability of wild and semi-wild resources in the study area. Like in many other developing countries among these factors agricultural expansion is the major threatening factor both for herbaceous and tree resources. In most cases agricultural land expansion is associated with population pressure as mentioned by the study participants. Cruz-Garcia (2012) also associated this with homogenizing of the landscape and considered it as a threat to the maintenance of the habitat where wild and semi-

wild plants grow. Moreover, the continuous escalating price for grain crops indirectly influences communities to have more cropland which result in pushing people to deforest the remaining forest patches for cultivation of grain crops.

Thus, all concerned actors including policy makers have to work towards mechanisms that alleviate or minimize factors that halt the loss of these valuable resources so as to contribute to sustainable development goals. There is also an urgent need to design and implement in-situ and ex-situ conservation projects in order to contribute for the conservation of plant resources and preservation of the associated knowledge. Otherwise, dwindling of resources around settlements may have negative implications on wild and semi-wild plant resources availability and also on future transfer and continuity of medicinal plant knowledge. Moreover, if plant resources are not available nearby, it would be difficult for elder knowledgeable persons to walk long distances from their residence to transfer knowledge as in most cases knowledge transfer is made based on practices (chapters 2,3.4 and chapter 5).

6.2 Development, policy and research recommendations

6.2.1 Development and policy recommendations

Based on the findings of the study, the following recommendations for policy makers and development practitioners are suggested:

- Given the rapid land use changes, the protection, maintenance and sustainable management of edible wild leafy vegetables, fruits and medicinal plant species must begin with improving the management of the remaining vegetation which is natural habitats of these species. We recommend that this be the first priority for development practitioners, and conservation workers and by all who are directly or indirectly involved in these resource.

- Agricultural, forest and health extension workers working at local level need to be aware of the importance of promoting the cultivation and use of prioritized edible wild and semi-wild leafy vegetables and fruit bearing species in home gardens and crop fields as this will facilitate of controlling access and use due to defined land and plant ownership.

• Encourage rural communities to cultivate and use edible wild leafy vegetables, fruits and medicinal plant species, provide options to acquire quality seeds and planting materials, and also identify appropriate storage mechanisms to increase shelf life of these plants.

• Species that have highest use value, for example *Balanites aegyptiaca* by Maale communities and *Solanum dasyphyllum* by Ari communities could be considered as model species for promoting cultivation and development of use of leafy vegetables in the study area. Identifying model species by actively engaging local communities is important for supporting cultivation and afforestation programmes in ways that also support efforts to conserve and sustainable use edible and medicinal plants. Thus, model species preferred by local communities should be identified, prioritized and their cultivation should be supported to combat loss of important plant species.

• Creating market demand and facilitating better market outlets will encourage communities to cultivate edible wild and semi-wild fruit bearing species.

• Minimizing and if possible alleviating factors that threaten the resource is a viable strategy for protection of edible wild and semi-wild vegetable and fruit species and should be supported by complementary *in-situ* and *ex-situ* conservation strategies to conserve and sustainably utilize the remaining resource and the associated knowledge.

• Preserving the hitherto documented knowledge and establishing data repository system on medicinal and food plants is strongly recommended under the existing high rate of deforestation and land use changes and loss of traditional knowledge.

6.2.2 Research Recommendations

Based on the study, the author proposes the following topics to be considered by researchers.

• Similar studies need to be conducted in other areas and communities living in other remote areas that have not been studied thus far before plant resources and traditional knowledge are lost due to changes in land uses, climate and lifestyles.

• Though wild and semi-wild leafy vegetables and fruits could play important roles in improving the quality and diversifying diets but their value chains are underdeveloped. Prices of wild and semi-wild fruits are very low compared to cultivated species and this obviously discourages domestication and cultivation. Studies to identify options for improving the value chains for the wild and semi-wild fruits are proposed to promote their cultivation and use.

• Research should also address post-harvest handling technologies of various species of wild and semi-wild leafy vegetables and fruits considering local resources and conditions. It is also

important to focus on developing technologies that improve growth, productivity and yield of leafy vegetables and fruits.

• Studies are needed to accurately quantify the nutrient contents of wild and semi-wild vegetable and fruits species to better understand the relative contribution of these species to nutritional security of consumers. Moreover, research that focuses on identifying options to improve nutritional quality of these foods is also necessary to improve their use.

• Among many, the major medicinal plant species for the treatment of human diseases are *Solanum dasyphyllum*, *Indigofera spicata*, *Plumbago zeylanica*, and *Meyna tetraphylla.* These species deserve further studies. Multiple use species such as *Oxalis radicosa* are also good candidates for consideration for further phytochemical and pharmacological research.

• Further studies to support the use of plants for treating livestock diseases are also recommended. For instance, Blackleg disease affects livestock production not only in the study area but also in many other parts of the country. Therefore, research should focus on species used for the treatment of blackleg disease (Table 5.1.1). Moreover, research should also consider "the association between the occurrence of blackleg disease and the consumption of fresh maize stalks". Phytochemical studies and pharmacological testing of popular medicinal plants species used for livestock disease is also suggested for *Lepidium sativum*, *Allium sativum*, *Clausena anisata, Croton macrostachyus*, *Ozoroa insignis*, *Sida rhombifolia*, *Cissampelos mucronata*, *Vernonia theophrastifolia* and *Vernonia amygdalina*.

• Phytochemical and pharmacological investigation are proposed for medicinal plant species such as *Ozoroa insignis*, *Tagetes minuta*, *Momordica foetida*, *Momordica pterocarpa*, *Pelargonium quinquelobatum*, *Chasmanthera dependens*, *Cissampelos mucronata*, *Olea europaea*, and *Nicotiana tabacum* that are used for the treatment of similar human and livestock ailments (from Table 6.2). In the long run, studies need to include the propagation, silviculture and management aspects of the different medicinal plants of Ethiopia.

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Thesis summary

Wild and semi-wild plant resources that have food and medicinal importance are distributed at different habitats in Ethiopia and play an important role in the livelihood of different communities. This study discussed ethnobotany of these resources with special emphasis on the use, management and conservation of wild and semi-wild edible and medicinal plants by the two ethnic groups in southern Ethiopia.

Chapter 1 presents a general introduction of the study. It provides background information about the relevance of edible and medicinal plants and followed by describing the importance of the study and scientific problem statement. It also highlights the research objectives and the major research questions that were addressed in the study. It also briefly explains the research methodology and approaches used for the study.

Chapter 2 explores dealt a detailed analysis and discussions of an ethnobotanical study of wild and semi-wild leafy vegetable species that are found and used by the Maale and Ari ethnic groups. The two communities consumed in total 30 leafy vegetable species, which were crucial ingredients in the preparation of traditional dishes, more frequently during periods of food shortage. The study revealed that the transfer of local knowledge within the community on wild and semi-wild leafy vegetables is not differentiated by gender or age and thus enables knowledge continuity. However, harvesting and cooking activities are considered as women's tasks by the communities. The study also found out that taste, marketability and above ground edible biomass as the main farmers' criteria for selection leafy vegetables for cultivation. Major threats to wild and semi-wild leafy vegetables are identified and recommended that these factors has to be minimized and supported by complementary in-situ and ex situ conservation strategies.

Chapter 3 examined ethnobotany of wild and semi-wild edible fruits. The two ethnic groups use 52 species of wild and semi-wild fruits which were especially important for their diet in times of food shortage. The study revealed species such as *Balanites rotundifolia* and *Dobera glabra* in

Maale and *Carissa spinarum* and *Vitex doniana* in *Ari* as the most important fruit bearing species. No significant variations in ethnobotanical knowledge regarding fruits were found among gender and age groups. The study revealed that low prices, poor market and outlet opportunities hamper wild and semi-wild fruits trade. Thus, creating demand and facilitating better market outlets will encourage communities to cultivate wild and semi-wild fruits in the future. The major threat to the availability of wild and semi-wild fruits in the study area were tree felling and conversion of forest to agricultural land. The study recommended maintenance and enrichment planting of the most important species as plausible management interventions in addition to preserving the local knowledge and implementing conservation strategies.

Chapter 4 evidenced the use and management of medicinal plants that are used by the Maale and Ari ethnic groups. It shows how medicinal plants are important for the health care of the Maale and Ari communities. In total 128 plant species were found and also 89 % of the study participants reflected traditional medicine as the first line of treatment. The dominant ways of medicinal plant knowledge acquisition and transfer is vertical. The study revealed that gender and site significantly influenced the number of human medicinal plants known. The fact that knowledge transfer was predominantly to family members and in particular to first-born sons may negatively affect its continuity and may result in knowledge loss if medicinal plant resources become scarce in the landscape in the near future. Marketing of medicinal plants harvested from wild and semi-wild stands is not common. Low income obtained from marketing of medicinal plants and herbal treatments may have strong implications on the future conservation of medicinal plants in the landscape. The study suggested few species such as *Solanum dasyphyllum, Indigofera spicata, Plumbago zeylanica, Meyna tetraphylla*. and *Oxalis* for consideration for phytochemical and pharmacological testing to verify their efficacy and determine their dosages. Predominantly harvested plant parts were leaves, which are known to have relatively low impact on medicinal plant resources. However, expansion of agricultural land and lack of cultivation efforts by local communities were the main factors that directly or indirectly affect the availability of medicinal plant resources in the landscape. Therefore, land use planning and development initiatives in the area and beyond need to sharply focus on strategies that could contribute in alleviating the major threats affecting medicinal plant

resources in the landscape and encourage their cultivation to enhance their availability and complement ex-and in-situ conservation.

Chapter 5 presented insight on the ethnoveterinary medicinal plants used, popular (familiar) by the Maale and Ari ethnic groups. Forty six (46) plant species were used for the treatment of livestock diseases by the study communities. The most frequently cited cattle disease was blackleg, for which 21 plant species were found. The study also showed how ethnoveterinary plant knowledge is significantly affected by gender and site. Knowledge on ethnoveterinary plants was predominantly held by males, who cited more plant uses than females. This may affect the future conservation of medicinal plants especially in homegardens, as women play a major role in tending these gardens. The study suggested species such as *Lepidium sativum, Allium sativum, Clausena anisata, Croton macrostachyus, Ozoroa insignis, Sida rhombifolia, Centella asiatica, Cissampelos mucronata, Vernonia theophrastifolia* and *Vernonia amygdalina* for future phytochemical studies and pharmacological testing. The study also recommended the association of blackleg disease with the consumption of fresh maize stalks for further research.

Chapter 6 demonstrated the synthesis of other chapters of the thesis. This chapter critically discusses and reflects on the major findings of the research. The discussions and reflections are based on answering the major research questions that were addressed in different chapters of the thesis. Moreover, this chapter provided the major development, policy and research recommendations of the study.

PE&RC Training and Education Statement

With the training and education activities listed below the PhD candidate has complied with the requirements set by the C.T. de Wit Graduate School for Production Ecology and Resource Conservation (PE&RC) which comprises of a minimum total of 32 ECTS (= 22 weeks of activities)

Review of literature (6 ECTS)

- Importance of wild edible and medicinal plants (2010)
-

Writing of project proposal (4.5 ECTS)

- Ethnobotany and diversity of wild and semi-wild edible and traditional medicinal plants
-

Post-graduate courses (7.5 ECTS)

- Cognitive issue in survey responses; Mansholt Graduate School, Wageningen (2010)
- Doing interpretative analysis; Mansholt Graduate School, Wageningen (2010)
- Multivariate analysis; PE&RC, Wageningen (2010)

Laboratory training and working visits (6 ECTS)

- Bamboo and rattan green industry development for INBAR member countries; People's Republic of China; International Centre for Bamboo and Rattan, INBAR, China (2016)

Invited review of (unpublished) journal manuscript (1 ECTS)

- Environmental Development: impacts of productive safety net programme farmers' investments in sustainable land management: a case study in the Central Rif Valley of Ethiopian (2014)
-

Deficiency, refresh, brush-up courses (12 ECTS)

- Technography, researching technology and development; TAD, Wageningen (2010)
- Methods, techniques and analysis of field research; Wageningen (2011)

Competence strengthening / skills courses (2.1 ECTS)

- Project and time management; Valley Consult, Wageningen (2010)
- Information, literacy including Endnote; WUR Library, Wageningen (2010)

PE&RC Annual meetings, seminars and the PE&RC weekend (1.2 ECTS)

- PhD Student's day of WGS (2010)
- Seminar of Biosystematics group (2010)

Discussion groups / local seminars / other scientific meetings (5.5 ECTS)

- Workshop: working with communities on integrated natural resources management; oral presentations; Holetta, Ethiopia (2008)
- Relevant theme symposia of WGS; Wageningen (2010)
- TAD Lunch time seminar; Wageningen (2010-2012)
- Interpretative discussion group; Wageningen (2010-2012)
- Research review meetings and other scientific meetings; Ethiopia (2010-2014)

International symposia, workshops and conferences (4.4 ECTS)

- Enabling communities to improve mountain in livelihoods and landscapes; oral presentation; Nairobi, Kenya (2004)
- International symposium on the rehabilitation of dry land forests in Ethiopia: ecology and management; oral presentation; Mekelle, Ethiopia (2004)

CURRICULUM VITAE

Berhane Kidane Mengesha was born on April 18, 1966 in Jinka town, Southern Ethiopia. After attending primary and secondary schools in Jinka town, he joined Hawassa College of Agriculture, Addis Ababa University, and completed his study in Plant Sciences and Technology with distinction in 1985. After completing his studies, Berhane joined the Ethiopian Institute of Agricultural Research (EIAR), the former Institute of Agricultural Research (IAR), and worked in various departments with different capacities. He then went to Dresden University of Technology, Germany to attend graduate programme and obtained MSc degree in Forestry in 1994. He came back to Ethiopia and joined the Agricultural Development Bureau of the Southern Ethiopia and served the Bureau by assuming different positions for close to four years. In May 1998, he rejoined the Ethiopian Institute of Agricultural Research, and served the institute till 2010. During this period, he served as head of the Forestry Research Department in the research center, in addition to serving as researcher.

Berhane joined Wageningen University in 2010 to peruse his PhD study that resulted in this dissertation. His PhD focused on Ethnobotany of wild and semi-wild edible and medicinal plants used by the Maale and Ari ethnic groups in Southern Ethiopia. His research findings have been published as journal articles, conference proceedings, and book chapter and contributed to knowledge generation and science.

In December 2014, the Ethiopian Environment and Forest research Institute (EEFRI) was established by upgrading the Forestry Research Center of EIAR. Berhane joined EEFRI and serve as the Head of Non-timber Forest Products Research Division until June 2015. From July 2015 to May 2019, Berhane served EEFRI as Director of Forest Resources Utilization Research, which encompasses non-timber, timber utilization and also bio-energy and biochemical research divisions.

Berhane's experiences in research while working in the research institutes include: ethnobotanical, ecological, Agroforestry, non-timber, bioenergy, integrated watershed management, action and participatory research

PUBLICATIONS:

Journals and book chapters

Berhane Kidane, Tinde van Andel, L.J.G. van der Maesen, Zemede Asfaw. 2014. Ethnoveterinary medicinal plants used by the Maale and Ari ethnic communities in southern Ethiopia. *Journal of Ethnopharmacology* 153, 274-282.

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