Assessment of Plant Diversity and Utilization of Wild Medicinal Species by Households Proximate to Arabuko Sokoke Forest in Kilifi County of Kenya

BY

Ahmed, Bakari Maunguja (B.Sc. Range Management, University of Nairobi)

A thesis submitted to the Board of Postgraduate Studies in partial fulfilment of the requirements for the degree of Master of Science in Range Management in the Department of Land Resource Management and Agricultural Technology, Faculty of Agriculture, University of Nairobi

© August, 2016

DECLARATION

THIS THESIS IS MY ORIGINAL WORK AND HAS NOT BEEN PRESENTED FOR THE AWARD OF A DEGREE IN ANY OTHER UNIVERSITY.

SIGNATURE: ……………………………………DATE: ………………………………………..

MAUNGUJA BAKARI AHMED

Department of Land Resource and Agricultural Technology, Faculty of Agriculture, University of Nairobi.

THIS THESIS HAS BEEN SUBMITTED FOR EXAMINATION WITH OUR APPROVAL AS THE SUPERVISORS:

SIGNATURE: …………………………………... DATE: ………………………………………..

DR. OLIVER V. WASONGA

Department of Land Resource and Agricultural Technology, Faculty of Agriculture, University of Nairobi.

SIGNATURE: ………………………………….. DATE: ………………………………………..

DR. OSCAR K. KOECH

Department of Land Resource and Agricultural Technology, Faculty of Agriculture, University of Nairobi.

SIGNATURE: ………………………………….. DATE: ………………………………………

DR. MELCKZEDECK K. OSORE

Kenya Marine and Fisheries Research Institute, Mombasa, Kenya.

DEDICATION

To my parents, Abubakar Maunguja and Rehema Wandaa; who are my source of inspiration and encouragement throughout my life, may God bestow His Mercy on you.

ACKNOWLEDGEMENT

First and above all, I thank God for His blessings and for giving me the strength to proceed successfully with my studies.

I would like to express my gratitude to my supervisors Dr. Oliver V. Wasonga, Dr. Oscar K. Koech and Dr. Melckzedeck K. Osore for their continuous guidance throughout my study. This work would not be possible without their patience, criticism and thoughtful guidance that contributed to this thesis. My gratitude also goes to Kenya Coastal Development Project (KCDP) for offering me a Master of Science scholarship and for funding this research. I also thank KCDP for offering me opportunities to participate and present my work in conferences. This provided me with opportunity to interact with scientists from various institutions who guided me in the right direction.

My cordial thanks goes to my field assistants Mr. Godfrey Mashauri, Mr. Alex Mwalimu, Ms Priscilla Nassoro and Mr. Nathaniel Shida for their excellent support during my fieldwork. I greatly appreciate Kenya Forestry Research Institute (KEFRI) and the administrative officers of the different villages of Arabuko area for their assistance in identifying knowledgeable individuals and herbalists, and for the cooperation by respondents who participated in the data collection. I am also grateful to my friends Dr. Abdulghani and Mohamed Adan for making my stay in Malindi safe and enjoyable. I acknowledge my colleagues Lutta Alphayo, Klerkson Okomboli and Sakimba Kimiti for providing me with statistical advice. I extend my gratitude to my dear wife and friend Mwanahija Khamis for her motivation and editing support.

Finally, to my siblings Jamila, Athman, Mishi, Ahmed, Ibrahim, Babu and friends who contributed to my study through practical and moral support. Thank you for everything and may Allah bless you in return.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

ABBREVIATIONS AND ACRONYMS

ASF	Arabuko Sokoke Forest
ASFMT	Arabuko Sokoke Forest Management Team
CEPF	Critical Ecosystem Partnership Fund
CITES	Convention on International Trade in Endangered Species
EARPO	Eastern Africa Regional programme Office
DBH	Diameter at breast height
FAO	United Nations Food and Agriculture Organization
FGD	Focus group discussion
KEFRI	Kenya Forestry Research Institute
KII	Key informant interview
Km	Kilometer
Kshs	Kenyan shillings
NGO	Non Governmental Organization
NTFPs	Non timber forest products
RoK	Republic of Kenya
SPSS	Statistical Package for the Social Sciences
TEK	Traditional ecological knowledge
USD	United States dollar
VIF	Variance Inflation Factor
WHO	World Health Organization
WWF	World Wide Fund for Nature

ABSTRACT

Forests play fundamental roles in the provision of goods and services that are of utmost importance for the subsistence and commercial needs of the rural communities worldwide. However, there has been a reduction in the natural forest due to threats that are mainly attributed to anthropogenic activities. The advent of climate change is likely to worsen the situation. The pressure on forest resources is catalyzed by expansion of markets for forest products, agricultural expansion and infrastructural development. For instance, an upsurge in the number of herbal users in the urban and rural areas has increased the pressure on the forests, while modernization and changes in lifestyle have led to loss of traditional knowledge on utilization and conservation of forest resources. However, there is little empirical evidence on factors affecting knowledge and the status of the utilized and marketed plant resources from the forest. This study was therefore carried out in Arabuko Sokoke forest in Kilifi county of Kenya to determine plant species diversity, and their distribution in the disturbed and undisturbed areas of the forest; assess knowledge, utilization and contribution of medicinal plants to communities adjacent to the Arabuko Sokoke Forest. The study also analysed marketing channels for the traded herbal species and challenges in the trade. Plot and plotless techniques were used to gather ecological data on frequency, density, diversity and distribution of plants in the Arabuko Sokoke forest, whereas key informant interviews, focus group discussions and household interviews were used to gather information on ethnobotanical knowledge and household socioeconomic data.

The highest plant species richness (78 species) and diversity (2.86±0.07) was recorded in the mixed community as compared to the brachystegia and cynometra communities. This was attributed to the favorable microclimatic and edaphic conditions in the mixed forest community. Species diversity was significantly ($P<0.05$) higher in the disturbed areas (2.55±0.06 in cynometra community and 2.86±0.07 in the mixed community) than in the undisturbed areas (2.25±0.07 in cynometra community and 2.51±0.07 in the mixed community). The results also showed a higher number of woody plants with small diameter (4.0 to 33.9 cm), which depicts good generation recruitment in the forest.

The results of the multiple regression model showed that age, use of herbal remedies, formal education of the household head and households' engagement in agriculture as the chief source of livelihood influenced the knowledge on medicinal plants. Anthropogenic factors such as charcoal production and commercialization of herbal products contributed considerable threat to medicinal plants. The results show that majority (71%) of households use plant medicine for treatment of the common diseases. In addition to scarcity of some forest species and poor market linkages, lack of proper processing and storage technologies, as well as value addition were mentioned as the key challenges in herbal medicine trade. The results also show that most of the traded plant products were obtained from the wild, and therefore pointing at the potential threat to the resource base in the absence of appropriate conservation strategy.

From the results of this study, we recommend community awareness on sustainable forest utilization. The study further recommends the preservation of ethnobotanical knowledge through documentation and promotion of knowledge transmission to the youth. In addition, in situ conservation, domestication of the rare marketed wild medicinal plants and enhancement of market linkages is necessary to ensure maximum economic returns from herbal medicine trade.

Keywords: Medicinal plants; Use values; Knowledge on medicinal plants; Species diversity; Trade of herbal products; Arabuko Sokoke forest

CHAPTER ONE

INTRODUCTION

1.1 Background

Forests cover 31% of the earth land area, and about 240 million people live in and around these forest ecosystems (United Nations Food and Agriculture Organization (FAO), 2010; World Bank , 2003). In Africa, forests contribute 17% of the world's forest land size and they are the source of livelihoods for the adjacent communities (Schippmann *et al*., 2006). Decline in forest cover has been recorded around the globe (FAO, 2010; Achard *et al.*, 2002), and the threats to biodiversity in these ecosystems are attributed to anthropogenic and natural disturbances (Foody *et al.,* 2003; Salafsky *et al.*, 2008). The latter is manifested in the form of extreme weather conditions and climate change, while the former is through deforestation catalyzed by the need for agricultural expansion, infrastructural development and energy production. Anthropogenic activities have greatly impacted the diversity and distribution of species in the forest ecosystems and in some instances leading to species reduction (Fashing *et al.,* 2004; Sodhi and Brook, 2006; Brook *et al*., 2008; Mligo, 2015).

In Kenya forests makes up to 7% of the total land size and this is below the targeted cover of 10% (Republic of Kenya (RoK), 2008a, 2014). An estimated 3.6% of the Kenya's Gross Domestic product is derived from forests through direct and indirect contribution to the local and national economies (RoK, 2014). In addition, and perhaps more important these ecosystems serve as major sources of subsistence needs for the poor communities living around them (Sunderlin *et al.,* 2005; Matiku *et al.,* 2013). The non timber forest products (NTFPs) include wild plants harvested for: their medicinal values; dietary requirements; poisons; glue; ornamental; animal feed; natural fiber; and for symbolic uses. These NTFPs are vital to the livelihood of rural communities since they account for significant proportion of their household incomes (Larsen and Smith, 2004; Belcher *et al.,* 2005), and particularly of the economically vulnerable communities (Shackleton *et al.,* 2007).

One of the important NTFPs extracted from forest ecosystems are medicinal plants. A study conducted in Tanzania and Uganda by (Ndangalasi *et al.*, 2007) showed that, majority of harvested plant species in Uzungwa Scarp Forest Reserve and Bwindi Impenetrable National Park were medicinal. Likewise, Arabuko Sokoke Forest Management Team (ASFMT), (2002) noted medicinal plants as one of the main forest products harvested from Arabuko Sokoke forest. Wild medicinal plants can be collected and commercialized for livelihood improvement and poverty eradication (Akankwasah *et al.*, 2012). However, extensive collection and improper management of these species can result in decimation of resources found in the wild (Omwenga *et al.*, 2015). Furthermore, disturbance due to anthropogenic activities in forests have resulted in changes in their diversity and community structure (Sunil *et al.,* 2011; Vaglio Laurin, 2016).

Since time immemorial people have interacted with their environment and developed various approaches to manage their ecosystems through the use of traditional ecological knowledge (TEK) and practices (Berkes *et al.,* 2000). This knowledge, including that of plants, is important in management of natural resources (Berkes *et al.,* 2000; Ticktin and Johns, 2002). Berkes and Turner (2006) have associated the success of natural resource management with the integration of TEK into the modern conservation strategies. However, in the recent past TEK and especially the ethnobotanical knowledge is being lost since majority of the young generation are less interested in the earlier ways of life (Cox, 2000). This has adverse implications for use and cultural importance of TEK and practices. In attempt to underscore the importance and promote use of technical indigenous knowledge, various indices have been developed to measure indigenous knowledge on plant species, their relative importance as well as the transmission of the knowledge to the new generation (Ladio and Lozada, 2004; Reyes-García *et al.*, 2006; Pardo-de-Santayana *et al.*, 2007). Such studies have been aimed at documenting such knowledge to ensure its transmission to the new generation.

1.2 Problem statement

It is widely known that from time immemorial, man has co-existed with forest resources and have developed sustainable ways of exploiting them to ensure availability for posterity. However, this is no longer the case as wild plants are increasingly being harvested for commercial purposes in disregard of their socio-cultural uses thus undermining their sustainability. For instance, there has been a dramatic increase in demand of herbal products that has been attributed to increased awareness of the advantages of herbal therapy, expansion of local and international markets, affordability and availability of herbal plant products (Lange, 1998; Mulliken and Crofton, 2008). Human disturbance and over-extraction of plant resources from the wild has detrimental impact on biodiversity, wild species availability and ecological balance of these natural habitats. Most of the forest plant resources that are targeted for subsistence and commercial purposes are rarely conserved outside their natural habitats. In addition, unsustainable human activities profoundly influence forest plant diversity and structure often leading to irreversible ecological damage (Fashing *et al.*, 2004).

Arabuko Sokoke forest is known to have high plant species diversity with several being endemic (Burgess *et al.*, 1998). Currently, commercialization of herbal products from this ecosystem for distant markets has been reported by ASFMT (2002). However, no effort has been made to understand the influence of these trends and other human disturbance on the species diversity and the general forest structure.

The findings of studies already conducted on medicinal plants in coastal area of Kenya have shown high diversity of herbal plant species in the region (Pakia, 2001; Kaingu *et al.*, 2013, 2014). However, species use values, communities' ethnobotanical knowledge, marketing channels and economic contribution of medicinal plants to households' wellbeing have not been well documented.

1.3 Justification of the study

Livelihoods of a large proportion of the rural populace that live adjacent to forest ecosystems rely on the goods and services derived from forest resources. A clear understanding of human influence on forest structure, plant species diversity, distribution and use dynamics is therefore important in guiding decisions on forest utilization and conservation strategies.

Most studies on ethno-medicinal plants conducted worldwide and in Kenya, have focused on documenting medicinal resources that are used by different ethnic communities. Findings from such studies have been intended to guide the advancement of medical research and development. However, in order to ensure sustainable conservation of important species, there is need to understand the dynamics of traditional knowledge with a view to promoting its transmission to the new generation, as well as integrating it with conventional conservation approaches for better results. Currently, knowledge of medicinal plants is the most vulnerable to loss among the various forms of traditional botanical knowledge (Case *et al.,* 2005). Therefore, there is the danger of losing the cultural values that have been attached to traditional plant cures. This study was therefore undertaken with the aim of generating information on plant diversity and distribution of plant species in disturbed and undisturbed areas of Arabuko Sokoke forest; use values that indicate the relative importance of species to communities; economic contribution of herbal remedies to household livelihoods; and threats and conservation of medicinal plants in the study area.

The results of this study are expected to form a baseline for developing strategies for conservation and sustainable utilization of forest plant resources. Documentation of local knowledge of plant resources will serve as a means of restoring communities' confidence in their own knowledge and practices, and curb loss of indigenous knowledge through promotion of its transmission to the new generation. The findings of this study will be of benefit to various stakeholders including researchers who may want to explore further research agenda, conservationist, herbalists, County governments, Kenya Forestry Research Institute (KEFRI), among others. The government agencies may use the information to guide decisions on conservation interventions and policy formulation.

1.4 Broad objective

The overall objective of this study was to assess plant diversity and structure as well as utilization, threats and conservation status of medicinal plants in Arabuko Sokoke area in order to inform sustainable utilization measures and conservation of plant resources for posterity.

1.5 Specific objectives

The specific objectives for this study were to:

1) Assess plant species diversity and structure in cynometra, mixed and brachystegia plant communities of Arabuko Sokoke forest.
2) Assess relationship between local knowledge on use, threats and conservation of wild medicinal plants in the study area.

3) Determine the use value (cultural and practical) of medicinal plants, and their contribution to households' livelihoods in the study area.

1.6 Research hypotheses

1) There is no significant diference in diversity and distribution of plant species in cynometra, mixed and brachysteia communities of Arabuko Sokoke forest.
2) There is no correlation between knowledge on use, threats and conservation of traditional medicinal resources in the study area.
3) Medicinal plants have no significant cultural, practical and economic contribution to household livelihoods in Arabuko Sokoke area.

1.7 Thesis organization

The schematic organization of this thesis is shown in Figure 1.1. The thesis is organized into seven chapters. Chapter one comprises the background information of the study regarding contribution of NTFPs to household livelihoods, human influence on diversity and distribution of plant species, ethnobotanical knowledge and measure of relative importance of plants. The chapter also presents the problem statement, justification and objectives of the study. Chapter two presents literature review on: human influence on forests' plant diversity and distribution; trends and factors influencing ethno-medicinal knowledge; utilization and contribution of medicinal plants to livelihoods; threats and conservation of medicinal plants; and the estimation of use value of species. The study area and study design are presented in Chapter three. Chapter four presents the plant species diversity and size class distribution in Arabuko Sokoke forest. Chapter five comprises the nexus between knowledge, utilization, threats and conservation of wild medicinal plants, while the use value and contribution of medicinal plants to household livelihoods in the Arabuko Sokoke area is presented in Chapter six. Chapter seven summarizes the findings from Chapter four to six, and provides recommendations and conclusions based on the key findings of the study. References and appendices are provided at end of the thesis.

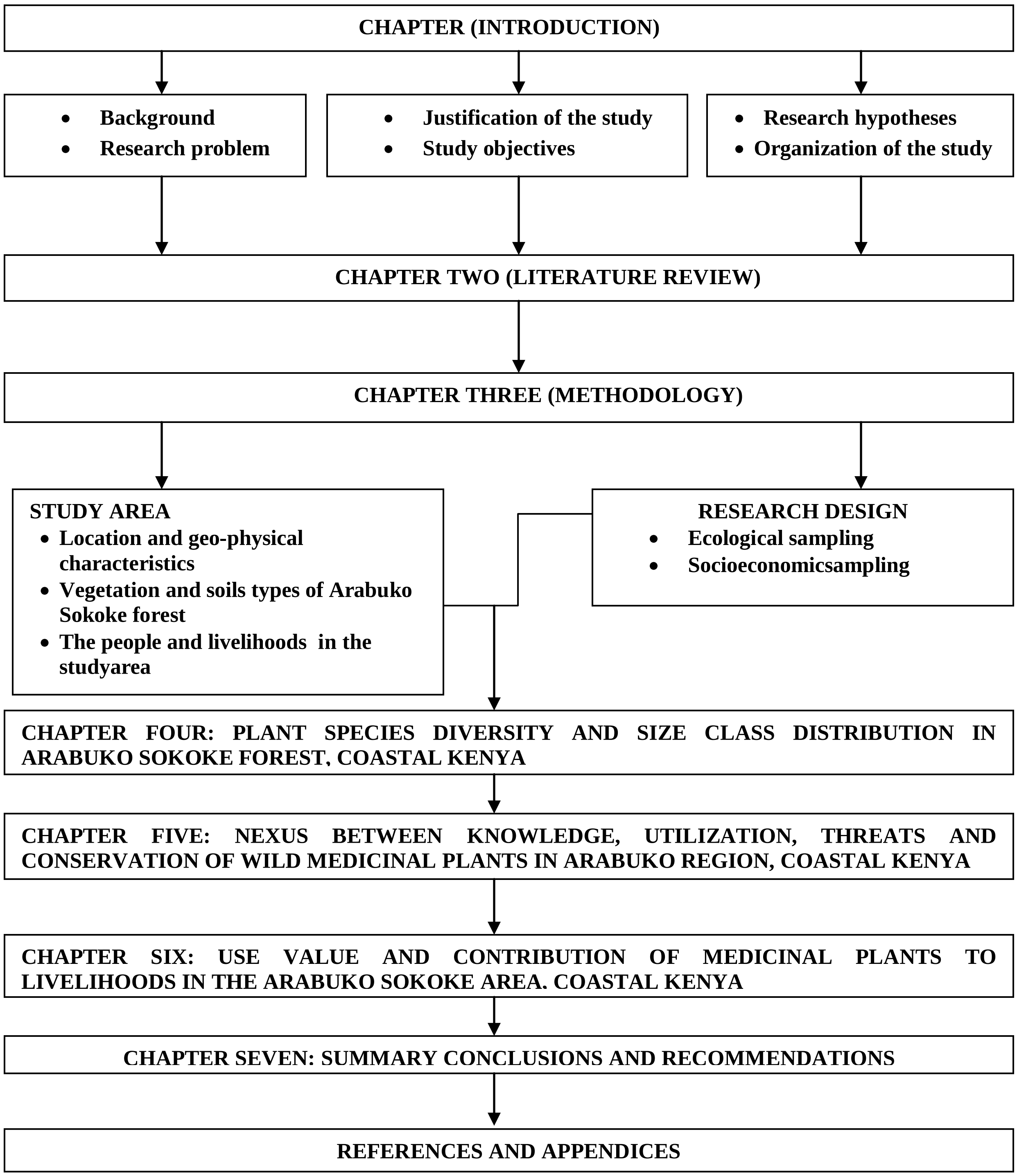

Figure 1.1: Thesis Plan

CHAPTER TWO
LITERATURE REVIEW

2.1 Human influence on forests' plant diversity and structure

Forests cover considerable part of the world's terrestrial land surface and support millions of people living adjacent to them (FAO, 2010; World Bank, 2003). These ecosystems account for significant roles in sustaining environmental integrity through carbon sequestration and hydrological services (Godoy *et al.*, 2002), as well as providing subsistence needs and economic benefits to communities though direct utilization and sale (Godoy *et al.*, 2002; Larsen and Smith, 2004; Sunderlin *et al.,* 2005; Shackleton *et al.*, 2007). Decline in forest area has been recorded around the world (FAO, 2010) and this had been attributed to natural disturbances and anthropogenic factors (Brook *et al.*, 2008) that leads to biodiversity loss either through loss of species or decrease in species' abundance (Brook *et al.,* 2008).

Anthropogenic activities profoundly influence plant diversity and structure in the forest ecosystems of the world, and this pressure may lead to irreversible ecological damage (Fashing *et al.,* 2004). Removal of forest biota through extraction of forest products for subsistence or economic purposes influence the floristic composition and forest structure (Fashing and Gathua, 2004; Fashing *et al.,* 2004; Mligo, 2015), and this may lead to conversion of forests to shrub-dominated stands (Ribeiro *et al.,* 2015). For instance, a study conducted in three forests in Tanzania have shown that anthropogenic disturbance negatively influence species richness and community diversity (Mligo, 2015). Other studies have shown that, human disturbance affect the size class distribution of forest species and therefore affecting regeneration potential of forest species (Kimaro and Lulandala, 2013; Mwase *et al.,* 2007). As reported by Sodhi and Brook

(2006), human activities can result in species extinction and this is mainly due to large scale perturbation such as clearance of forest for agriculture.

2.2 Trends and factors affecting knowledge on medicinal plants

For decades, knowledge of medicinal plants has existed in majority of African cultures (Sindiga, 1995). However this knowledge is vulnerable to acculturation and it is rapidly disappearing (Cox, 2000). In a study to determine knowledge and use of medicinal plants among the Maasai community in the Amboseli region of Kenya, Kiringe (2005) found that the young generation were not interested in knowing their cultures including the knowledge and use of ethno-medicinal plant resources. Similarly, Cox (2000) indicated that both traditional knowledge systems, languages and cultures are fading away because the young generation is not interested in knowing their ancient ways of life.

Knowledge of traditional medicine is passed through generations by oral means, training by knowledgeable individual or through inheritance (Owour and Kisangau, 2006). This makes medicinal plant knowledge to be susceptible to loss since in some cases the apprentice might not be interested in the knowledge (Kigen *et al.,* 2013). Additionally, some of the aged healers who hold vast knowledge of ethno-medicinal plants, do not have apprentices (Owour and Kisangau, 2006) or prefer secrecy during collection of herbal products (Nanyingi *et al.,* 2008) and therefore they end up dying with their knowledge unrecorded (Kigen *et al.*, 2013).

Various studies have shown that local knowledge change with respect to modernization, education system, socio-cultural factors and economic development (Benz *et al.,* 2000; Voeks and Leony, 2004; Ladio and Lozada, 2004; Reyes-García *et al*., 2005, 2007; Pardo-de-Santayana*et al.,* 2007). Okello *et al.* (2010) and Bussmann *et al.* (2006) blame the loss of ethnobotanical knowledge to changes in lifestyles. The authors related lifestyle changes to the emulation of western cultures and ideologies. Additionally, knowledge of medicinal plants is tremendously impacted by the availability and use of modern remedies. This has made communities to abandon their traditional means of curing and preventing diseases (Case *et al.*, 2005). Similarly, Okello *et al.* (2010) noted that people tend to lose their interest in medicinal plants due to the availability and accessibility of allopathic medicines.

Immense knowledge of medicinal plants in the elderly compared to the young generation has been reported by Kiringe (2005) in a study conducted among the Maasai community in Kenya. In contrast, Bjorå *et al.* (2015) found that age did not have significant influence on the knowledge of use of Aloe species among nine ethnic communities of Kenya. Modern education system could also be blamed for the loss of traditional botanical knowledge as children spend most of their time in schools and therefore they fail to gain knowledge of botanical resources and their uses, which is entirely gained through the traditional informal system. In contrast, Kiringe (2005) found that knowledge of ethno-medicine was neither affected by formal education nor occupation of the members of the Maasai community. In this study, the author identified occupation as a measure of departure from the normal Maasai lifestyle of nomadic pastoralism to agro-pastoralism.

2.3 Utilization and contribution of medicinal plants to livelihoods

Since time immemorial plants are known to provide social and cultural benefits to various communities around the world. In Africa, some of these plants are essential source for curative and preventive remedies for various ailments (Sindiga, 1995). Utilization of medicinal plants in the sub-Saharan Africa is estimated to be about 70- 80% (WHO, 2002). The proportion might be higher since the use of medicinal plants extends beyond the essential role in healthcare to the provision of fuel, cosmetics and construction materials. For instance, in Kenya the medicinal plant resources have also been exploited for the provision of construction materials, tools, fuel as well as fodder for livestock (Nanyingi *et al.*, 2008; Njoroge *et al.*, 2010).

Most of the people in the Kenya's rural areas depend on traditional medicine for their healthcare needs (Owour and Kisangau, 2006; Kigen *et al.*, 2013). In some communities, herbal medicine remains the predominant remedy over the western medicine (Kiringe, 2005). Despite the increase in manufacture and distribution of modern medicines, collection and use of medicinal plants remain an integral component in peoples' and animals' primary healthcare in both developing and developed nations, (Sindiga, 1995; Taylor *et al*., 2001; Hamilton, 2004; Bussmann, 2006). Chirchir *et al.* (2006) reported that about 90% of the Kenyan population has at least once made use of medicinal plants for myriad health conditions. For instance, various ethnic communities in the coastal areas of Kenya have been reported to use ethno-medicinal plant resources to manage different health problems (Pakia, 2001; Kaingu *et al.*, 2013, 2004; Wekesa *et al.*, 2015).

The high dependence on traditional medicine can be related to its low cost, availability, efficacy, cultural acceptability and inaccessibility of modern health facilities (WHO, 2002; Kiringe 2005; Bussmann *et al.*, 2006; Owour and Kisangau, 2006; Nanyingi *et al.*, 2008; Kaingu *et al.*, 2011). There has also been an upsurge in the number of urban populace that consider herbal remedy as integral part of their primary healthcare system (Kigen *et al.*, 2013). Therefore, herbal plants have a role in the economic wellbeing of individuals involved in its trade. These plants resources generate income for the collectors, traders and healers who are involved in the trade (Pakia, 2001; Larsen and Smith, 2004; RoK 2008b).

Non timber forest products, including medicinal plants, play vital role in livelihood improvement and income generation (Mulliken and Crofton, 2008; Uprety *et al*., 2011), especially among the rural communities that are economically vulnerable (Shackleton *et al.,* 2007). In Europe, herbal products that are collected from the wild or cultivated are traded and generate lot of income to actors involved in the trade (Lange, 1998, 2006). In Kenya, herbal products are traded locally and internationally thus making significant contribution to the national GDP (RoK, 2008b). Medicinal plant resources have the potential of providing materials that can be used for the production of phytomedicines. Efficacy trials and pharmacological studies on some of the Kenya's medicinal plants have proved their potential use in the treatment of various diseases (Irungu *et al.,* 2007; Mwitari *et al.,* 2013).

2.4 Threats and conservation of medicinal plants

A number of wild plant species, especially the medicinal and aromatic species, are facing threat from exploitation since only very few of them are cultivated (Schippmann *et al.,* 2002) despite the increasing extraction pressure. In the recent past, there has been an increasing demand for medicinal products that has led to their increased exploitation (Rai *et al.,* 2000), thus threatening their survival in the natural habitats (Jeruto *et al*., 2008). Reliance on forest products by communities has been observed in Kenya where forest biomass constitute 80% of the energy used by the rural and urban populace (RoK, 2014). In Arabuko Sokoke forest, logging for timber and charcoal making are some of the main threats to forest conservation (ASFMT, 2002; Oyugi *et al.,* 2008; Ndang'ang'a *et al.,* 2016).

Globally, the loss of wild medicinal flora has been attributed to land use changes and unsustainable utilization. As indicated by Kala (2005), unsustainable utilization of wild medicinal plants has been as a result of increase in commercialization of herbal products.

Mulliken and Crofton (2008) noted that increased commercialization has led to overharvesting of economically viable medicinal plants, some of which are threatened as indicated by Convention on International Trade in Endangered species (CITES). The dramatic increase in demand for medicinal plants has been attributed to the expansion of local and international markets for herbal products (Sindiga, 1995). Other causes of population decline of medicinal plants include indiscriminate harvesting of the species such as uprooting, drought, falling for firewood, construction, agricultural expansion, wild fires and overgrazing (Schippmann *et al*., 2006; Nanyingi *et al.,* 2008; Okello *et al.,* 2010; Njoroge, 2012).

Over the years, communities have been interacting with their environments and have developed various strategies to manage their ecosystems through the use of TEK (Berkes *et al.,* 2000; Berkes and Davidson-Hunt, 2006). Local knowledge has been reported to be important in the conservation of natural resource and biodiversity in Nandi County (Jeruto *et al.,* 2008) and coastal areas of Kenya (Wekesa *et al.,* 2015). However, traditional knowledge on natural resource management becomes more successful when integrated with the modern conservation approaches (Berkes and Turner, 2006). The importance of local knowledge on natural resource management has captured global attention and various conservation organizations are now involving the locals in their management programmes (Agrawal and Gibson, 1999). This is mainly based on understanding how people interact with their environment and the strategies they use in conserving these environments (Berkes and Davidson-Hunt, 2006).

Without clear management strategies, most of the medicinal plant species would be threatened with extinction (Omwenga *et al.,* 2015). Successful solutions to management of wild medicinal plants that have been recommended in Ethiopia and Kenya include in situ and ex situ conservation (Njoroge *et al.,* 2010; Kidane *et al.,* 2014). Currently, individuals and households have been reported to undertake conservation of medicinal plants in different parts of Kenya (Nanyingi *et al.,* 2008; Bjorå *et al.,* 2015). Public awareness in regards to sustainable utilization and conservation of wild plant stocks is equally important in ensuring conservation of medicinal plants in Kenya (Bussmann *et al.,* 2006; Jeruto *et al.,* 2008; Kigen *et al.,* 2013).

2.5 Measuring importance of plant species to communities

Previous studies on ethno-medicinal plants mainly documented botanical knowledge of species, parts used and their mode of preparation (Owour and Kisangau, 2006; Mesfin *et al.,* 2009; Kipkore *et al.,* 2014; Shiracko *et al.,* 2016). In the recent past, there has been a change towards quantitative ethnobotany that determines the relative importance of species to communities (Reyes-Garcia *et al.,* 2006; Benz *et al.,* 2000). Numerous ethnobotanical indices have been developed by different researchers such as informant consensus indices (Phillips and Gentry, 1993a, 1993b; Phillips 1996); informant agreement ratio (Trotter and Logan, 1986); and indices that rely on researcher's subjective allocation of plant importance (Prance *et al.,* 1987; Turner 1988). The most utilized indices are those based on informant consensus (Albuquerque *et al.,* 2006) because they tend to eliminate researcher's biasness (Phillips, 1996). The researcher's subjective method is biased because it is influenced by researcher's judgments (Tardio and Pardo-de-Santayana, 2008). Informant agreement ratio has been used in determining the effective or the mostly used medicinal plants in treatment of certain ailment (Trotter and Logan 1986; Collins *et al.,* 2006).

Turner (1988) developed a measure of cultural significance as an estimate from quality of use, intensity of use and exclusivity of use. However, Pieroni (2001) modified the index developed by Turner (1988), by developing one that had additional variables such as plant part used; multifunctional food use; taste score; and food-medicinal role among others. Phillip and Gentry

(1993a) developed the use value of plant, which is defined as the proportion of the number of uses cited by informant and the number of interviews for that species with the informant. Albuquerque *et al.* (2006) modified the index developed by Phillip and Gentry (1993a), and defined it as the summation of the number of use mentioned by informant for species divided by the total number of informants.

Other researchers have developed plant value by capturing the actual economic value of plant species by estimating their financial contribution to households' consumption and earnings (Godoy *et al.,* 2002; Reyes-Garcia *et al.,* 2006). However, some of these techniques are positively correlated therefore they can be used interchangeably (Albuquerque *et al.,* 2006; Tardio and Pardo-de-Santayana, 2008). Cultural indices can be used to provide imperative assessment and meaningful values that shows the relative importance of species to a community or region (Turner, 1988). From the estimation of cultural importance of species, it is possible to identify the most utilized and underutilized families, species and growth forms.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

3.1.1 Location and geo-physical characteristics

This study was conducted among communities living around Arabuko Sokoke Forest in Kilifi County located within the coast line of Kenya. The county covers an area of about 12,609.7km^2 and lies between 2º 20' and 2°40' South, and 39º 5' and 40º 14' East. The county borders Taita Taveta County on the west, Mombasa County on the south, Kwale County on the south west and Tana River County on the North. The county is divided into seven sub-counties; Kilifi South, Kilifi North, Ganze, Magarini, Kaloleni, Malindi and Rabai (RoK, 2013). The area comprises the former Malindi and Kilifi districts and has a human population of 1,109,735 (RoK, 2010). The average annual rainfall in the county ranges from 300 to 1300mm with areas such as the Arabuko Sokoke forest receiving the highest rainfall. Arabuko Sokoke forest is approximately 41,600 ha and lies between 39°50′E longitude and 3°20′S latitude (ASFMT, 2002).

Arabuko Sokoke forest is the largest forest patch of the Eastern Africa coastal forests ecoregion that extends from Somalia to Mozambique (Burgess *et al.,* 1998). The forest is divided into forest reserve (which constitutes the larger area of the forest) and a national park, and therefore managed by both Kenya Wildlife Service and by Kenya Forest Service. The eastern region of the forest lies at an altitude of about 45m above the sea level, while the western and central part of the forest rises to about 60 to 200 m, and reaches highest point of 210 m in the southwest (ASFMT, 2002; Gooch 2007; Glenday, 2008; Oyugi *et al*., 2008). Rainfall in Arabuko Sokoke forest ranges from 600-900mm per annum in the North West to 1000-1100mm/year in the eastern sides of the forest (ASFMT, 2002; Schrodt, 2005; Glenday, 2008).

3.1.2: Vegetation and soils types of Arabuko Sokoke forest

The forest is rich in biodiversity consisting of a number of endemic flora and fauna (Burgess *et al.*, 1998; Gooch, 2007; Glenday, 2008) and is recognized as a top biodiversity hotspot in East African coastal forests (Myers *et al.*, 2000; ASFMT, 2002). It has a diverse floral species, and among them 50 are considered as globally rare (Matiku, 2005). The forest is divided into three major blocks based on distinct plant associations (forest types), as shown in Figure 3.1. The three plant communities differ on the basis of plant species associations, canopy structure and soil type. The dominant vegetation community types include mixed forest, brachystegia forest and cynometra forest.

Mixed forest covers approximately 7,000 ha on the eastern part of the forest (ASFMT, 2002) with considerable high rainfall of 1000 to 1100mm per annum (Schrodt, 2005). The white Pleistocene lagoonal sandy and clay soil in this area supports variety of tree species including *Hymenaea verrucosa* Gaertn., *Encephalartos hildebrandtii* A. Braun and C.D Bouche, *Combretum schumanii* Engl., *Afzelia quanzensis* Welw. and *Manilkara sansibarensis* (Engl.) Dubard.

Brachystegia forest covers about 7,700 ha and is dominated by *Brachystegia spiciformis* Benth. The Brachystegia plant community occupies deep, loose, medium to coarse sandy soil which permits rapid percolation (Britton and Zimmerman, 1979; Schrodt, 2005). The Brachystegia forest has a loose canopy that rarely interlocks or exceeds 50% (Britton and Zimmerman, 1979; Matiku, 2005; Glenday, 2008).

Cynometra forest consists of impoverished thicket of 4 metre in height or below on the northwest, and changes to a rich forest that has trees exceeding 15 metres in height on the southern side (Britton and Zimmerman, 1979). Cynometra plant community covers about 23,500 ha on the western side of the forest, and is dominated by *Cynometra webberi* Bak.f., *Manilkara sulcata* (Engl.) Dubard and declining population of *Brachylaena huillensis* O. Hoffm. as a result of overexploitation (ASFMT 2002, Gooch, 2007). The cynometra community is found in infertile dark red loam sandy Magarini soil, and receive annual rainfall of 600-900mm (Schrodt, 2005; Britton and Zimmerman, 1979).

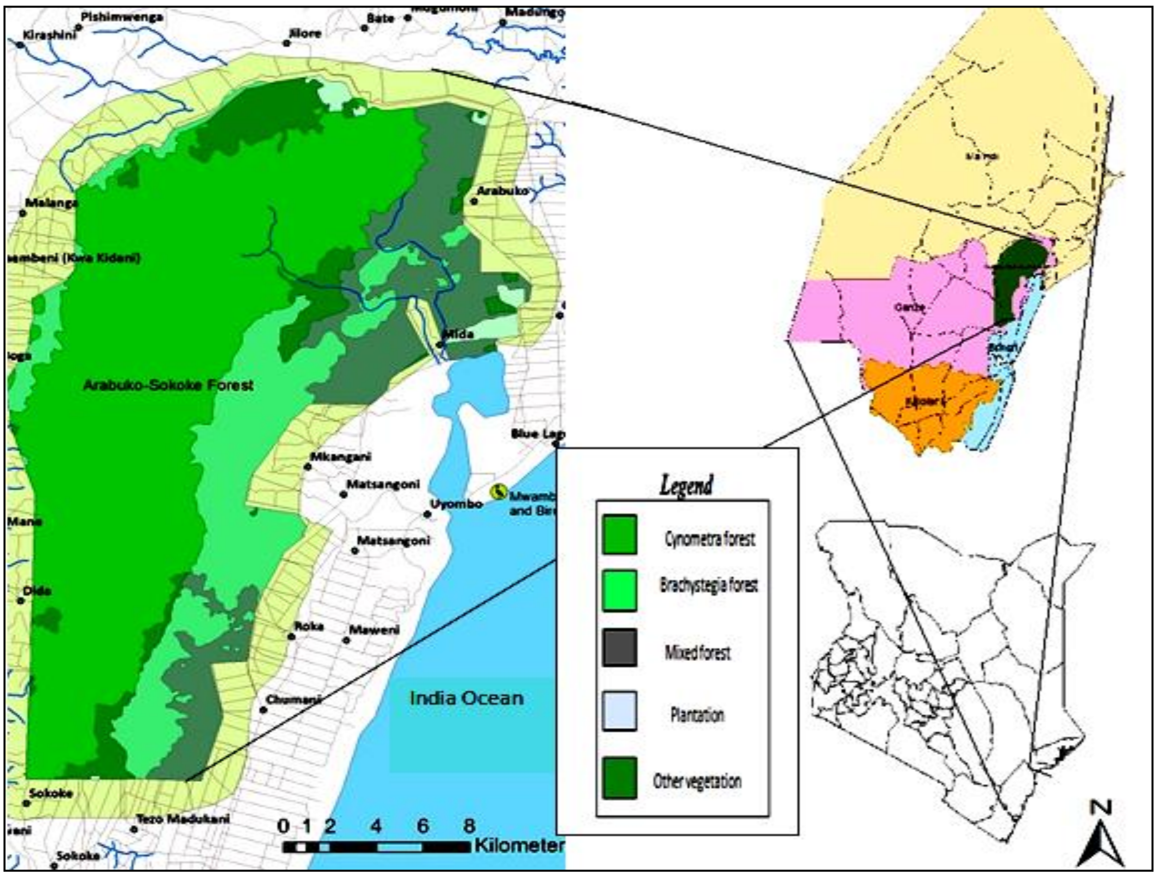

Figure 3. 1: The study area showing the major plant communities in Arabuko Sokoke forest and its surroundings

3.1.3 The people and livelihoods in the study area

Arabuko Sokoke forest is surrounded by 50 villages with the main ethnic group being the Giriama. The Giriama are the most traditional community among the Mijikenda (a group consisting of nine tribes) found in the coastal areas of Kenya (Wekesa *et al.,* 2015). However, a small group of the Sanya community still lives on the northern side of ASF. Agricultural land productivity in the study area is low and the mean size of the farm holdings is 6.9 ha. A larger proportion of the forest-adjacent communities are small scale farmers who grow maize and cassava, cowpeas, green grams and beans as the main subsistence crops (RoK, 2013; World Wide Fund for Nature-Eastern Africa Regional programme Office (WWF-EARPO), 2006; ASFMT, 2002). The main cash crops grown are coconut, cashew-nut, mango and sesame.

Arabuko Sokoke forest provide a myriad of wood and NTFPs for subsistence and commercial purposes to the communities adjacent to it. The main non wood products from the forest include fruits, medicinal plants, honey, fodder and bush meat (Matiku *et al.,* 2013; ASFMT, 2002). Forest goods account for significant proportion of annual households' income of the surrounding communities of ASF (Matiku *et al.,* 2013). The highest income accrue from forest related employment activities such as marketing of butterfly pupae, honey and employment as tour guides (Matiku *et al.,* 2013). As indicated by RoK (2013), extraction of medicinal, butterfly farming and tree seedlings production are the major nature based income generating activities in forests found in Kilifi County.

3.2 Research design

3.2.1 Ecological sampling

Three dominant vegetation communities that are found in ASF namely, mixed, brachystegia and cynometra sites were selected for this study. Each of the study communities was further zoned into disturbed (≤ 2km from the forest edge) and undisturbed (≥ 2km from the forest edge) sites. In the disturbed sites, disturbance was quantified by anthropogenic activities such as fuel wood collection, medicinal plant harvesting, logging for timber and poles as evident in the presence of tree stumps and footpaths. In each of the disturbed and undisturbed sites of the three plant communities, six line transects measuring 600 m were established 500 m apart. A total of four sampling plots each measuring 10 m by 10 m set at 150 m intervals were laid along each of the established transects, in all the three plant communities (Figure 3.2) to enable sampling for diversity, frequency and density. The point centered quarter (PCQ) method was used to sample plant size distribution, whereby twenty sampling points were set at 100m intervals along the laid transects in each disturbed and undisturbed sites of the three plant communities.

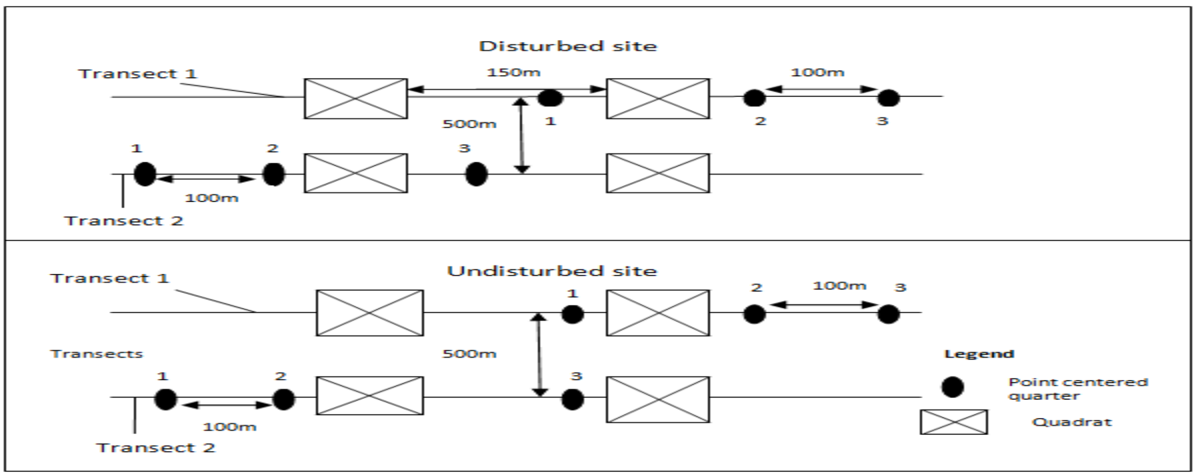

Figure 3. 2: Study layout

3.2.2 Socioeconomic sampling

Eight villages adjacent to the forest were sampled in this study namely; Mnazi Mmwenga, Mugururenі, Kaliapapo, Dzunguni, Nyongoro, Zia la lufa, Sosobora and Kabelengani. The villages were selected with assistance from KEFRI personnel who have been working with communities around the forest for long. The sampling ensured that the selected villages represented the population living in the four sides of the forest (West, East, North and West). Purposive and snowball sampling techniques as illustrated by Mugenda and Mugenda (1999) and Tongco (2007) were employed in the sampling exercise.

Purposive sampling technique entailed targeting individuals with vast knowledge of medicinal plants and therefore, knowledgeable individuals in plant medicine were identified for key informant interviews (KIIs) and focus group discussions (FGDs). Snowball method as described by Shafie (2010) involved referral technique where interviewed individuals were asked to mention and direct the interviewer to other knowledgeable person(s). A total of five FGDs comprising 8-10 men and women participants, and 33 KIIs were conducted in this study. A systematic sampling approach was used to administer structured questionnaire to households. Interviews were done after every three households starting with the households closest to the forest edge in each village until a sample size of 207 was attained.

CHAPTER FOUR

PLANT SPECIES DIVERSITY AND SIZE CLASS DISTRIBUTION IN ARABUKO SOKOKE FOREST, COASTAL KENYA

ABSTRACT

Forests play fundamental role in the provision of ecosystem services and goods that contribute significantly to rural households' income. However, these ecosystems are increasingly threatened by anthropogenic activities that lead to biodiversity loss. Understanding forest resources dynamics is therefore important in guiding design of sustainable conservation strategies. This study used plot and point centered quarter techniques to determine diversity, abundance and distribution of plants species in Arabuko Sokoke forest in Kilifi County of Kenya. Species diversity was found to be significantly higher ($P<0.05$) in the disturbed areas than in the undisturbed areas under mixed and cynometra communities. There was, however, no significant difference ($P>0.05$) in species diversity between disturbed (2.40 ± 0.07) and undisturbed area (2.61 ± 0.07) of brachystegia community. The results also showed an increasing number of woody plants with small diameter sizes which shows good recruitment of woody species. The study indicates that the forest has high diversity in the disturbed and undisturbed sites. However, proper management of the forest is necessary to protect the forest from future adverse effects of unsustainable anthropogenic activities on the biodiversity and forest structure.

Key words: Plant density; Shannon Weiner index; Disturbed sites; size class distribution; Diameter at breast height

4.1 INTRODUCTION

Biodiversity around the world is under threat due to climatic changes and anthropogenic factors, with the latter being the major contributor to biodiversity losses observed over the years (Foody *et al*., 2003). The global forest cover has been reducing at an alarming rate in the period ranging from the year 1990 to 2010, with Africa being second to Asia in net forest loss (FAO, 2010). To avert biodiversity loss, protected areas were established since the early 1970s but the degree of conservation and management has been low (Liu *et al*., 2001) due to high dependence on forest products for commercial and subsistence needs (Schippmann *et al*., 2006; Oyugi *et al.*, 2008).

Forest disturbance due to anthropogenic activities may lead to change in species diversity and forest structure. For instance, Shrestha *et al*. (2012) have shown that human disturbance can enhance diversity by opening canopy, thus supporting understory species. However, human disturbance as a result of heavy dependence on forest for goods and services may negatively influence vegetation structure and composition (Muposhi *et al.*, 2016).

In Kenya, the forest cover is less than 10% (RoK, 2014). Arabuko Sokoke forest is the largest remaining coastal protected forest found in Kenya, and it is a habitat for several rare, endemic and threatened flora and fauna (ASFMT, 2002; Burgess *et al*., 2007). Furthermore, this forest has been recognized as a hotspot for the conservation of biodiversity (Myers *et al*., 2000). Despite being a protected area, the forest faces threats, mostly from commercial and subsistence exploitation (Oyugi *et al.*, 2008).

Extraction of wild plant resources has affected many forests in Kenya and consequently majority of plant species in their natural environments face threat of declining population and species extinction due to overharvesting (Kiringe, 2005). Taxonomic identification, evaluation of the extent of use and comparison of plants species across different sites is imperative for understanding of species habitats, biodiversity and degree of utilization of forest products.

Quantitative data on size class distribution, density and frequency of plants are key elements in understanding forest resource dynamics, species succession and levels of resource exploitation Furthermore, clear understanding of ecological changes helps in evaluating whether the sustainability of existing extraction activities (Ticktin, 2004). This study was conducted in the Arabuko Sokoke Forest to determine diversity, abundance and distribution of plant species in disturbed and undisturbed sites under three plant communities namely, brachystegia, mixed and cynometra.

4.2 DATA COLLECTION AND ANALYSIS

Plant species were identified and the number of individuals recorded in each of the sixty 10 m x 10 m plots mentioned in Chapter 3. Data from these plots were used to determine species diversity, frequency and density. Percent frequency and density of species within the plots in each study site were calculated as follows:

$$\text{Percent Frequency} = \frac{\text{Number of plots with the species present}}{\text{Total number of plots in the community}} \times 100$$

$$\text{Density} = \frac{\text{Total number of individuals of a species}}{\text{Area of the quadrat}}$$

Species richness was determined using the following formula:

$$\text{Species richness} = \text{Total}\ number\ of\ species\ in\ a\ study\ site$$

Species diversity within disturbed and undisturbed sites of the three communities was calculated using Shannon-Weiner index (Magurran, 2004), presented below:

$$\mathrm{H}' = -\sum pi\ logpi$$

Where H′ is the Shannon-Weiner index, *pi* is the proportion of individuals made up of species *i*, log is the natural log of *pi*. A high value of H′ is therefore interpreted to mean high plant species diversity, and vice versa.

Sørensen's coefficient (SC), which is used to measure similarity between vegetation communities (Sørensen, 1948) was used to illustrate the degree of vegetation resemblance in disturbed and undisturbed areas in the three plant communities. This was calculated using the formula below:

$$\mathrm{SC} = \frac{2C}{A+B} x100$$

Where, SC is the Sørensen's coefficient; C is the number of common species that are present in community 1 and 2, A is the total number of species in community 1, while B is the total number of species in community 2. The higher the similarity coefficient, the high number of species that are shared between any two sites, the reverse is true for low SC.

To determine the size class distribution of species, the point centered quarter (PCQ) method was used to sample vegetation along the established transects in accordance with Mitchell (2010). Species nearest to the sampling point in each quarter was recorded. In addition, the distance of the nearest species to the sampling point and the diameter at breast height (DBH) of the species was recorded.

The Genstat statistical package (12th Edition) was used for the analysis of collected data. The descriptive analysis was performed to generate frequencies and averages for the measured attributes. T-test was used to determine whether species diversity and similarity was significantly different in the disturbed and undisturbed areas of the three plant communities.

4.3 RESULTS

4.3.1 Plant species richness and diversity

A total of 116 woody plant species belonging to 40 different families were recorded in the study sites. Trees, shrubs and lianas were represented by 62, 47 and 7 species, respectively. Families Rubiaceae, Fabaceae, Annonaceae, Apocynaceae, Euphorbiaceae, Celestraceae and Combretaceae had the highest numbers of species, in descending order. Figure 4.1 shows that the number of plant families varied among sites with the highest frequency occurring in cynometra community (36), mixed (32) and the least was recorded in the brachystegia community (31). The highest represented family in the three communities was the family Rubiaceae. Most families were presented in both mixed, cynometra and brachystegia plant communities with exception of family Asteraceae, Bombaceae, Boraginaceae, Burseraceae, Buxaceae, Connaraceae, Flacourtiaceae, Malvaceae, Myrtaceae, Olacaceae, Salvadoraceae, Verbenaceae and Zygophyllaceae.

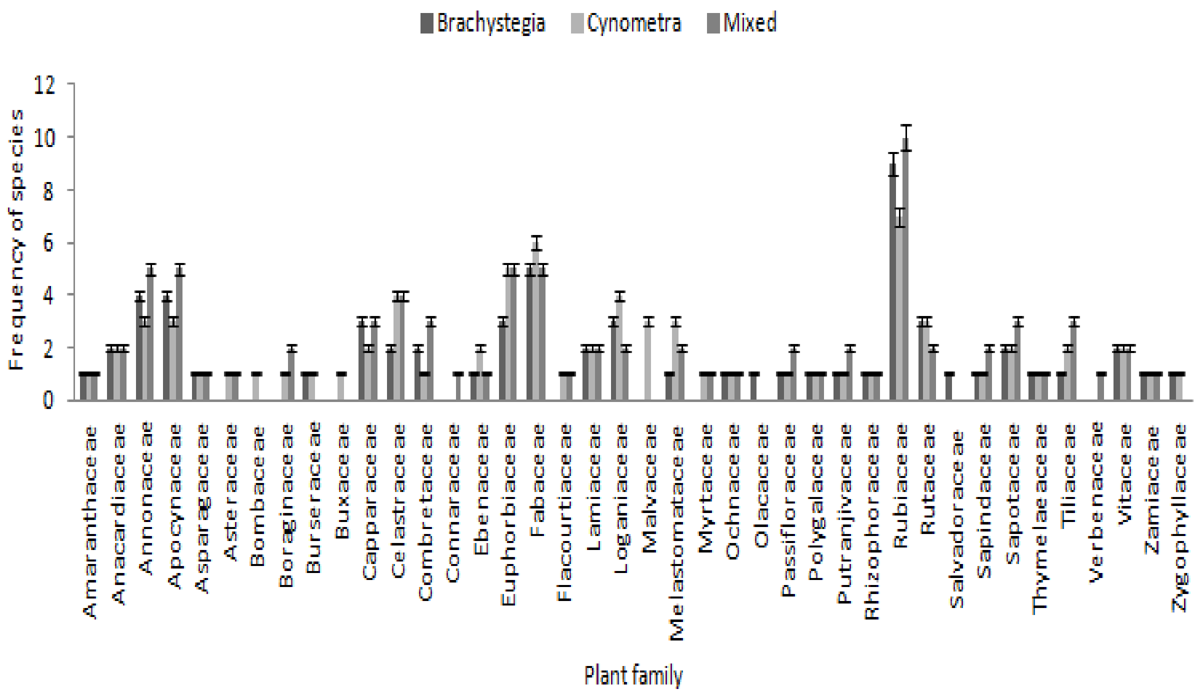

Figure 4. 1: Plant families encountered in the sampled sites

A total of 63 species were recorded in brachystegia community with 57 occurring in disturbed sites, while 49 were present in the undisturbed areas. *Canthium mombazense* had the highest overall average frequency in both disturbed (90%) and undisturbed (90%) sites (Figure 4.2). However, *Haplocoelum inoploeum*, *Julbernardia magnistipulata* and *Teclea trichocarpa* were the most dominant species in undisturbed site, both having a frequency of 100%. Species that had frequencies of above 50% in the disturbed site included *Chazaliella abrupta*, *Heinsia crinita*, *Manilkara sansibarensis*, *Canthium mombazense*, *Teclea trichocarpa*, *Suregada zanzibariensis*, *Strychnos henningsii*, *Brachystegia speciformis*, *Ochnathomasiana*, and *Memecyclon zanguebarica.* Species such as *Polyathia stuhlmanii*, *Drypetes natalensis*, *Euclea natalensis*, *Balanites wilsoniana*, *Cremaspora triflora*, *Dobera glabra*, *Grewia forbesii*, *Afzelia quanzensis*, *Carissa tetramera*, *Commiphora africanum* and *Encephalartos hildebrandtii* were present in either disturbed or undisturbed sites and not both.

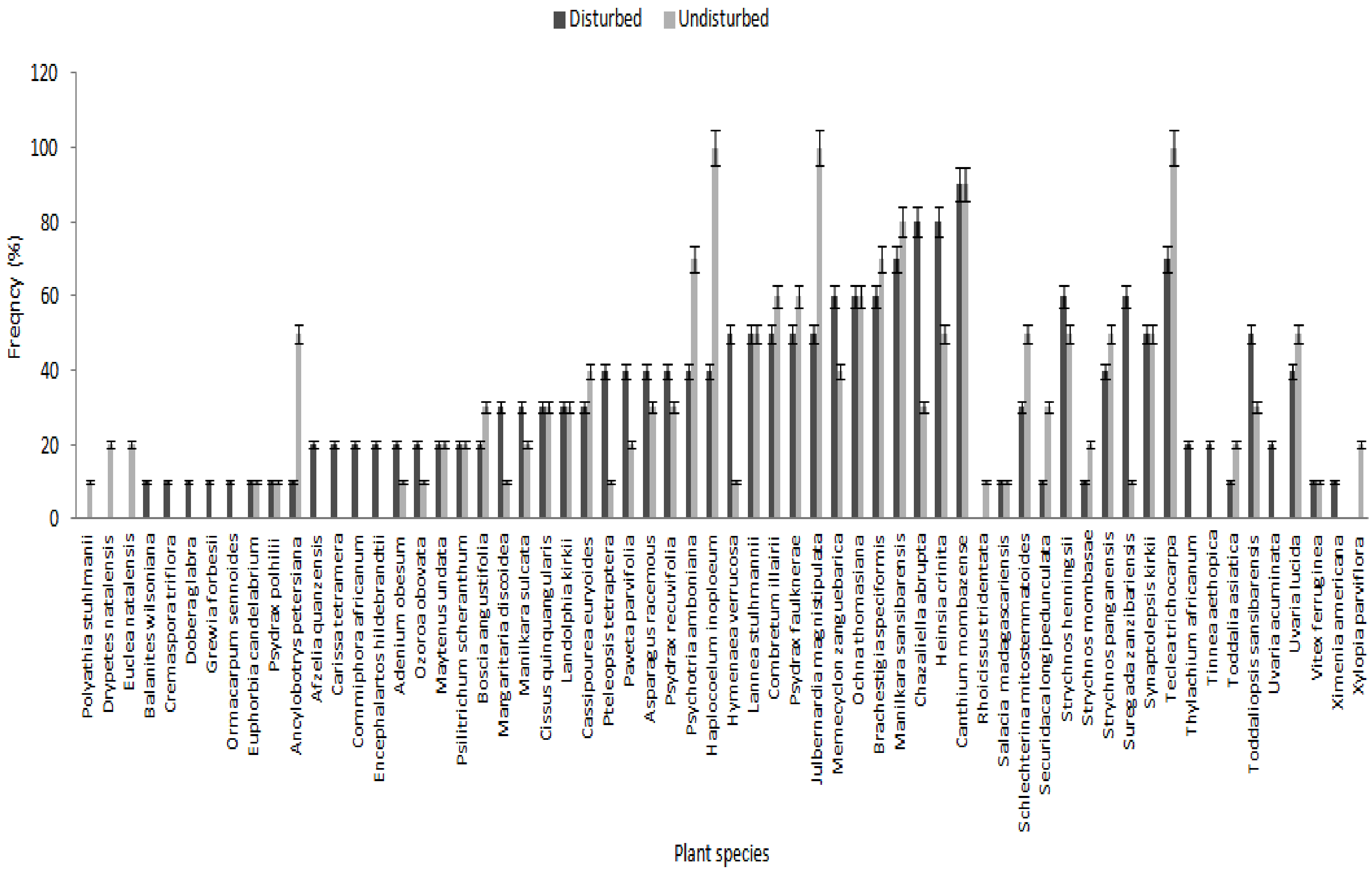

Figure 4. 2: Frequency of plant species in the brachystegia community

Figure 4.3 presents frequencies of plants species recorded in the cynometra community. A total of 73 plant species were recorded in cynometra community with 71 present in disturbed areas while 44 were found in the undisturbed site. The most frequent species in disturbed site of cynometra community was *Uvaria acuminata,* while undisturbed area was dominated by *Croton pseudopulchellus*, *Cynometra webberi* and *Uvaria acuminata*. *Strychnos decusata* and *Memecylon sansibaricum* were the only species which were not present in disturbed areas. However, frequencies of majority of the species recorded in disturbed site were less than 50%, out of which 25 had frequency of only 10%.

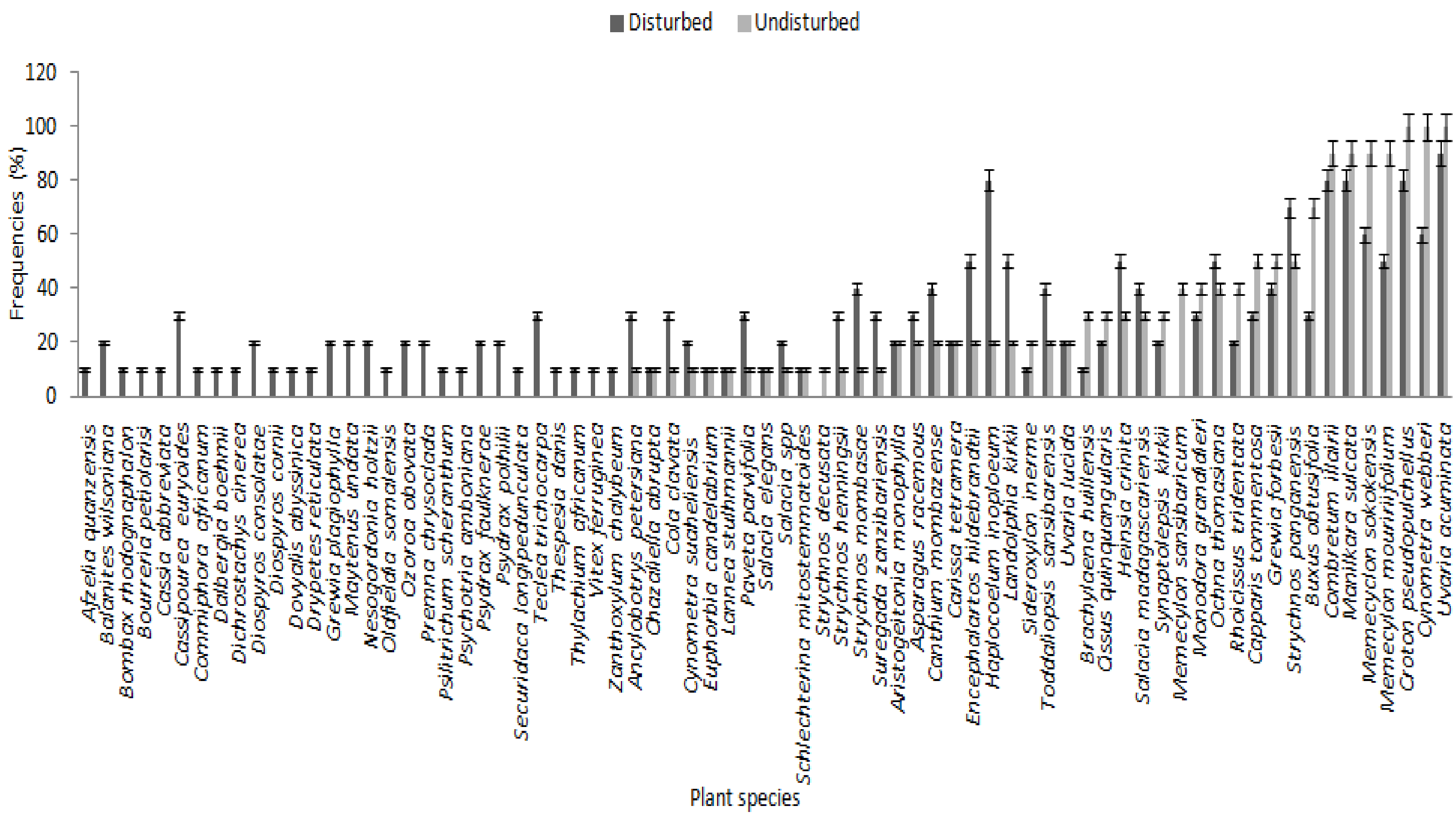

Figure 4. 3: Frequency of plant species in the cynometra community

Seventy eight species were recorded in the mixed community, with 53 recorded in undisturbed sites and 69 in the disturbed areas (Figure 4.4). *Canthium mombazense* was dominant in the disturbed area of mixed community, while *Synaptolepsis kirkii* was most frequent in undisturbed areas. *Vitex ferruginea*, *Margaritaria discoidea*, *Lannea stulhmannii*, *Encephalartos hildebrandtii*, *Ehretia bakeri*, *Xylopia parviflora*, *Deinbollia borbonica*, *Brachylaena huillensis* and *Dichrostachys cinerea* were not recorded in disturbed area but had lower frequencies of less than 20% in undisturbed site.

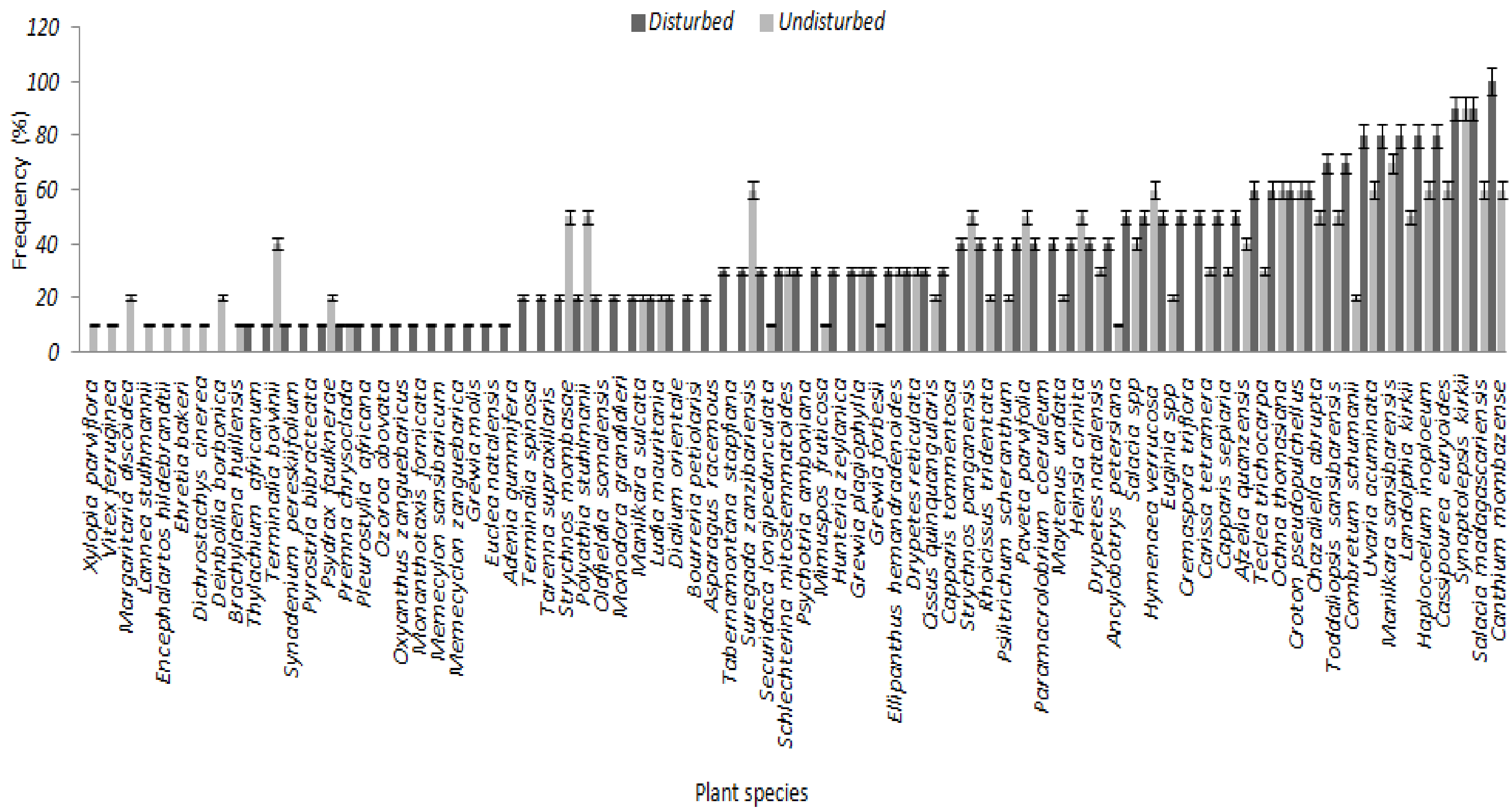

Figure 4. 4: Frequency of plant species in the mixed community

There was significant difference in species diversity between the disturbed and undisturbed areas of cynometra and mixed communities (Table 4.1). Species diversity in undisturbed area (2.61±0.07) was not significantly higher ($P<0.05$) than disturbed area (2.40± 0.07) in the brachystegia community. Mixed community had the highest overall diversity index compared to brachystegia and cynometra communities, while the lowest diversity of (2.25±0.07) was recorded in the undisturbed site of cynometra.

Table 4.1: Species diversity (H′ ±SE) in disturbed and undisturbed areas

Plant community	Disturbed areas	Undisturbed area	t
Cynometra	2.55±0.06	2.25±0.07	3.18*
Mixed	2.86±0.07	2.51±0.07	3.43*
Brachystegia	2.40±0.07	2.61±0.07	-2.03

Two tailed unpaired test; *= Significant at $P\leq0.05$

The highest mean Sørensen's quotient of similarity recorded in the three plant communities was 46.26±1.50 (Table 4.2). Lowest degree of similarity was recorded in disturbed cynometra (37.76±1.98). Dissimilarity indices of the three plant communities were found to be greater than their respective similarity indices. Sørensen's quotient of similarity for the disturbed area of mixed community (46.36±1.68) was found to be significantly higher ($P<0.05$) than that of undisturbed area (39.54±2.31) of the same community. Sørensen's quotient of similarity showed no significant difference ($P>0.05$) in the cynometra and brachystegia communities.

Table4. 2 Mean species similarity (mean ± SE) in disturbed and undisturbed areas

Plant community	Site			Sørensen's quotient	
	Disturbed	Undisturbed	t	Similarity index	Disimilarity index
Cynometra	37.76±1.98	54.76±1.39	-7.02	46.26±1.50	53.74±1.50
Mixed	46.36±1.68	39.54±2.31	2.40*	42.95±1.46	57.05±1.46
Brachystegia	40.07±1.84	49.98±1.33	-4.36	45.03±1.25	54.97±1.25

Two tailed unpaired test; *= Significant at $P\leq0.05$

4.3.2 Density of plant species common in the three communities

Plant species density varied from 10 to 1430 individuals per hectare (Table 4.3). *Canthium mombazense* had the highest overall density which accounted for 2.4% of the total individuals in all communities, while *Schlechterina mitostemmatoides*, *Lannea schweinfurthii*, *Securidaca longipedunculata*, *Paveta parvifolia*, *Suregada zanzibariensis*, *Ozoroa obovata*, *Encephalartos hildebrandtii* and *Vitex ferruginea* had the lowest density (10 individuals/ha) in the site where they were present. Lower densities (<70 species/ha) of *Encephalartos hildebrandtii*, *Vitex ferruginea*, *Afzelia quanzensis*, *Ozoroa obovata* and *Lannea schweinfurthii* were recorded in all sites where they were present. *Thylachium africanum* was found to be present in disturbed areas of cynometra, brachystegia and mixed communities but absent in their respective undisturbed sites. The results in Table 4.3 reveal that *Canthium mombazense* had the highest density in the mixed sites and undisturbed brachystegia communities. Overall, the highest plant density of common species was recorded in the disturbed mixed community, followed by undisturbed mixed and undisturbed brachystegia communities, in that order.

Table 4. 3: Density (Mean density ± STD) of common plants in the three communities

	Cynometra		Mixed		Brachystegia	
Species	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed
Haplocoelum inoploeum	340±32.40	90±21.21	850±78.18	380±19.66	290±22.17	570±48.09
Manilkara sulcata	940±63.19	1150±90.03	240±84.35	120±0	30±0	90±21.21
Strychnos panganensis	980±66.58	470±57.71	590±92.87	560±60.17	410±27.54	760±70.14
Uvaria acuminata	860±49.27	730±41.38	780±59.94	940±49.67	40±14.14	NP
Maytenus undata	30±7.07	NP	320±70.24	80±28.28	20±0	110±63.64
Ochna thomasiana	550±60.83	70±5.00	630±83.60	750±83.13	400±32.04	480±45.61
Teclea trichocarpa	110±25.17	NP	690±75.03	70±15.28	910±67.33	1270±40.57
Strychnos madagascariensis	500±63.51	30±*	90±35.36	210±49.7	70±*	50±7.07
Thylachium africanum	210*	NP	40±*	NP	170±49.5	NP
Vitex ferruginea	20*	NP	NP	10*	10*	40*
Ancylobotrys petersiana	490±32.15	120*	450±86.55	70*	140*	610±69.07
Paveta parvifolia	430±30.55	10*	480±59.44	850±66.71	320±95.57	130±35.36
Encephalartos hildebrandtii	60±4.47	30±7.07	NP	10*	30±7.07	NP
Landolphia kirkii	560±44.38	480±42.42	660±43.34	520±58.57	150±36.06	390±75.58
Cassipourea euryoides	210±52.92	NP	610±79.27	920±67.13	90±17.32	260±65.57
Cissus quinquangularis	210±106.07	60±10.00	190±58.59	80±28.28	110±20.82	270±30.00
Synaptolepsis kirkii	280±14.14	480±45.83	790±32.70	1190±83.48	880±67.68	820±64.27
Canthium mombazense	520±35.59	50±7.07	880±34.90	1430±89.76	930±34.64	1360±48.85
Grewia forbesii	260±46.55	470±52.25	110±37.86	210*	70*	NP
Afzelia quanzensis	20*	NP	70±5.48	50±5.00	30±7.07	NP
Ozoroa obovata	20*	NP	10*	NP	40±14.14	10*
Heinsia crinita	300±54.31	130±49.33	NP	340±58.05	460±42.00	430±46.69
Psilitrichum scheranthum	70*	NP	830±91.79	90±7.07	190±21.21	260±28.28
Salacia madagascariensis	370±66.52	150±26.46	710±52.55	570±32.71	60*	30*
Toddaliopsis sansibarensis	160±35.59	50±21.21	670±50.28	740±86.2	180±18.17	220±35.12
Suregada zanzibariensis	90±26.46	10*	370±40.41	690±86.2	180±18.97	40*
Psydrax faulknerae	80±28.28	NP	80*	90±21.21	130±23.02	280±15.06
Schlechterina mitostemmatoides	10*	100*	430±96.09	340±47.26	280±49.33	460±59.75
Psychotria amboniana	60*	NP	420±87.18	NP	340±50.66	930±62.64
Rhoicissus tridentata	30±7.07	160±40.82	80±8.16	90±49.5	NP	20*
Carissa tetramera	30±7.07	210±63.64	590±77.91	350±41.63	140±14.14	NP
Lannea schweinfurthii	10*	10*	NP	10*	50±0	90±8.37
Securidaca longipedunculata	10*	NP	280±72.34	20*	10*	310±51.32
Asparagus racemous	50±11.55	90±21.21	50±21.21	NP	320±55.98	350±89.63
Chazaliella abrupta	20*	60*	750±30.82	770±55.95	980±77.04	290±66.58

Note: STD is zero when two or more quadrats have equal numbers of the same species;*species present in a single quadrat; NP: species not present

4.3.3 Size class distribution of sampled plant species

Majority of the sampled plant species were found to be in the lower DBH category of 4.0 to 33.9 cm and the numbers of species decreased with increase in DBH (Figure 4.5). Most of plants species in the cynometra site were within the DBH class of 4.0-13.9 cm, which accounted for 67.5% and 42.5% in cynometra's disturbed and undisturbed sites, respectively. Majority of species in the disturbed mixed community were within the DBH category of 24.0-33.9 cm, while undisturbed brachystegia community recorded higher percentage (45%) of sampled species in the 4.0-13.9 cm DBH category. There were no species in the disturbed cynometra community that had DBH of 44.0 to 64.0cm. Similarly, disturbed mixed community recorded no species in the 44.0-53.9 cm and 54.0-63.9 cm DBH categories. Plant species were present in all the seven DBH classes of the brachystegia community but their numbers decreased with increase in diameter size. The number of species under DBH of 44 to >64 cm was higher in the undisturbed sites than in the same size classes of the disturbed areas.

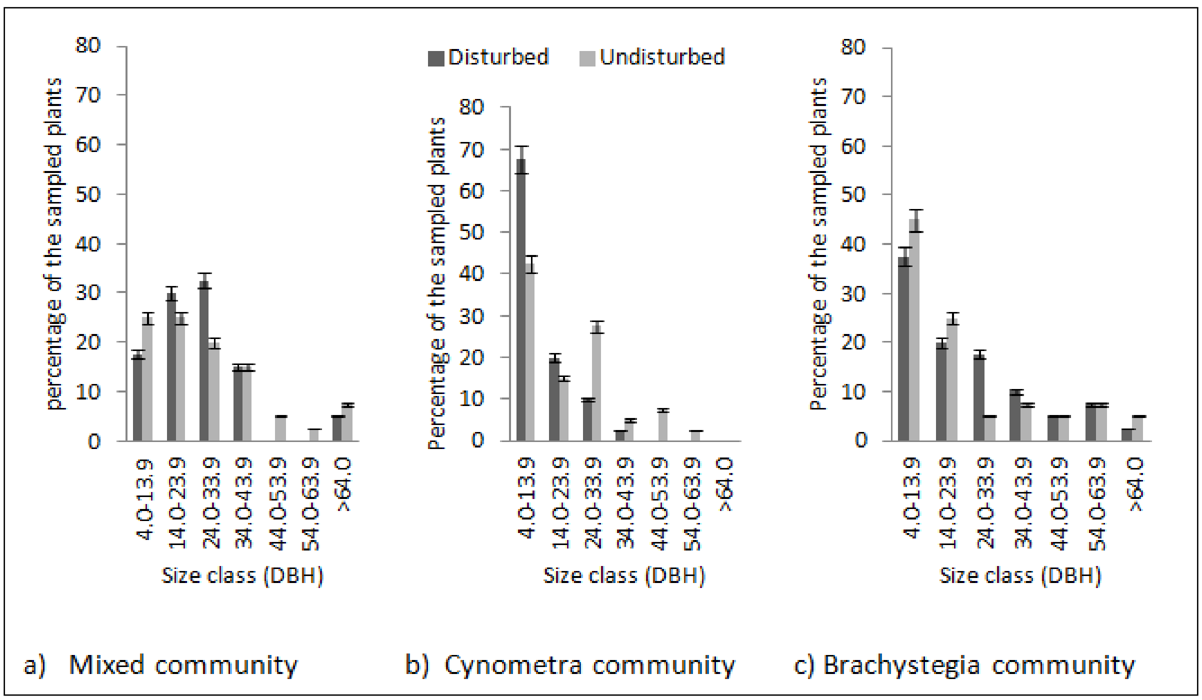

Figure 4. 5 : Distribution of woody species size class by community

4.4 DISCUSSION

4.4.1 Species richness and diversity

The highest species richness and diversity were found in the mixed forest community as compared to the other two communities. This is partly attributed to the fact that mixed community is composed of various species while brachystegia and cynometra communities were dominated by members of single genera or family. However, this could be attributed to other factors that create microclimatic conditions that are favorable for various species thus influencing biodiversity and species richness of different habitats. High species richness and diversity in the mixed site can partly be attributed to the high rainfall pattern that is experienced in areas dominated by this plant community which could have favoured a number of species. Abiotic and biotic characteristics such as soil characteristics, canopy architecture, species height, wildfires, human disturbance among other factors confer competitive capacity that may lead to dominance of certain species therefore resulting in low richness and diversity.

The results of this study are similar to those of Kimaro and Lulandala (2013) who reported that disturbed forest areas in Ngumburuni forest of Tanzania had higher species richness than undisturbed sites due to anthropogenic disturbance. As reported by Althof (2005), heterogeneous environments of small sunny gaps and microclimatic variation created after disturbance leads to increased species diversity in disturbed areas of Kakamega forest. However, results by Findlay and Houlahan (1997) from a study in Canada showed a decline in species richness in forest areas that are influenced by anthropogenic activities.

The Shannon Weiner diversity index of more than 2.2 which was obtained in all three plant communities in this study shows that Arabuko Sokoke forest is a high diversity ecosystem. This is because an ecosystem is considered as medium to high diversity when its diversity index is greater than 2 (Barbour *et al*., 1999). Difference in diversity is likely due to heterogeneous edaphic characteristics and climatic variations that exist in the three communities. The topographical and climatic factors such as precipitation, temperature, geological age, slope and radiation are known to influence species diversity (Irl *et al*., 2015). According to Mligo (2015) climate is one of the influential components that determine growth of species within East African coastal forest that are characterized by diverse habitats types and high diversity in restricted habitats.

In the current study, species diversity was found to be higher in the disturbed sites than in the undisturbed sites of cynometra and mixed forest, which could be attributed to emergence of species that are suppressed in closed canopies. This finding corroborate those by Shrestha *et al*. (2012) in Nepal that plant species diversity increases with human induced disturbance but up to a certain level of disturbance. This result contradicts those of Mligo (2015) who studied plant species richness, diversity and evenness in three forests of Tanzania. The author found lower species diversity in two forests that are anthropogenically disturbed. In Brazilian Caatinga forest, Ribeiro *et al*. (2015) reported a negative impact of anthropogenic disturbance on plant species diversity. On the other hand, the higher diversity in the undisturbed site of brachystegia than its respective disturbed sites has also been reported by Oyugi *et al.* (2008). This result is attributed to a loose canopy structure in brachystegia plant community as compared to mixed and cynometra communities. Therefore, species diversity in the disturbed and undisturbed areas of brachystegia community may be as a result of the combined effects of canopy structure and human disturbance. Sufficient sunlight enhances the growth of understory and sun-loving species in open canopies thus resulting in high species diversity. Open canopies support seedling establishment, growth and development of some species that tend to be suppressed in closed canopy forests (Gray and Spies, 1996; Giliba *et al*., 2011; Aigbe and Omokhua, 2015), whereas human disturbance reduce the abundance of certain species in the disturbed area of brachystegia plant community (Oyugi *et al.*, 2008).

4.4.2 Density of plant species common in the sampled communities

Common species in the three plant communities are not evenly distributed in the forest because of their unique climatic and edaphic requirements. The results of this study show that there is a lower density of common species in cynometra community than the mixed and brachystegia plant communities. This is partly due to high mono-dominance of *Cynometra webberi* that occupied larger area of the plant community that could have been shared with other species. Furthermore, the variation in plant densities can be attributed to site heterogeneity, which plays critical role in species occurrence, distribution and density. Kala (2005) noted that environmental factors affect densities and distribution of plants in various habitat types in the Himalayan region of India.

The result of this study is similar to that reported by McGeoch *et al.* (2008) in Kakamega forest of Kenya. The authors reported higher densities of common liana species in anthropogenic-disturbed areas than in forest areas where extractive uses was prohibited. Likewise, a study conducted in Kakamega of Kenya by Althof (2005) found that degree of disturbance and the age of different forest sites were the key factors influencing the occurrence of different plants.

Lower density of certain common species such as *Lannea schweinfurthii* and *Afzelia quanzensis* can be associated with previous intensive logging in Arabuko Sokoke forest (ASFMT, 2002). These findings corroborate those of Oyugi *et al*. (2008) who reported negative influences of human activity on the structure and density of some of the forest species present in Arabuko forest. Similarly, Aigbe and Omokhua (2015) noted that the rarity and density of some economically important trees is determined by pattern and degree of exploitation.

4.4.3 Size class distribution of the sampled plant species

The results show that there is an inverse relationship between the DBH and number of sampled plants, implying that the number of individuals increased with decrease in DBH. This may be interpreted to mean that there were more young trees than old ones, a possible indicator of high recruitment rate, as well as selective exploitation of larger trees for timber and other uses. Since DBH is a measure of the age of an individual plant (Althof, 2005), the higher number of small sized plants indicates good recruitment process in the forest site (Oyugi *et al.,* 2008; Fashing *et al.,* 2004).

High abundance of small diameter tree species has also been reported in tropical forest of Cameroon (Bobo *et al*., 2006). Lower number of large sized trees has been attributed to selective harvesting of larger trees (Kimaro and Lulandala, 2013; Althof, 2005). However, Hartshorn (1980) attributed the low abundance of big trees to slow growth associated with most indigenous forest species.

In a study on high value trees conducted in South Africa, Obiri *et al*. (2002) found that diameter size was the major determinant of level of exploitation of some of forest species. A population structure with low number of small trees that can potentially attain higher diameters through growth over time is an indication of low recruitment and forest destruction (Mwase *et al.*, 2007). However, as noted by Fashing *et al.* (2004) short term studies on forest ecology cannot be used to predict tree population dynamics and therefore longer time scale studies can better elicit the effects of disturbance on population structure and composition.

4.5 CONCLUSION

Although the results of this study arise from short duration study, they demonstrate that Arabuko Sokoke Forest has high plant species diversity and good generation recruitment of species in both the disturbed and undisturbed sites. Long term studies on forest structure and dynamics in response to human disturbance are indispensable to further confirm these results.

CHAPTER FIVE

NEXUS BETWEEN KNOWLEDGE, UTILIZATION, THREATS AND CONSERVATION OF WILD MEDICINAL PLANTS IN ARABUKO REGION, COASTAL KENYA

ABSTRACT

Botanical knowledge of the rural communities is gradually disappearing due to acculturation, globalization and change of lifestyles. This knowledge is normally held by the elderly generation and is passed on orally to the next generations. This study assessed the relationships between knowledge, use, threats and conservation of wild medicinal plants among the community proximate to Arabuko Sokoke forest in the coastal region of Kenya. Positive and significant correlations were found between knowledge and age of the respondents; and herbal usage by households. Household size, main source of livelihood and education of the household head were negatively correlated to knowledge of the medicinal plants. The results showed that *Oldfieldia somalensis*, *Tinnea aethopica* and *Premna chrysoclada* were the high priority plant species used for treatment of respiratory problems, gastrointestinal complaints and malaria, respectively. Charcoal production, climate change and commercialization of herbal products were some of the reported threats to wild medicinal plants, in the study area. Understanding of the local knowledge on plant species, their uses, threats and existing conservation strategies is expected to provide a baseline for engaging the community in sustainable exploitation of plant resources and protection of the forest ecosystem.

Keywords: Local knowledge of plants; Medicinal plant species; Common diseases; Conservation of medicinal plants; Multiple regression

5.1 INTRODUCTION

Globally, local knowledge of medicinal plants is embedded in most indigenous cultures and forms part of most rural health care. Local knowledge varies across demographic, socio-cultural, economic and ecological spheres (Ladio and Lozada, 2004; Pardo-de-Santayana *et al.,* 2007; Reyes-García *et al.,* 2007). However, this knowledge is vulnerable to acculturation and it is rapidly disappearing (Phillips and Gentry 1993; Njoroge and Bussmann 2006). Begossi *et al.* (2002) reported that elderly individuals in Brazil held local knowledge of plants used as herbal remedies than the younger generation. Similarly, Ghimire *et al.* (2005) indicated that knowledge of plants is known to be rich among the elderly populations as compared to the new generation. As indicated by Cox (2000), the traditional knowledge systems, languages and cultures are fading away because new generations are not interested in knowing their ancient and traditional way of life. Mcmillen (2012) and Da Silva Sousa *et al*. (2012) blame the loss of local knowledge to urbanization, migration, globalization, tourism and availability of industrialized products and services. Understanding disparities in level of ecological knowldege among groups of different characteristics can be vital in recognizing community processes that contribute to erosion of traditional knowledge (Ladio and Lozada, 2004).

Despite habitat degradation and reduction of wild medicinal plant resources, utilization of these resources is on the rise due to their essential role in health care and other multiple uses such as food, fuel, condiments and construction. Habitat destruction due to indiscriminate collection of herbal medicine is mainly attributed to the rise in demand for herbal products (Chirchir *et al.*, 2006). Njoroge (2012) reported that increased commercialization of herbal plants, climate change among other factors are key in driving the loss of medicinal plants.

Different studies have documented threats to medicinal plants that include collection for commercial purposes, climate change and variability, demand for construction, heavy livestock grazing, increased human population, lack of policy guidance and fragmentation of natural habitats (Kala, 2000, 2005; Schippmann *et al*., 2006; Semwal *et al*., 2007; Uprety *et al*., 2011; Njoroge, 2012). Most of these threats have been associated with anthropogenic activities and have intensified with commercialization of herbal medicine (Matu, 2010). Rising demand for plants' products by rural and urban populace calls for their sustainable exploitation and conservation to ensure their availability for posterity (Bussmann *et al*., 2006).

Although many studies have been conducted on phytomedicines in Kenya, none of them has attempted to establish the relationship between knowledge of the species medicinal plants, utilization, perceived threats and conservation measures by the communities. This study compared knowledge, utilization, threats and conservation of wild medicinal plants across different socio-demographic attributes of the community living around ASF, in the coastal region of Kenya. The findings of this study are expected to provide entry point for engaging the community in conservation and targeting of wild plant species for in situ and ex situ conservation.

5.2 DATA COLLECTION AND ANALYSIS

Focus group discussions and key informant interviews question guides, and semi structured questionnaire were used to collect data as described in Chapter three of this thesis. A list of 10 medicinal plants species was compiled from FGDs and KIIs for the purpose of assessing the relationship between knowledge, utilization, threats and conservation among the respondents. Knowledge, use, threat and conservation were rated as 0 for species that were not recognized by the respondents; not used in the household; species not perceived as threatened; and species not conserved. On the other hand, a value of 1 was assigned to species known by the respondents; reported as used in the household; regarded as threatened; and conserved. Information on socioeconomic and demographic attributes of households hypothesized to influence knowledge of the medicinal plants were collected.

Pairwise ranking which has been used in ethnobotanical studies by Martin, (1995) and Addis *et al*. (2013) was employed in ranking the three most common diseases in the area and the most effective species used in treatment of each of them. This was done by pairing two types of ailments and asking the participants of FGDs to indicate which among the pairs was common in the area. The participants were further asked to list four most effective medicinal plant species that are used to treat each of the three most common diseases (previously ranked). Furthermore, each of the four species was paired with the rest and 10 key informants were asked to indicate which among the pairs was most effective in treatment of each of the three common diseases. Plant species were ranked from the most to the least preferred based on sum of scores obtained from the key informants.

Statistical Package for the Social Sciences (SPSS) was used for analysis to generate descriptive statistics such as frequencies, percentages and averages. Multiple regression was conducted to show how well the demographic and socioeconomic attributes predicted knowledge of medicinal plants species among respondents. Multicollinearity test was performed to determine the level of correlation in the independents variables. Independent t-test was conducted to indicate predictor variables that had statistically significant contribution to the equation. Pearson product-moment correlation (r) was performed to indicate the relationship between knowledge, utilization, threat and conservation of selected medicinal plants.

5.2.1 Description of the dependent variable used in the multiple regression model

This study assumed that knowledge of plant medicine varied across demographic and socioeconomic characteristics of the households. Therefore, it was hypothesized that knowledge is a function of individual and household's attributes among other variables. Knowledge was considered a continuous outcome variable which represented the number of medicinal species cited or known by the respondent.

5.2.2 Description of the hypothesized explanatory variables for the multiple regression model

1) Age of respondent

Knowledge of medicinal plants was hypothesized to be influenced by the age of the respondent. Local knowledge has been reported to be vulnerable to acculturation (Phillips and Gentry, 1993; Njoroge and Bussmann, 2006), and was therefore expected to be lower among the youth as opposed to the older generation (Begossi *et al*., 2002). Age of the respondent was assigned a value of 1 if it was less than 30 years, and 2 for age of 30 and above.

2) Gender of respondent

Women are mostly associated with collection of edible, medicinal plants and firewood for home consumption, while men normally harvest plants mainly for commercial purposes such as poles, timber and charcoal. Therefore, the female respondents were expected to be more knowledgeable on herbal plants than their male counterparts. A male respondent was allocated a value of 1 and female assigned a value of 0.

3) Education of household head

Level of education of the household head was expected to influence knowledge, use and interest in plants (Ouhaddou *et al.,* 2014). Educated individuals have a higher opportunity for income generation and therefore are expected to have little interest in medicinal plant knowledge and use. This is because they are likely to use their income to access modern health services as opposed to their counterparts who would mostly rely on the inexpensive and easily available wild medicinal plants. Uneducated household heads and those who had only attained primary education were allocated a value of 1, and 2 for household heads who had attained either secondary or post secondary education.

4) Household size

The size of a family was hypothesized to be directly proportional to its needs. It was expected that larger families are likely to be poorer than the smaller ones due to higher constraints on available resources, leading to high reliance on medicinal plants, which are cheap and readily available. Household size was measured in terms of the number of individuals in a family.

5) Distance to health facility

It was hypothesized that the shorter the distance to a health centre, the lower the probability of that household would rely on plant medicine. The reverse was taken to be true when household's members have to walk longer distances to access health services because they are expected to rely more and be knowledgeable on medicinal plants. Therefore, distance to health facilities was expected to negatively influence the knowledge of herbal remedies. Distance to health centre was measured in kilometers (km).

6) Use of plant medicine

It was expected that households that use herbal remedies for their primary healthcare have immense knowledge in both cultivated and wild medicinal plants. Value of 1 was allocated to respondents that used plant medicine and 0 to households that did not use herbal remedies.

7) Main source of livelihood

Households that chiefly depend on agriculture were hypothesized to interact more with the environment and therefore were expected to be more knowledgeable on medicinal plants than their counterparts who mainly rely on other sources of livelihoods such as employment. This variable was allocated a value of 1 if the main livelihood source was agriculture or pastoralism, and 2 for employment and trade as the main livelihood activity.

8) Per capita daily income

Per capita daily income which is the average income earned by a person in a day was calculated by summing the household's annual income from (total annual sales of agricultural produce, annual value of goods produced at home, wage of household and remittances from employed household members) was divided by the number of days in a year (365). This was further divided by the total number of a household's members. Households with lower income were expected to rely mostly on medicinal plants by virtue of them being readily available and cheap. They were therefore hypothesized to be more knowledgeable on medicinal plant species than those with higher income. Per capita income was estimated in Kenya shillings (Ksh).

9) Age of household head

Younger household heads were expected to be less knowledgeable on medicinal plants than the older ones. The reverse was hypothesized to be true since the level of local knowledge is expected to increase with age. Age of a household head was assigned a value of 1 if less than 30 years, 2 for age category of over 30 years.

10) Number of livelihood sources

Households with more livelihood options were expected to be wealthier thus would rely less on medicinal plants since they can afford the cost of modern health care services. This was hypothesized to lead to poor knowledge of the ethno-medicinal species by such households. The reverse was taken to be true for households with fewer or no alternative livelihoods. This variable represented the actual number of livelihood activities pursued by a household.

11) Distance to all weather roads

Households that are far from roads were expected to rely mostly on medicinal plants by virtue of poor accessibility to modern health facility. Families that are far from roads were therefore hypothesized to be more knowledgeable on such species than their counterparts who were near the roads. Distance was measured in km away from the road.

12) Distance to forest

Distance travelled to forest was hypothesized to be negatively correlated to use and knowledge of wild medicinal plants, implying that those living nearer to the forest are likely to be more knowledgeable on wild medicinal plants than those whose homesteads are far from the forest. Distance was measured in kilometer away froms the forest edge.

13) Remittances from employed relatives

Wages remitted by family members employed elsewhere increases households' income and contributes to diversification of livelihood. Households benefitting from remittances were expected to be less dependent on traditional medicine than those who do not receive remittances.

Therefore, households that receive remittance were expected to be less knowledgeable on medicinal plants than their counterparts that never receive remmittances. Transfer of remittances was considered a dummy variable whereby households receiving remittances were assigned a value of 1 and 0 to those that did not receive wage transfers.

5.2.3 Specification of the multiple regression model

Multiple regression model was selected for this study since the dependent variable (number of medicinal plants cited by respondents) was a continuous variable, while the independent variables were continuous and dichotomous in form (Pallant, 2005; Cohen *et al.,* 2013). For logistic regression, the dependent variable should have two categorical values where binary regression is used or more than two categorical values/responses where multinomial logistic regression would be applicable (Pallant, 2005).

For a suitable multiple regression model, there was need to have normal distribution of the scores of the dependent variable; absence of multicollinearity and outliers; and sufficient sample size. In this model, the dependent variable was a function of the various independent explanatory variables that were correlated to some degree. Multicollinearity test was performed as part of the multiple regresssion in order to ensure that independent variables that were highly correlated ($r > 0.9$) were not included in the model. Tolerance value and variance inflation factor (VIF) were used to test possibility of multicollinearity. Tolerance was an indicator of how much of the variability of the specified predictor was not explained by the other predictor variables. It was calculated as $1-R^2$ for each variable, and a value less than 0.10 indicated multicollinearity. Variance inflation factor is the inverse of tolerance value ($1/1-R^2$) and value of greater than 10 indicated possibility of multicollinearity (Pallant, 2005).

The multiple regression equation was specified as below (Cohen *et al.*, 2013):

$$Y=\alpha+\beta_1P_{1i}+\beta_2P_{2i}+\beta_3P_{3i}+\beta_4P_{4i}+\beta_5P_{5i}+\ldots.. \beta_zP_{ki}$$

Where Y is the dependent variable, which was the knowledge of medicinal plant; α is the constant; $\beta_1 \ldots \beta_z$ denotes the βeta coefficient of each predictor variable (1 to z); i denotes number of household respondent (1 to 207); and $P_1 \ldots P_k$ are the predictor variables for the multiple regression model.

Preliminary analyses were conducted to ensure no violation of the assumption of linearity, normality; and making sure multicollinearity and singularity did not exist. A series of multiple regressions were conducted using number of medicinal plant cited as the regressand until the best fit of the model was attained. The criteria for evaluating the model were based on R square; adjusted R^2, F-statistics, t-values, the direction of influence of the independent variables, Beta standardized coefficients and the number of significant variables in the regression model.

5.3 RESULTS

5.3.1 Knowledge, utilization, threats and conservation of medicinal plants

Table 5.1 shows the knowledge, use, threats and conservation status of the ten most preferred wild medicinal plant species. *Grewia plagiophylla, Uvaria acuminata, Euclea natalensis* and *Oldfieldia somalensis* were the most known species among the respondents. *Euclea natalensis* (38.5%) and *Grewia plagiophylla* (94.1%) had their uses least and most known, respectively by the respondents. The least known and utilized wild plant species was *Clausena anisata,* whereby most of the respondents considered it as least threatened and therefore did not deserve conservation. Sixty one percent of the respondents regarded *Warburgia stulhmanii*as as threatened although only 19% of the respondents who had knowledge of the species had made attempts to conserve it. The most and least conserved species were *Grewia plagiophylla* (45%) and *Diospyros consolatae* (17%), respectively. Among the respondents who had perceived threats to the mentioned medicinal plants, only a few made attempts to conserve them.

Table 5. 1: Knowledge, utilization, threat and conservation of medicinal plants

Species	Frequency of respondents							
	Knowledge		Utilization		Threats		Conservation	
	Yes	No	Yes	No	Yes	No (%)	Yes	No
Diospyros consolatae	99 (47.8)	108 (52.2)	42 (42.4)	57 (57.6)	50 (50.5)	49 (49.5)	16 (17.0)	83 (83.0)
Oldfieldia somalensis	144 (69.6)	63 (30.4)	67 (46.5)	77 (53.5)	80 (55.6)	64 (44.4)	40 (27.8)	104 (72.2)
Warburgia stulhmanii	72 (34.8)	135 (65.2)	22 (30.6)	50 (69.4)	44 (61.1)	28 (38.9)	14 (19.4)	58 (80.6)
Grewia plagiophylla	202 (97.6)	5 (2.4)	190 (94.1)	12 (5.8)	52 (25.7)	150 (74.3)	91 (45.0)	111 (55.0)
Euclea natalensis	169 (81.6)	38 (18.4)	65 (38.5)	104 (61.5)	60 (35.5)	109 (64.5)	42 (24.9)	127 (75.1)
Xylopia parviflora	84 (40.6)	123 (59.4)	16 (19.0)	68 (81.0)	47 (56.0)	37 (44.0)	11 (12.8)	75 (87.2)
Uvaria acuminata	179 (86.5)	28 (13.5)	145 (81.0)	34 (19.0)	39 (21.8)	140 (78.2)	50 (27.9)	129 (72.1)
Acalypha fruticosa	115 (55.6)	92 (44.4)	29 (25.2)	86 (74.8)	47 (40.9)	68 (59.1)	21 (18.3)	94 (81.7)
Clausena anisata	57 (27.5)	150 (72.5)	18 (31.6)	39 (68.4)	12 (21.8)	43 (78.2)	11 (20.0)	44 (80.0)
Turaea wakefieldii	67 (32.4)	140 (67.6)	22 (32.8)	45 (67.2)	36 (53.7)	31 (46.3)	16 (23.9)	51 (76.1)

*****Percentages are presented in parentheses

The results of Pearson correlation analysis show that knowledge of *Diospyros consolatae, Clausena anisata,* and *Turaea wakefieldii* was significantly higher in men (P<0.05) than in female respondents (Table 5.2). *Grewia plagiophylla*, *Euclea natalensis, Uvaria acuminata* and *Acalypha fruticosa* were mostly recognized by female than male respondents. Knowledge of all species showed weak to moderate positive correlation with age of the respondents, with significantly higher (P<0.01) knowledge of medicinal species observed in older than younger generation. Knowledge of *Grewia plagiophylla* showed the weakest positive correlation with age (r=0.075). On the other hand, *Clausena anisata* and *Turaea wakefieldii* had the highest positive correlation with age compared to the other eight medicinal plant species. Relationship between utilization and perceived threat to medicinal plant species was positive and significant (P<0.05) for *Oldfieldia somalensis* and *Warburgia stulhmanii*, while that of *Turaea wakefieldii* was significant at (P<0.01). There was a significant and negative correlation (P<0.01) between perceived threat and conservation of *Oldfieldia somalensis*, with high levels of perceived threat associated with lower levels of conservation of the species. Knowledge of *Oldfieldia somalensis*, *Warburgia stulhmanii*, *Turaea wakefieldii* and *Diospyros consolatae* significantly increased farther away from the forest. All species showed positive correlation between use and threat indicating that high use intensity of medicinal species leads to increase in the danger of losing them.

Table 5.2: Correlation between knowledge, threat and conservation of medicinal plants, and age and gender of respondents

Species	Correlation coefficient					
	Knowledge-Gender of respondent	Knowledge-Age of respondent	Knowledge-Distance to forest	Knowledge-Distance to health center	Use-Threat	Threat-Conservation
Diospyros consolatae	0.156*	0.331**	0.147*	0.103	0.032	-0.144
Oldfieldia somalensis	0.085	0.251**	0.055*	0.093	0.190*	-0.257**
Warburgia stulhmanii	0.102	0.375**	0.082	0.001	0.282*	-0.040
Grewia plagiophylla	-0.049	0.075	0.113	-0.023	0.052	-0.078
Euclea natalensis	-0.028	0.243**	-0.014	-0.010	0.023	-0.083
Xylopia parviflora	0.092	0.317**	-0.172*	-0.038	0.064	-0.313
Uvaria acuminata	-0.041	0.316**	0.082	0.014	0.118	0.033
Acalypha fruticosa	-0.080	0.210**	0.031	-0.092	0.006	-0.118
Clausena anisata	0.167*	0.420**	0.125	0.131	0.007	-0.264
Turaea wakefieldii	0.150*	0.380**	0.224**	0.214**	0.394**	-0.042

*significant at 0.05 level; ** significant at 0.01 level

Seven types of threats to medicinal plants were identified in this study (Figure 5.1a). Charcoal production was cited as the major (26%) threat to wild medicinal plants, followed by climate change and drought (23%), clearing for cultivation (18.0%), commercialization of forest products (16%), deforestation (16%) and limited livelihood sources (10%). Domestication of wild medicinal plants was perceived as the most effective (52.7%) and appropriate measure for conservation of wild herbal plants (Figure 5.1b). Regulation on use and monitoring by government ministry and agencies such as Kenya Forestry Service and local chiefs; and formation of conservation groups were the third and fourth conservation measures mentioned by the respondents.

Figure 5.2 represents the most mentioned wild species that were deliberately left to grow on farms and/or domesticated by the households. *Grewia plagiophylla* was mentioned as the most domesticated species followed by *Uvaria acuminata*, *Afzelia quanzensis and Salvadora persica* in that order.

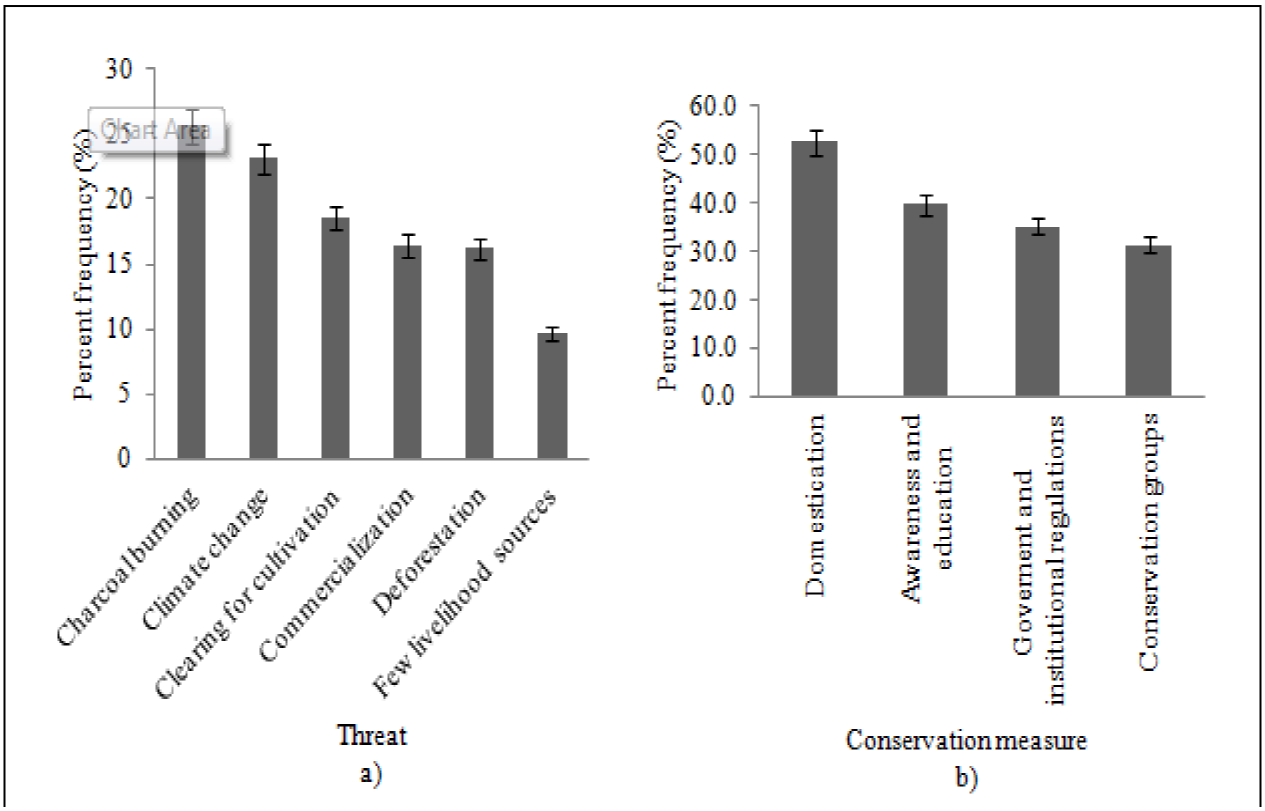

Figure 5. 1: Threats and appropriate conservation measures as perceived by respondents

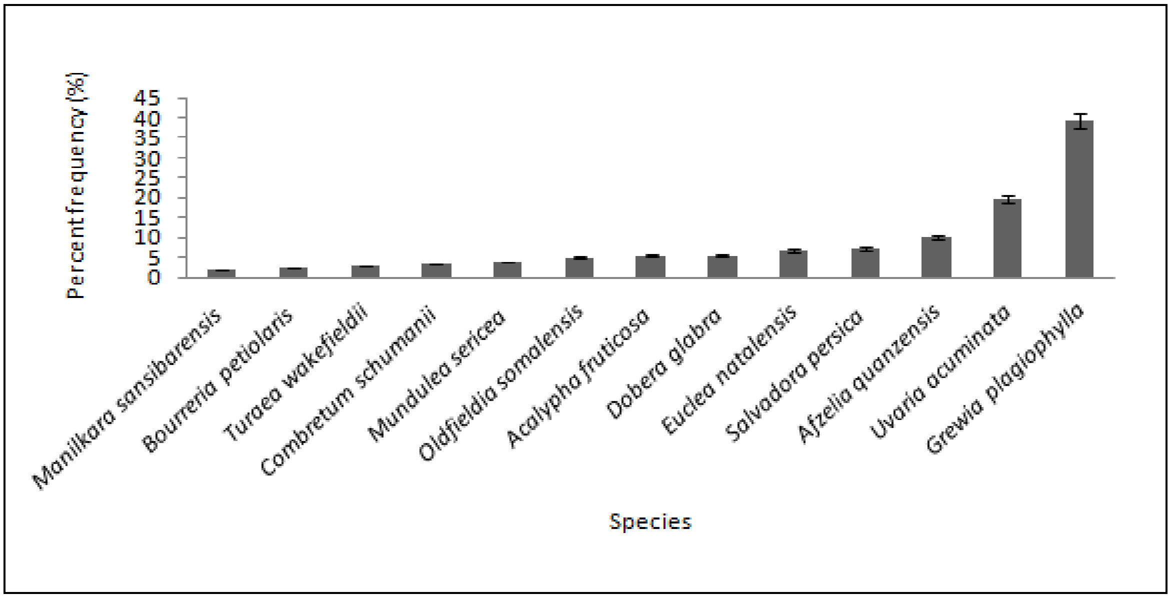

Figure 5. 2: Wild medicinal plant species domesticated by respondents

5.3.2 Factors influencing knowledge of wild medicinal plants

Majority of the respondents were females (56%), most (69%) of them over 30 years of age (Table 5.3). Most (63%) of the household heads had attained formal education. The average household size and per capita income were found to be 9 persons and Ksh 87, respectively, with 61% of the households depending mainly on agriculture for their livelihoods. The average distance to health facilitilities was 3.6 km, with majority (72%) of the respondents reported use of plant medicine as one of their health care options.

Table 5. 3: Descriptive results of independent variables used in the multiple regression model

Explanatory variable	Definition	Average recorded
Age of respondent	Age of household respondent in years. Scaled: 1 for ≤30 years, 2 for those above 30 years	142 out of the 207 respondents (69%) were above 30 years of age (Mode= 2)
Gender of respondent	Sex of the respondent Binary: 0 for female, 1 for male	115 out of the 207 respondents (56%) were female (Mode= 0)
Education of Household head	Highest level of education attained by the household head. Scaled: 1 for uneducated and primary level; 2 for secondary and tertiary education.	131 out of the 207 (63%) of household heads attainedsecondary or tertiary education (mode= 2)
Household size	Number of family members at the time of the interview.	Average household size was 9 persons
Distance to health facility	Distance to nearest modern medical clinic or dispensary measured in km	Average distance of household to health clinic or dispensary was 3.6 km
Use of plant medicine	Use of plant remedy for treatment of diseases Binary: 0 for no, 1 for yes	148 out of the 207 households (72%) used herbal remedies as one of their treatment option (mode= 1)
Main source of livelihood	Chief source of livelihood, value of 1 was assigned for agriculture, 2 for employment and business venture	126 out of the 207 households (61%) were mainly dependent on agriculture (mode=1)
Per capita income	Per capita daily income, calculated by dividing the household's annual income with number of days in a year and the number of persons in the household.	The mean per capita daily income was Kshs. 87 per individual

Table 5.4 shows the VIF value for the model ranged from 1.03 to 1.27. All the VIF values were below the cut-off point of 10 whereas all tolerance values were above the cut-off point of 0.1, thus the multicollinearity assumption was not violated.

Table 5. 4: Results of multicollinearity test for the explanatory variables

Variable	Tolerance (1/VIF)	VIF
Age of respondent	0.92	1.08
Gender of respondent	0.85	1.18
Education of household head	0.90	1.11
Household size	0.97	1.03
Distance to health facility	0.94	1.06
Use of plant medicine	0.79	1.27
Main source of livelihood	0.97	1.03
Per capita income	0.92	1.09

Table 5.5 shows the results of the multiple regression. The number of medicinal species mentioned by the respondents was significantly ($P<0.01$) higher in older respondents and in households that used herbal remedy for management of diseases than in younger respondents and households that exclusively used allopathic medicine. Respondents from smaller households were significantly ($P<0.01$) more knowledgeable than those from larger families. Total number of cited medicinal plants was significantly higher ($P<0.05$) in respondents whose chief livelihood source was agriculture than those whose main source of livelihood was small business ventures and employment. Medicinal plant knowledge was significantly ($P<0.05$) higher in households heads who were uneducated or who had attained primary education than those who had secondary and tertiary education. Use of plant medicine made the strongest contribution (Beta=0.38) to explaining knowledge of medicinal plants, implying that use of plant remedies had a considerable effect on knowledge of ethno-medicinal plants, as compared to the other predictor variables.

Table 5. 5: Multiple regression results using knowledge as the regressand

Variable	Unstandardized Coefficient (β)	Standardized coefficient (Beta)	t	P-value
Age of respondent	1.95	0.35	6.51**	0.00
Gender of respondent	-0.13	-0.03	-0.45	0.65
Education of Household head	-0.66	-0.11	-2.03*	0.04
Household size	-0.22	-0.31	-5.84**	0.00
Distance to health facility	0.52	0.10	1.78	0.08
Use of plant medicine	2.16	0.38	6.50**	0.00
Main source of livelihood	-0.26	-0.13	-2.45*	0.02
Per capita income	0.07	0.01	0.20	0.84
Constant	3.37		3.70	0.00

* Significant at 0.05 level; ** significant at 0.01level; R^2=0.470; Adjusted R^2 = 0.448

5.3.3 Species used in treatment of common diseases in Arabuko Sokoke area

Common diseases reported in areas surrounding Arabuko forest were malaria and fever, respiratory diseases such common cold and cough; and gastrointestinal diseases. Pairwise ranking of the species by respondents based on their effectiveness in curing each of the common diseases revealed the most preferred medicinal plant species for each ailment (Figure 5.3). Medicinal plants that were perceived important in the treatment of the three ailments included *Uvaria acuminata, Premna chrysoclada, Grewia plagiophylla, Lannea schweinfurthii, Warburgia stulhmanii, Clausena anisata, Oldfieldia somalensis, Abrus precatorius, Monodora grandidieri*, *Carissa edulis*, *Clerodendrum incisum* and *Tinnea aethopica*. *Premna chrysoclada, Oldfieldia somalensis,* and *Tinnea aethopica* were identified as high priority wild plant species for treatment of malaria, respiratory complaints and gastrointestinal diseases, respectively.

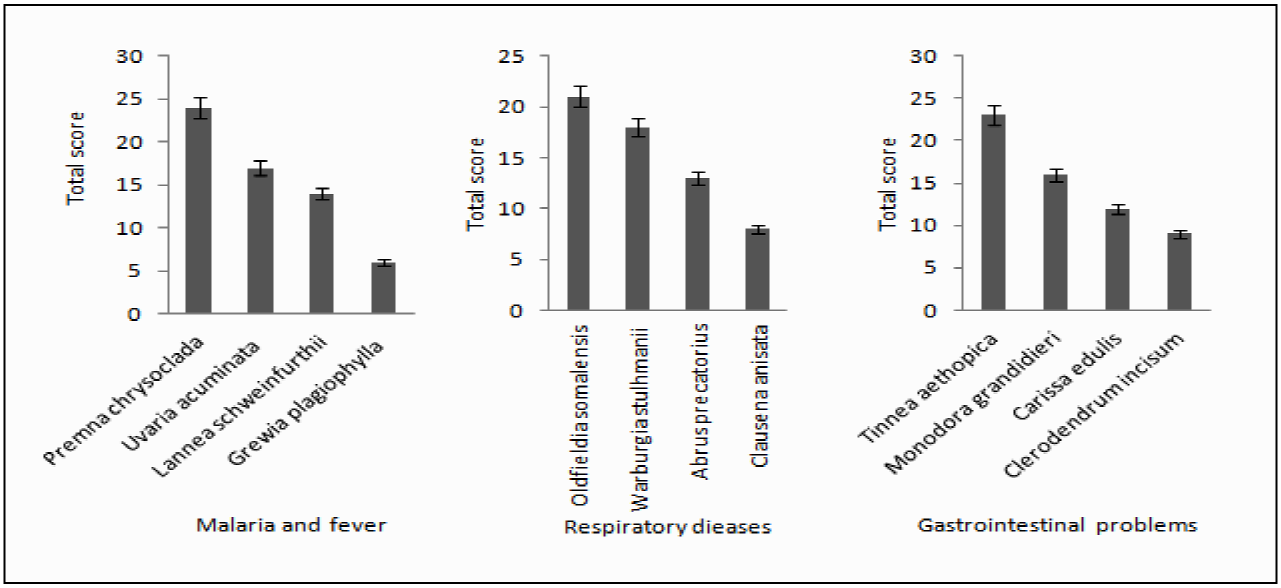

Figure 5. 3: Preferred medicinal plant species for treatment of the common diseases (Source: Pair wise ranking by author)

5.4 DISCUSSION

5.4.1 Knowledge, utilization, threats and conservation of herbal plants

More knowledge and high degree of utilization of *Grewia plagiophylla* and *Uvaria acuminata* by respondents regardless of age and gender could be attributed to its wider distribution and availability near homesteads. In a study conducted in Tanzania to document the transfer of medicinal plants knowledge, Mcmillen (2012) reported that the widely distributed medicinal plants such as *Zanthoxylum chalybeum* and *Albizia anthelmintica* were easily recognized and most mentioned by the respondents. Similarly, in a survey of medicinal plants used in Nyamira County in Kenya, Omwenga *et al.* (2015) found that *Urtica dioica*, which was present in all the study sites, was the most known species among the respondents as opposed to *Erythrina abyssinica* and *Rhus natalensis* that were rare in the study sites.

High recognition of *Uvaria acuminata* and *Acalypha fruticosa* by female respondents could be attributed to their importance in treatment of female related disorders such as female infertility and relieving labor pain, as revealed in the FGDs. The results of this study show that *Oldfieldia somalensis* and *Warburgia stulhmanii* were the most threatened species, as perceived by the community. This corroborates the report by IUCN (2015) that lists *Warburgia stulhmanii* as a vulnerable species owing to its decreasing population. The lower number of respondents who recognized *Warburgia stulhmanii* may partly be attributed to its narrow ecological distribution (Mcmillen, 2012). Additionally, the positive correlation between use and threats, and the negative correlation between threat and conservation imply that most people who use the species perceive them as threatened but were however not involved in their conservation.

Charcoal production and deforestation through timber extraction are some of the main threats to Eastern Africa Coastal Forests (WWF-EARPO, 2006; Critical Ecosystem Partnership Fund (CEPF), 2005) of which Arabuko forest is not an exception. In a study conducted in a group ranch near Amboseli National park of Kenya to document the anthropological and ecological threats to ethno-medicinal resources, Kiringe (2005) reported similar threats such as charcoal production, drought and over-exploitation caused by commercialization. The rise of charcoal production reported in this study can be attributed to the ready market in the nearby urban centers and along the Mombasa-Malindi highway. One of the threats in the study area was the commercialization of forest resources and according to Ndang'ang'a *et al.* (2016) logging of timber tree species was prevalent in the forest. Some of the species harvested for marketing were *Manilkara sansibarensis, Afzelia quanzensis, Brachylaena huillensis* (Gooch, 2007; Oyugi *et al.*, 2008; ASMT, 2002), all which have medicinal value. Deforestation and expansion of land cultivation was reported by Nanyingi *et al.* (2008) as some of the threats to the population of medicinal plant resources in the Samburu district of Kenya.

Market expansion for herbal products from the forest to distant markets (ASFMT, 2002) can put more pressure on the forest medicinal resources because of the increasing demand by both local and distant markets. Similarly, Njoroge *et al.* (2010) have linked the destructive harvesting of wild medicinal products to the expansion of markets in both the urban and rural areas. Additionally, Bussmann *et al.* (2008) reported that the bulk of medicinal plant materials sold in Kenya's markets are obtained from the wild. The results of the current study show that limited sources of livelihood have led to overreliance on the forest for economic, cultural and social needs. Matiku (2005) noted that inadequate alternative livelihood sources make communities adjacent to the forests to be more dependent on the forest resources, therefore contributing to the threats facing conservation of coastal forests of Kenya. Such overreliance on forests for household livelihoods normally leads to unsustainable utilization and forest destruction. Medicinal plant stocks are not an exception since they are also affected by deforestation and overharvesting of multiple purpose species for uses such as fuel wood, construction, among others. For example, *Albizia amara*, which is one of the priority medicinal plants in Mwingi district was reported by Njoroge *et al.* (2010) to be under threat because of its extensive use for charcoal and firewood.

Domestication of forest species have been recommended as a measure of reducing pressure of coastal forests of Kenya thus ensuring biodiversity conservation (Wekesa *et al.*, 2015). CEPF (2005) related threats to biodiversity to the lack of environmental awareness, in the coastal forests of Kenya. CEPF (2005) further proposed awareness creation on conservation issues as a strategy for successful conservation. Likewise, in a study on medicinal plant in Nandi areas of Kenya, Jeruto *et al.* (2008) noted that community awareness and education on the importance of conservation of wild species was of utmost importance in ensuring conservation of ethno-medicinal resources. In the current study, strengthening and adherence to government and institutional regulations on access to and utilization of forest resources was found to be imperative in guaranteeing sustainable use and management of forest ecosystems.

5.4.2 Influence of socioeconomic factors on knowledge of medicinal plants

In the current study, the vast knowledge of wild medicinal plants held by the older generation can be partly attributed to the experience and knowledge accumulated over the years, as well as the high degree of dependence on herbal medicine in the past as compared to currently. In Amboseli area of Kenya, Kiringe (2005) reported similar results, that the elderly were more knowledgeable than the younger generation. The author partly attributed this to the experience gained by the elderly and and the lack of interest in the Maasai culture among the youth. In a study to determine the knowledge on agro forestry in the Andean forest, Brandt *et al.* (2013) found that knowledge increased with age of the respondents. However, the authors attributed this to the loss of native species which meant that the older generation having encountered more species in their lifetime could cite more species than the youth.

This concurs with the results of Begossi *et al*. (2002) who reported similar findings in the Atlantic forest of Brazil. Similarly, Ladio and Lozada (2004) in their study conducted in northwestern Patagonia found that the total number of wild edible plants cited by respondents was positively correlated to their age. They attributed the high knowledge of medicinal plants of the older generation to their familiarity and longer experience with their environments as compared to the young generation. In contrast to these findings, Hanazaki *et al.* (2000) in their study conducted around Atlantic forest of Brazil reported that the younger respondents cited more medicinal plants than did the older generation. They attributed this to the fact that the youth were more open to the interviews than the elderly, and that the latter were more excited talking about their successful past than the current issues. Gender did not significantly affect knowledge of medicinal plants probably because, both women and men in the community are exposed to the same culture and they both acquire this knowledge from the older generation. The positive correlation of herbal usage to the knowledge of medicinal plants can be attributed to the fact that those who are dependent on medicinal plants need to know and identify the species in the wild as compared to their counterparts who did not or rarely use them.

Agriculture as the chief source of livelihood was positively correlated to knowledge on medicinal plants possibly because farming households interacted more with their environments than those who are mainly involved in trade and informal employment. The negative influence of formal education on the knowledge of medicinal plants can partly be attributed to the fact that educated individuals are more exposed to modern culture and therefore they are likely to lose interest in their own traditional ecological knowledge. A study conducted in Ethiopia by Giday *et al.* (2009), in Ethiopia revealed that illiterate individuals are likely to have more knowledge on medicinal plants than their literate counterparts due to exposure of the latter to modernization. The little knowledge on medicinal plants among household heads who had attained higher education is expected to result in less knowledge among their family members. This is because most of the traditional knowledge is passed orally through kinship and from parents to children (Kidane *et al.,* 2014; Kipkore *et al.,* 2014).

5.4.3 Priority species for the treatment of common diseases

Similar to the findings of the current study, Gathirwa *et al.* (2008) reported the use of *Lannea schweinfurthii* for treatment of malaria in Meru county of Kenya. However, in Tana River County, Kaingu *et al.* (2013) reported use of the same species in treatment of female reproductive health dysfunctions. Whereas Gathirwa *et al.* (2011) reported use of *Uvaria* *acumunata* for treatment of malaria in Kilifi County of Kenya, Kaingu *et al.* (2013) found that the species is used for treatment of excessive bleeding and painful menses in Tana River County. Contrary to the finding of this study, whereby *Clausena anisata* was found to be used against respiratory diseases, the same species was preferred for treatment of malaria and stroke (Okello *et al.*, 2010), and snakebites (Birhanu *et al.*, 2015), in the Mt. Elgon region of Kenya and Western Ethiopia, respectively.

In the current study, *Monodora grandidieri* and *Warburgia stulhmanii* were found to be important for treatment of gastric problems and respiratory complaints, respectively. However, in an earlier study by Weiss (1979) in the coastal areas of East Africa, *Monodora grandidieri* was reported to be used against helminths, while *Warburgia stulhmanii* was used for treatment of joint pains. Similar to the findings of the current study, Njoroge *et al*. (2010) reported the use of *Carissa edulis* for treatment of gastro-intestinal complaints in Mwingi district of Kenya. Giday (2003) found that the roots of *Carissa edulis* were important against rheumatism in Ethiopia. Use of *Abrus precatorius* for treatment of respiratory diseases has been reported in Siaya district (Johns *et al.*, 1990), and for treatment of pneumonia and asthma in Tana River County (Kaingu *et al.,* 2014). In addition, roots and seeds of *Abrus precatorius* are used against rheumatism, arthritis and bone fracture in India (Kala *et al.*, 2004).

5.5 CONCLUSION

The results of this study show that knowledge of medicinal plants vary with socioeconomic and demographic factors such as age of respondent, use of herbal remedies, education of household head and the main source of household livelihood. Generally, there is less transfer of knowledge of ethno-medicinal resources in the community surrounding Arabuko forest as is evident in little knowledge among the youth as compared to the elderly. The study further revealed that whereas the community were aware of the threats to medicinal plants, they made little effort to conserve them. Therefore, there is need to minimize loss of ethnobotanical knowledge through documentation and promotion of its transmission to the youth. In addition, it is necessary to educate the community living around the forest on sustainable utilization and conservation of forest resources to ensure that the high dependence on the forest resources that is already evident doesn’t result in loss of biodiversity in the future.

CHAPTER SIX

USE VALUE AND CONTRIBUTION OF MEDICINAL PLANTS TO LIVELIHOODS IN THE ARABUKO SOKOKE AREA, COASTAL KENYA

ABSTRACT

Medicinal plants have been part and parcel of the human and veterinary healthcare among rural populace since time immemorial. However, over the past decades there has been an increasing interest in herbal products among urban communities as well, thereby leading to commercialization of plant products. This study analysed the relative importance of plants (cultural and practical importance), marketed herbal species, and their contribution to households' healthcare in Arabuko Sokoke area. Data was collected through household interviews, key informant interview and focus group discussions. The results revealed a positive correlation between cultural and practical value. High proportion of households was found to use medicinal plant remedies, which were reported to have positive contribution to rural livelihoods. Scarcity of some traded forest species, lack of proper storage and processing technologies were found to be some of the challenges facing traditional medical practitioners and herbal medicine trade. The results also showed that majority of the marketed herbal products are harvested within the forest. Forest conservation efforts should therefore focus on the in situ protection and domestication of species with medicinal value to ensure responsible exploitation of plant resources.

Keywords: Cultural and practical indices; Use value; Traditional herbal practitioners; Trade of herbal products; Medicinal plant utilization

6.1 INTRODUCTION

Globally, approximately 12.5% of plants are known to have medicinal properties and majority of them are collected from the wild, while a few are cultivated (Schippmann *et al*., 2002). In Kenya, an increase in utilization of medicinal plants for primary health care has been recorded by Jeruto *et al*. (2015). Majority of these herbal species are extracted from forest ecosystems (Otieno and Analo, 2012). Likewise, Omwenga *et al.* (2015), in a study of medicinal plants used in the treatment of skin infections, gastrointestinal complaints, urinary tract and oral cavity infections in Nyamira County found that most of the herbal species were harvested from the forests.

Millions of people are increasingly dependent on wild and cultivated medicinal plants despite an increase in the manufacture and distribution of modern medicines (Hamilton, 2004). This can be attributed to plants' vital role in peoples' and animals' primary health care and livelihoods improvement (Mulliken and Crofton 2008; Taylor *et al*., 2001; Uprety *et al*., 2011). It is estimated that about 70-80% of world's population use medicinal plants for their primary health care (WHO, 2002). Chirchir *et al*. (2006) reported that about 90% of the population in Kenya has at least once made use of medicinal plants for various health conditions. In spite of the immense reliance on the medicinal plants by majority of households in developing and developed countries, only a few of these herbal plants have been studied (Taylor *et al*., 2001).

Majority of people who use and are involved in trade of herbal medicines are the rural communities who are attached to natural resources and are the collectors, healers, financially poor individuals and landless people (Hamilton, 2004; Njoroge, 2012). However this trend is changing as more and more people from urban areas continue to get involved in either processing and or trading of herbal products. For instance in Kenya the number of people in urban areas registering as traditional medical practitioners is on the increase (Njoroge, 2012). The growing reliance on herbal medicine is attributed to increased awareness of the benefits of herbal medicines, its availability and affordability, and low supply of pharmaceutical drugs in developing countries (Taylor *et al*., 2001).

Ethnobotanical studies tend to capture the importance of plants to communities by calculating indices that take into account various variables. Therefore, different researchers have developed different indices for estimation of plants' significance to humans. For instance, Tardio and Pardo-de-Santayana (2008) estimated plant significance value by the use of frequency of quotation or citation of a species by the respondents. Another technique of estimating this index involves making use of the number of usage reports (Kufer *et al*., 2005).

Phillips and Gentry (1993a) estimated use value of plants by evaluating individual species based on their cultural relevance. In addition, Pieroni (2001) determined the importance of edible plants by including variables such as availability, taste, part used, how the plant was used and the frequency of use. Use value estimation such as the one developed by Reyes-Garcia *et al.* (2006) estimated the significance of plants to humans by summing up three indices, which are cultural, practical and economic values. Measurement of plants' values is vital in evaluating natural resources (Tardo and Pardo-de-Santayana, 2008), assessing priority species or habitats and designing appropriate conservation strategies for the vulnerable plants or ecosystems (Kvist *et al*., 1995).

The measure of relative importance of medicinal plants to community offers a possible way of determining important species in the community that ought to be conserved. In addition, vital species of conservation concern can be determined through information on the source and marketing aspects. The purpose of this study was therefore to determine relative importance, economic contribution of medicinal plants to communities adjacent to Arabuko Sokoke forest, and to document marketed medicinal species and challenges in their trade. The findings are expected to provide empirical evidence to guide conservation and improvement of the trade of herbal products in Kenya.

6.2 DATA COLLECTION AND ANALYSIS

Semi structured questionnaire, focus group discussion (FGD) and key informant (KII) question guide were used as described in Chapter three of this thesis. Focus group discussions and KIIs techniques were used to identify medicinal plants, their local names, traded species, their origin, availability, plants' parts used, preparation methods and diseases treated. Key informant interviews were complemented by guided walks and observations to record species that were mentioned by respondents and encountered in the study area.

Additional data on most traded species and their origin was obtained through interviews with 33 key informants who comprised of 21 traditional medical practitioners and 6 medicinal plant collectors (MPCs). A structured questionnaire was used to conduct interviews with 207 household heads or their representatives from the selected 8 villages. Questions and discussions were conducted in the Swahili and Giriama languages that were well understood by the respondents. The respondents were asked to list plants that have medicinal properties and then asked to mention other uses of the same species. As suggested by Kvist *et al*. (1995) and Reyes-Garcia *et al*. (2006), closed questions were used to gain more understanding of current uses (practical use). Respondents were asked to recall the plants that they have brought in their household in the last six months and their intended uses.

Further questions were designed to elicit more information on utilization of medicinal plants for five use categories that included animal feed, food, fuel, construction and others (ornamental, fencing, for making tools, traditional and religious purposes), as well as diseases experienced in the household and medicinal plants used for the treatment of these diseases. In order to determine cost incurred or saved in using medicinal plants for the treatment of various diseases, the respondents were asked how much they would pay for treatment of the reported diseases if they were to purchase medicine from herbalists, clinics or over the counter in chemists. A similar approach has been used by Godoy *et al.* (2002) in Bolivia and Honduras, and Matiku *et al.* (2013) in Kenya.

Scientific and vernacular names of plant species mentioned by the respondents were identified by use of available literature (Beentje *et al*., 1994; Robertson, 1999; Kenya indigenous forest conservation programme, (1995) and expert knowledge.

Cultural, practical and total values of species were calculated using the formulae by Reyes-Garcia *et al.* (2006). Cultural value was calculated as follows:

$$CV_s = Uc_s * Ic_s * \sum IUc_s$$

Where: CV_s is cultural value of species s; Uc_s is the total number of uses reported for medicinal plants divided by the five potential uses of a species considered in the study (i.e. firewood, construction, food, livestock feed and others). Food category included all medicinal plant species that can be used for direct consumption such as edible fruits, vegetables or spices. This category included fruits eaten or sucked because of their sweet taste by children and women while in the forest but are not carried home. Species under the category of others included ornamental, those used for making tools, fencing, and other traditional and cultural purposes. Ic_s is the number of respondents who listed species s as useful divided by the number of participants in free listing. IUc_s is the number of respondents who mentioned each use of species s divided by the total number of participants.

Practical value was calculated using the following formula:

$$PV_s = UP_s * Ip_s * Dup_s$$

Where: PV_s is practical value of species s; UP_s is the number of different uses mentioned for species s divided by the six potential uses of species considered in the study; Ip_s is the number of times species s was brought to a household divided by the total number of informants participating in the interviews; and Dup_s is the duration of each use (i.e. 1 day for species used as food, 7 days for animal feed and fuel, 90 days for the category of medicine and 'others', and 180 days for species that can be used for construction).

Total value was estimated by summing the cultural and practical values of each species as follows:

$$V_s = CV_s + PV_s$$

Where: V_s is the total value of species s*;* CV_s is the cultural value of species s*;* and PV_s is the practical value of species s.

Statistical Package for the Social Sciences was used to generate descriptive statistics such as frequencies, averages and percentages. Correlation analysis was conducted to determine the relationship between cultural and practical values. Species with the highest value were considered as highly preferred while those with low values were less preferred. Frequencies and average values for type of medicine used and cost of herbal and modern medicine were also determined.

6.3 RESULTS

6.3.1 Use value of the medicinal plant species

The most culturally important cultivated and semi-wild medicinal plants that had highest scores were *Azadirachta indica, Zanthoxylum chalybeum***,** *Passiflora edulis* and *Grewia plagiophylla* (Table 6.1). Wild medicinal plants with the highest use value included species such as *Oldfieldia* *somalensis, Uvaria acuminata*, *Afzelia quanzensis*, and *Diospyros consolatae*. Cultural values and practical values ranged from 0.001 to 33.447 and 0 to 15.216, respectively. *Azadirachta indica* had the highest cultural and practical value. Seventeen of the species had practical value of 0 because they were not brought for use for any of the six possible use categories but were cited as medicinal plants.

The communities cited 63 plant species which were distributed in thirty one plant families. Family Fabaceae was the highest represented family with 8 different species recognized as medicinal by the respondents. Based on the growth forms, tree species were represented by 68% of all species cited, followed by shrubs (18%), herbs (11%) and Liana (3%). Whereas some forest species such as *Ximenia americana and Lannea schweinfurthii* had high cultural value, their practical values were found to be low. *Ozoroa obovata, Acacia nilotica, Afzelia quanzensis, Adenia gummifera, Combretum illairii, Securidaca longipedunculata, Deinbollia borbonica, Capparis sepiaria, Dichrostachys cinerea* and *Dichrostachys cinerea* were not reported to be used for any of the six potential use categories.

Table 6.1: Medicinal plants species in and around Arabuko Sokoke forest

Scientific name	Family	Local name	Life form	Habitat/source	Cultural value	Practical value	Total value
Azadirachta indica A.Juss.	Meliaceae	Mkilifi	Tree	Semi-wild	33.447	15.216	48.663
Grewia plagiophylla K.Schum	Tiliaceae	Mkone	Tree	Semi-wild	2.568	8.466	11.034
*Zanthoxylum chalybeum*Engl.	Rutaceae	Mdhungu	Tree	Semi-wild	5.446	4.406	9.852
Passiflora edulis Sims.	Passifloraceae	Mpashioni	Liana	Cultivated	4.978	0.403	5.381
Mangifera indica L.	Anacardiaceae	Mwembe	Tree	Cultivated	0.170	2.382	2.552
*Hoslundia opposita*Vahl	Lamiaceae	Mtserere	Shrub	Semi-wild	2.340	0.092	2.432
Psidia guajava L.	Myrtaceae	Mpera	Tree	Cultivated	2.345	0.026	2.371
Anacardium occidentale L.	Anacardiaceae	Mkanju	Tree	Cultivated	1.701	0.079	1.780
*Uvaria acuminata*Oliv.	Annonaceae	Mrori	Shrub	Wild	0.566	0.782	1.348
Moringa oleifera Lam.	Moringaceae	Mzungwi	Tree	Cultivated	1.191	0.063	1.254
*Diospyros consolatae*Chiov.	Ebenaceae	Mbathe	Tree	Wild	0.354	0.711	1.065
Oldfieldia somalensis (Chiov.) Milne-Redh	Euphorbiaceae	Mbirandu	Tree	Wild	0.402	0.656	1.058
Aloe volkensii Engl.	Aloaceae	Kitozi	Herb	Cultivated	0.636	0.076	0.712
Cocos nucifera L.	Arecaceae	Mnazi	Tree	Cultivated	0.596	0.001	0.597
Polyathia stuhlmanii (Engl.) Verdc.	Annonaceae	Mwangejeni	Shrub	Wild	0.459	0.116	0.575
Lannea schweinfurthii (Engl.) Engl.	Anacardiaceae	Mnyumbu	Tree	Wild	0.068	0.463	0.531
*Thespesia danis*Oliver	Malvaceae	Mhowe	Tree	Wild	0.391	0.015	0.406
Tamarindus indica L.	Fabaceae	Mkwaju	Tree	Semi-wild	0.338	0.026	0.364
Cassia abbreviata Oliv.	Fabaceae	Muhumba	Tree	Wild	0.175	0.123	0.298
Cajanus cajan (L.) Millsp.	Fabaceae	Mbalazi	Tree	Cultivated	0.268	Not reported	0.268
Xylopia parviflora(A. Rich.) Benth.	Annonaceae	Mbarawa	Tree	Wild	0.157	0.068	0.225
*Euphorbia candelabrium*Kotschy	Euphorbiaceae	Chaa	Tree	Wild	0.219	Not reported	0.219
Bourreria petiolaris (Lam.) Thulin	Boraginaceae	Mbundukwi	Tree	Wild	0.136	0.083	0.219
Croton pseudopulchellus Pax	Euphorbiaceae	Myama	Tree	Wild	0.201	0.008	0.209
Euclea natalensis A.DC F. White	Ebenaceae	Mkipa	Tree	Wild	0.190	0.008	0.198
Eucalyptus grandis W. Hill ex Maiden	Myrtaceae	Mgamu	Tree	Cultivated	0.078	0.092	0.170
Lantana camara	Verbenaceae	Mshomoro	Shrub	Semi-wild	0.155	Not reported	0.155
Cissampelos Pareira L.	Menispermaceae	Kasikiropaka	Herb	Semi-wild	0.117	0.02	0.137
Flueggea virosa (Roxb.ex Willd) Voigt	Euphorbiaceae	Mkwamba	Tree	Wild	0.130	0.001	0.131
Senna occidentalis (L.) Link.	Fabaceae	Mtsalafu	Herb	Semi-wild	0.049	0.075	0.124
Ximenia Americana L.	Olacaceae	Mtundukula	Tree	Wild	0.120	0.001	0.121
*Combretum schumanii*Engl.	Combretaceae	Mkode	Tree	Cultivated	0.115	Not reported	0.115
Pentarrhinum insipidum E.Mey.	Apocynaceae	Vujeyatsi	Herb	Wild	0.018	0.084	0.102
Uvaria lucida Benth.	Annonaceae	Mdzaladowe	Liana	Wild	0.098	0.001	0.099
Croton menyhartii Pax.	Eurphorbiaceae	Myamawanyika	Shrub	Wild	0.078	0.012	0.090
Salvadora persica L.	Salvadoraceae	Mjungumoto	Tree	Wild	0.078	0.004	0.082
Toddaliopsis sansibarensis (Engl.) Engl.	Rutaceae	Mkuro	Shrub	Wild	0.054	0.023	0.077
Premna chrysoclada(Bojer) Gürke	Lamiaceae	Mvuma	Shrub	Wild	0.074	Not reported	0.074

Table 6.1 (Continued)

Scientific name	Family	Local name	Life form	Habitat/source	Cultural value	Practical value	Total value
Acacia nilotica (L.) Willd. Ex Del.	Fabaceae	Munga	Tree	Wild	0.067	Not reported	0.067
Vitex ferruginea	Lamiaceae	Mfudu	Tree	Wild	0.053	0.013	0.066
Brachylaena huillensis O. Hoffm	Asteraceae	Muhuhu	Tree	Wild	0.061	0.004	0.065
Citrus sinensis (L.) Osbeck.	Rutaceae	Mchungwa	Tree	Cultivated	0.030	0.03	0.060
Capsicum frutescens L.	Solanaceae	Mpilipili	Herb	Cultivated	0.053	0.005	0.058
*Tinnea aethopica*Kotschy ex Hook.f.	Lamiaceae	Katsembeke	Herb	Semi-wild	0.037	0.021	0.058
Solanum incanum L.	Solanaceae	Mtondo	Shrub	Semi-wild	0.041	Not reported	0.041
Adansonia digitata L.	Malvaceae	Mbuyu	Tree	Cultivated	0.029	0.005	0.034
Ozoroa obovata (Oliv.) R & A. Fernandes	Anacardiaceae	Mkayukayu	Tree	Wild	0.033	Not reported	0.033
Afzelia quanzensis Welw.	Fabaceae	Mbambakofi	Tree	Wild	0.026	Not reported	0.026
Carica papaya L.	Caricaceae	Mpapai	Tree	Cultivated	0.015	0.011	0.026
Adenia gummifera (Harv.) Harms	Passifloraceae	Mgore	Tree	Wild	0.023	Not reported	0.023
Mundulea sericea (Willd.) A. Chev.	Fabaceae	Mthupa	Tree	Wild	0.015	0.007	0.022
*Combretum illairii*Engl.	Combretaceae	Mshindaalume	Shrub	Wild	0.017	Not reported	0.017
*Securidaca longipedunculata*Fresen.	Polygalaceae	Mboho	Tree	Wild	0.016	Not reported	0.016
*Deinbollia borbonica*Scheff.	Sapindaceae	Mgalamwaka	Tree	Wild	0.014	Not reported	0.014
Jatropha carcus L.	Euphorbiaceae	Mbonokoma	Tree	Cultivated	0.010	Not reported	0.010
Capparis sepiaria L.	Capparaceae	Mkidhunya	Tree	Wild	0.008	Not reported	0.008
Sterculia Africana (Lour.) Fiori	Malvaceae	Morya	Shrub	Semi-wild	0.007	Not reported	0.007
Dichrostachys cinerea(L.) Wight & Arn	Fabaceae	Mkingiri	Tree	Wild	0.004	Not reported	0.004
Acalypha fruticosa Forssk.	Eurphorbiaceae	Mtsatsa	Shrub	Wild	0.002	0.001	0.003
Strychnos madagascariensis Poir.	Loganiaceae	Mjaji	Tree	Wild	0.001	0.001	0.002
Pyrenacantha kaurabassana Baill.	Icacinaceae	Ria	Herb	Wild	0.001	0.001	0.002
Warburgia stulhmanii Engl.	Canellaceae	Mhirihiri	Tree	Wild	0.001	Not reported	0.001
Turaea wakefieldii	Meliaceae	Mwalagakuku	Tree	Wild	0.001	Not reported	0.001

There was a significant positive correlation ($P<0.01$) between cultural and practical values of all species recorded in this study (Table 6.2).

Table 6. 2: Correlation between the species cultural and practical values

		Cultural value	Practical value
Cultural value	Pearson Correlation	1	.882**
	Sig. (2-tailed)		.000
	N	63	63
Practical value	Pearson Correlation	.882**	1
	Sig. (2-tailed)	.000	
	N	63	63

** Correlation is significant at the 0.01 level (2-tailed)

6.3.2 Utilization and economic contribution of medicinal plants

More than 71% of the interviewed households used medicinal plants for treatment of various ailments. Households that reported collection and purchase of medicinal products from herbalists constituted 25.7% of all users (Figure 6.1a). Only a very few (2.9%) of the traditional medicine users purchased herbal remedies from traders and herbalists. About 29% of the households interviewed did not use the herbal medicine and therefore depended on modern health care.

Three use categories of medicinal plants in treatment, prevention and cure of both human and livestock diseases as well as reasons for their choice are shown in Figure 6.1b and 6.1c. Majority (51%) of the respondents reported utilization of medicinal plants for the treatment of human ailments, while 43% of the respondents used medicinal plants for both human and veterinary health care. Use of the plants for veterinary purposes alone, was the least (5%) mentioned among the respondents. Most (54%) of the respondents mentioned availability of medicinal plants as one of the reasons why they used them, while 53% of the respondents reported efficacy as the underlying reasons for use of herbal medicine. In addition, a few (30%) respondents preferred herbal medicine because they have no side effects.

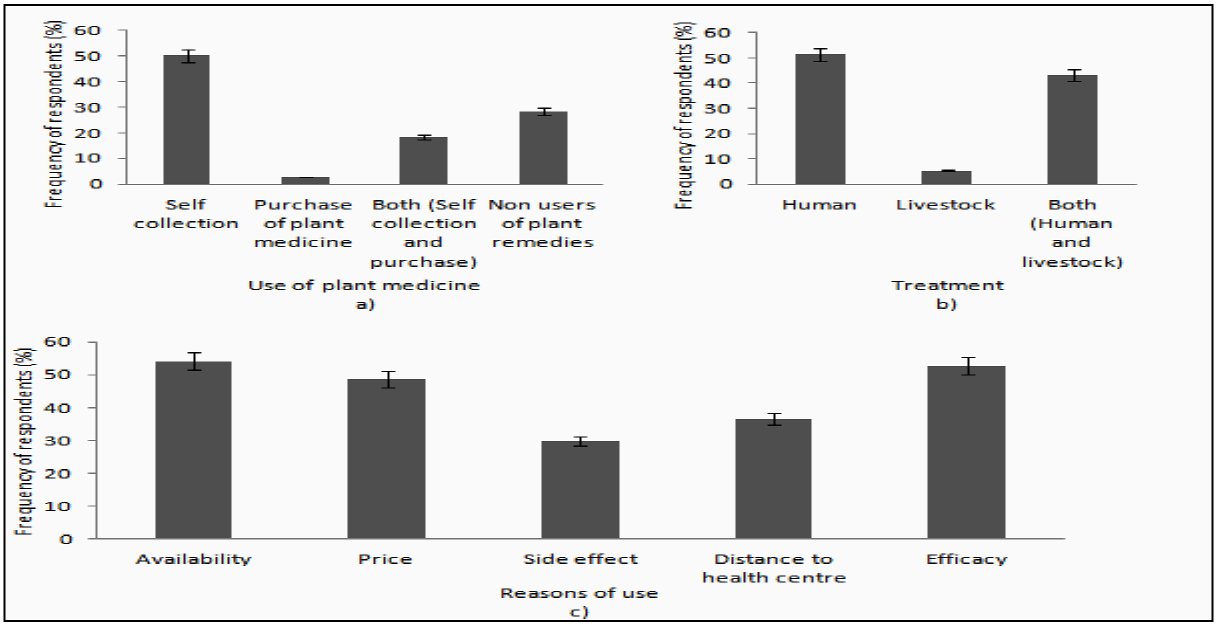

Figure 6. 1: a) Proportion of respondents using medicinal plants; b) Extent of use c) Reasons for choice of plant medicine

Skin diseases, eye and ear problems, malaria and hypertension were the diseases that were mostly treated using modern medicine as reported by the respondents (Figure 6.2). Cut and wounds were mostly treated by herbal remedies as reported by 76.2% of the households that have experienced such health problems. Combination of herbal and allopathic medicine was not reported for the treatment of cut and wounds, skin diseases, eye and ear problems, diabetes and snakebites. All the dermatological ailments reported were treated using allopathic medicine.

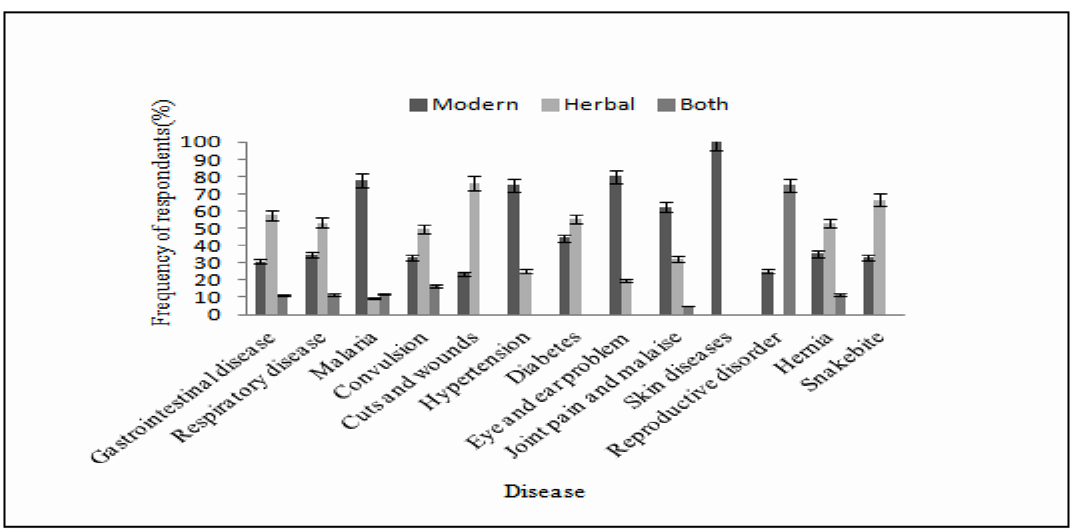

Figure 6. 2: Treatment choices for the common diseases experienced in the study area

The average cost of herbal therapy ranged from USD 1.09 to USD 3.62 (Table 6.4). Lowest and highest average costs saved from using medicinal plants rather than conventional medicine was USD 1.42 and USD 8.78 for gastrointestinal complaints and dermatological problems, respectively. The cost of treating snakebite using herbal remedy surpassed the use of allopathic medicine by USD 2.72. Low average cost of conventional medicine was recorded for all diseases since some households preferred to purchase modern medicine over the counter in chemists, which was cheaper than to seek medication from health centres.

Higher costs were recorded for serious illness such as diabetes, skin diseases, hernia and female reproductive disorders. Herbal remedies used for the treatment of gastrointestinal complaints; cough and cold; cuts and wounds; ear and eye complaints; joint pain and general body malaise; and malaria were obtained free of charge since most herbal plants were harvested from farmlands. For instance, *Azadirachta indica* which is available in all the sampled villages was used in treatment of four types of diseases that were experienced in the sampled households.

Table 6. 3: Reported diseases, choice of treatment and associated costs

Disease	Species used	Average cost (USD)			Number of days of medication and success rate (%)					
		Modern	Herbal	Incurred (-) /saved (+)	Modern		Herbal		Both (modern and herbal)	
					Days	Success	Days	Success	Days	Success
Gastrointestinal disease	*Cissampelos Pareira* *Anacardium occidentale* *Azadirachta indica* *Passiflora edulis* *Hoslundia opposita* *Moringa oleifera*	1.45	Negligible	1.45	2	100	2	100	5	100
Cough and cold	*Aloe volkensii* *Oldfieldia somalensis* *Zanthoxylum chalybeum* *Azadirachta indica* *Turaea wakefieldii*	1.78	Negligible	1.78	6	96	4	100	5	100
Malaria	*Azadirachta indica*	4.41	Negligible	4.41	5	95	3	75	4	100
Convulsion	*	4.71	2.45	2.26	2	100	5	100	4	100
Cuts and wounds	*Hoslundia opposita* *Aloe volkensii* *Zanthoxylum chalybeum*	3.37	Negligible	3.37	6	100	11	100	Not reported	Not reported
Hypertension	*Psidia guajava* *Moringa oleifera*	7.11	1.09	6.02	7	100	5	80	Not reported	Not reported
Diabetes	*	12.50	3.62	8.88	9	100	9	100	Not reported	Not reported
Eye and ear problem	*Cajanus cajan*	2.04	Negligible	2.04	5	88	4	100	Not reported	Not reported
Joint pain and malaise	*Oldfieldia somalensis* *Azadirachta indica*	1.91	Negligible	1.91	3	100	2	100	3	100
Skin disease		8.97	Not reported	8.97	30	100	Not reported	Not reported	Not reported	Not reported
Hernia	*Diospyros consolatae*	5.98	1.63	4.35	6	100	8	100	7	100
Snakebite	*	FR	2.72	-2.72	3	100	4	100	Not reported	Not reported

*Species not known by respondent, FR: free of charge

6.3.3 Traded medicinal plants and their sources

Table 6.4 presents plant species, used plant parts and availability of traded medicinal plants as perceived by local herbalists and medicinal plant collectors. Forty four different traded medicinal plant species belonging to 24 families were identified in the study site. Plant families with the highest number of cited medicinal species were Euphorbiaceae (6 species) and Rutaceae (5). The most cited source of traded medicinal plants in the study area was the forest (31), followed by bushes (19) and farms (9). The most traded plant part was the roots, which applied for 84% of all the species sold and/or used by collectors and herbalists. Use of bark, whole plant, seeds and leaves alone was found to be rare.

Table 6. 4 : Medicinal plants used by the community and their availability

Plant family	Scientific name	Local name (Giriama)	Source	Part used/marketed	Availabilty
Olacaceae	*Ximenia americana L.*	Mtundukula	Forest, bush land	Roots	Rare
Boraginaceae	*Bourreria petiolaris* (Lam.) Thulin	Mbundukwi, Mbunduki	Forest	Roots	Rare
Anacardiaceae	*Ozoroa obovata* (Oliv.) R & A. Fernandes	Mkayukayu	Forest	Roots, Bark	Common
Lamiaceae	*Premna chrysoclada* (Bojer) Gürke	Mvuma	Forest	Roots, Leaves	Rare
Annonaceae	*Uvaria acuminata* Oliv.	Mrori	Forest, bush land	Roots, Leaves	Common
Annonaceae	*Monodora grandidieri* Baill.	Mdzalasimba	Forest	Roots, Leaves	Common
Rutaceae	*Zanthoxylum chalybeum* Engl.	Mdhungu, Mjafari	Farm	Roots, Bark	Common
Annonaceae	*Polyathia stuhlmanii* (Engl.) Verdc.	Mwangajeni	Forest	Roots, Bark	Moderate
Polygalaceae	*Securidaca longipedunculata* Fresen.	Mboho	Forest	Roots, Leaves	Rare
Combretaceae	*Combretum illairii* Engl.	Mshindaalume	Forest	Bark, Leaves	Common
Euphorbiaceae	*Oldfieldia somalensis* (Chiov.) Milne-Redh	Mbirandu	Forest	Roots, Bark	Rare
Ebenaceae	*Diospyros cornii* Chiov.	Mkulu	Forest	Bark	Rare
Salvadoraceae	*Dobera glabra* (Forssk.) Juss. ex Poir	Mkuha	Forest	Roots	Common
Ebenaceae	*Diospyros consolatae* Chiov.	Mbathe	Forest, bush land	Roots	Common
Rutaceae	*Toddaliopsis sansibarensis* (Engl.) Engl.	Mkuro	Forest	Roots	Rare
Rutaceae	Toddalia asiatica(L.) Lam.	Chikuro	Forest, bush land	Roots	Rare

Table 6.4 (continued)

Plant family	Scientific name	Local name (Giriama)	Source	Part used/marketed	Availabilty
Malvaceae	*Thespesia danis* Oliver	Muhowe	Forest	Roots, Leaves	Rare
Passifloraceae	*Adenia gummifera* (Harv.) Harms	Mgore	Forest	Roots	Rare
Euphorbiaceae	*Croton pseudopulchellus* Pax	Muyama	Forest, bush land	Roots, Leaves	Common
Capparaceae	*Capparistomentosa* Lam.	Mguji	Forest	Roots	Rare
Ebenaceae	*Euclea natalensis* A.DC F. White	Mkipa	Forest, bush land	Roots	Moderate
Anacardiaceae	*Lannea schweinfurthii* (Engl.) Engl.	Mnyumbu	Forest	Roots, Bark	Common
Lamiaceae	*Tinnea aethopica* Kotschy ex Hook.f.	Katsembeke	Bush land	Whole	Common
Burseraceae	*Commiphora africanum* Endl.	Mutola	Forest	Roots, Bark	moderate
Euphorbiaceae	*Flueggea virosa* (Roxb.ex Willd) Voigt	Mkwambawari, Mkwambasima	Forest, bush land	Roots, Leaves	Moderate
Eurphorbiaceae	*Croton menyhartii* Pax.	Muyama wa nyika	Forest, bush land	Roots, Leaves	Common
Bignoniaceae	*Fernandoa magnifica* Seem.	Muhalanda	Forest	Roots	Rare
Lamiaceae	*Clerodendrum incisum* Klotzsch	Mrusapungu	Forest	Roots, Leaves	Rare
Lamiaceae	*Clerodendron kirkii* Baker	Mkula usiku	Forest	Roots, Leaves	Moderate
Salvadoraceae	*Salvadora persica* L.	Mjungumoto	Farm, bush land	Roots, Bark	Common
Eurphorbiaceae	*Acalypha fruticosa* Forssk.	Mtsatsa mubomu	Forest, bush land	Roots, Leaves	Moderate
Apocynaceae	*Pentarrhinum insipidum* E.Mey.	Vuje ya tsi	Bush land	Roots	Moderate
Euphorbiaceae	*Croton talaeporos* Radcl.-Sm.	Musunduzi	Forest	Roots , Leaves	Moderate
Rutaceae	*Clausena anisata* (Willd.) Hook.f.ex Benth.	Kadhimi kapala	Farm, Bush land, forest	Roots	Common
Meliaceae	*Turaea wakefieldii*	Mwalagakuku	Bush land	Roots, Bark Leaves	Moderate
Annonaceae	*Anonna sqaumosa L.*	Mtomoko	Farm	Roots ,Leaves	Common
Canellaceae	*Warburgia stulhmanii* Engl.	Mhirihiri	Forest	Bark, Leaves	Rare
Verbenaceae	*Lantana camara*	Mshomoro	Farm, bush land	Roots, Leaves	Common
Aloaceae	*Aloe volkensii* Engl.	Kitozi	Farm	Leaves	Common
Moringaceae	*Moringa oleifera Lam.*	Mzungwi	Farm	Leaves , Seeds	Common
Caricaceae	*Carica papaya* L.	Mpapai	Farm	Roots	Common
Rutaceae	*Citrus limon* (L.) Burm.f.	Mkapu, Mlimau	Farm	Roots, Leaves	Common
Sapindaceae	*Allophylus pervillei* Blume	Mnyangakitswa	Bush land	Roots , Leaves	Rare
Malvaceae	*Sterculia Africana* (Lour.) Fiori	Morya	Bush land	Roots, Bark	Common

Fifteen marketed plant species were identified as rare plants and were present in the forest, bushes or both (Figure 6.3). In addition, the availability of few medicinal plant species was found to fall between rare and common (moderately available). The plants' parts sold for the purpose of treatment of human and veterinary diseases included roots, bark, leaves and seeds. The most traded plant part was roots (53%) which was sold in powder or dried form. On the other hand, the least traded plant part was the seeds (1%).

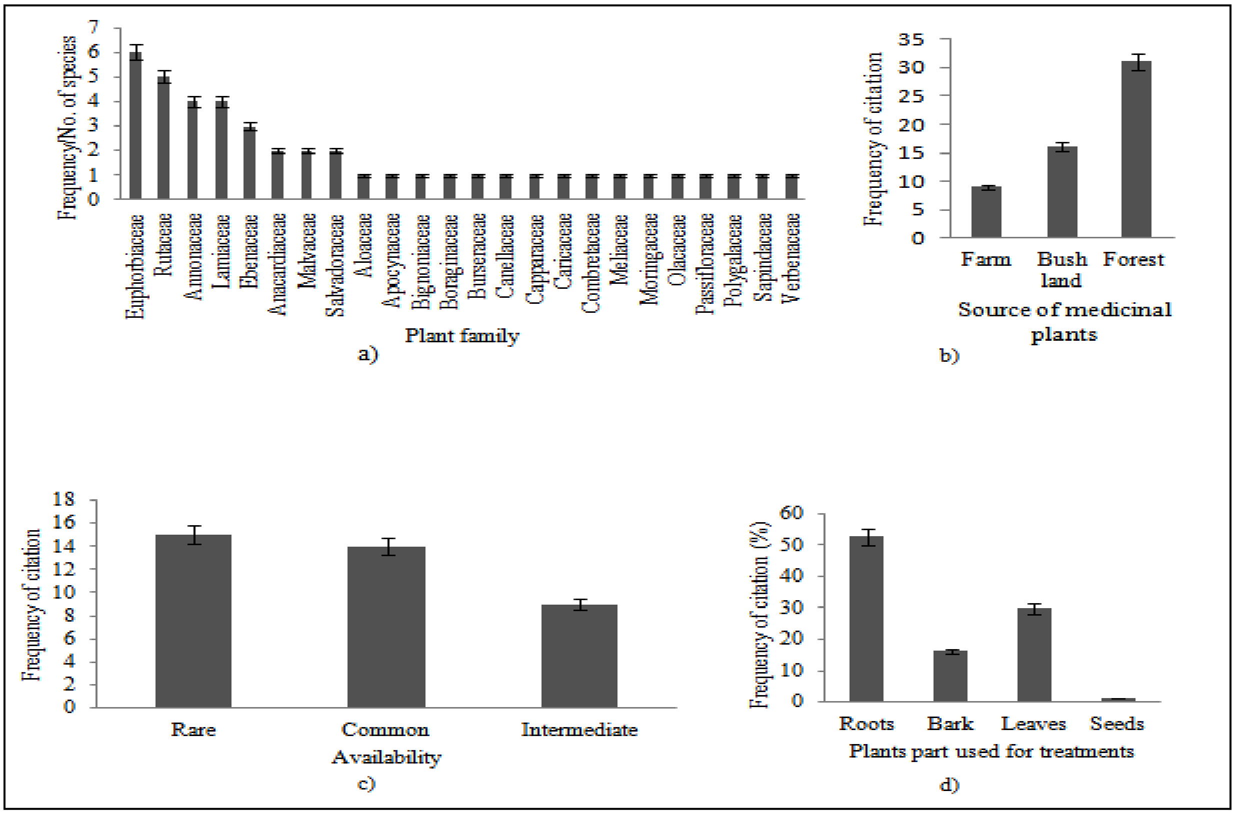

Figure 6. 3: Plant family, source, availability and parts of medicinal plants traded

It was reported that the trade of herbal medicines is undertaken by three actors namely; traders including medicinal plant collectors, traditional healers and the consumers. The traditional healers either collect medicinal plant parts from the forest or around their farms and directly sell or use them in treating their clients (Figure 6.4). Moreover, it was reported that in some instances, they do buy medicinal plant products that are hard to find from traders (collectors) or those harvested from other regions besides Arabuko forest.

The traders reported that they do sell some medicinal plants to other traditional medical practitioners located in the urban centers. Traders would travel to nearby town and sell their products to traditional herbalists who would in turn sell to the final consumers. Alternatively, herbalist based in major towns would place an order for specific herbal products from the gatherers and later on travel to the villages to collect them in raw, decoction or powdered form. This marketing channel was reported for species such as *Polyathia stuhlmanii (Engl.) Verdc.*, *Dichrostachys cinerea* (L.) Wight and Arn, *Combretum illairii* Engl.**,** *Securidaca longipedunculata* Fresen., *Flueggea virosa* (Roxb.ex Willd) Voigt and *Croton menyhartii* Pax.

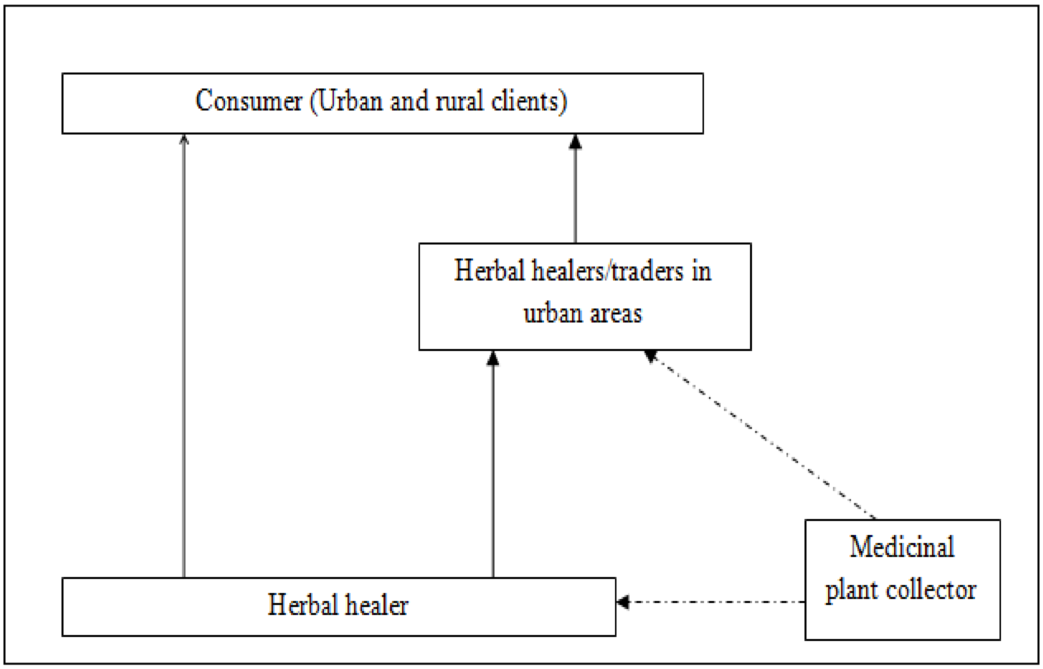

Figure 6. 4: Marketing channels of herbal products from Arabuko Sokoke forest

The reported major challenges in herbal medicine trade included: lack of ready market due to acculturation and younger generations associating herbal medicine with witchcraft; low prices offered by urban herbalists who purchase medicinal plants from the area; lack of proper storage, value addition and processing technologies; and scarcity of some species implying that traders and herbalists had to travel long distances for collection.

6.4 DISCUSSION

6.4.1 Cultural and practical values of medicinal plants

Generally, high cultural and practical indices were obtained from cultivated species and those available around homesteads and farms. This confirms that availability and accessibility have significant influence on use values of species. For instance, *Azadirachta indica*, *Zanthoxylum chalybeum***,** *Grewia plagiophylla* and *Hoslundia opposita* which were mostly cited by respondents in the current study, were mainly found within the homesteads and farms. The significant and positive correlation between cultural importance and practical use is similar to the findings of Reyes-Garcia *et al*. (2006), who reported a positive correlation between practical value and cultural value in Bolivian Amazon. The authors associated this relationship to a positive association of the passive knowledge and actual utilization.

According to majority of the respondents, most of the species are used for both construction and fuel. This might be due to the fact that they are found in the vicinity of homesteads and that they provide quality wood preferred for construction. This confers with Bonet and Valles (2002) who noted that easily available species that are well known to locals are mostly preferred and they tend to be the mostly used species. De Lucena *et al.* (2007) pointed that the high use value estimated for these kind of species does not reflect their intrinsic importance but it is due to their availability and visibility to human communities.

Medicinal plant species such as *Pentarrhinum insipidum* and *Warburgia stulhmanii* were known to a few respondents because they were mostly found in other areas other than the study area and hence their lower cultural and practical values. These results correspond to those of Stepp and Moerman (2001) who reported that a plant species availability, abundance and commonness have an impact on its cultural significance and utilization. Therefore, common and abundant species are normally widely known and tend to be the mostly used for various purposes than the uncommon and rare plant species. This contradicts the findings of De Lucena *et al*. (2007) who studied the correlation between availability of woody species and their use values in North Eastern Brazil. The authors found weak relationships between phytosociological parameters (including availability) and use values of plant species. In the current study, majority of species reported to be important for medicine and used by households belonged to family Fabaceae. Likewise, Kigen *et al.* (2016) in a study conducted in Nandi County of Kenya found that most of the mentioned species with medicinal properties belonged to family Fabaceae.

6.4.2 Contribution of medicinal plants to livelihoods

The results of this study indicated that most households used wild and cultivated medicinal plants for human and veterinary health care. Similar studies conducted in Kenya by Nagata *et al*. (2011) and Chirchir *et al*. (2006) found that the majority of the households utilized medicinal plants to treat both livestock and human diseases. The reasons for use of medicinal plants by households in the current study were found to be similar to those reported among the Maasai community of Kenya by Kiringe (2005).

As indicated by Kaingu *et al.* (2011) and Nagata *et al*. (2011), long distance to modern health facilities, lack of financial resources and unreliable transport services are some of the reasons that have made herbal healers and herbal medicine to be more reliable and crucial to personal wellbeing. Likewise, affordability and unavailability of modern healthcare facilities have been noted as some of the reason for preference of medicinal plants by households (WHO, 2002).

The high proportion of self collection and use of medicinal plant resources can be attributed to the fact that the species for prevention or cure of common ailments were easily available around the homesteads. Kiringe (2005) in a study to determine knowledge and use of medicinal plants among the Maasai community reported the presence of home treatment despite the availability of traditional health practitioners. The author attributed this to the abundance of medicinal plants in the study area and the fact that most of the community members have learnt the preparation of herbal remedies at home.

In the current study, it was found that medicinal plants were mostly used as remedies for common diseases such as malaria, gastrointestinal symptoms and respiratory problems. These results corroborate those from studies conducted among the Nandi, Maasai, Luo and Suba communities in Kenya that reported similar common diseases (Jeruto *et al*., 2015; Nagata *et al*., 2011; Maundu *et al*., 2001). Wide utilization of phytomedicines for treatment of common cold, flu, digestive disorder, stomach ulcer and headache has also been reported in Germany (Calixto, 2000). Consultation of herbalists for the treatment of serious diseases may partly be attributed to the complexity of preparing some of the herbal remedies. The traditional medical practitioners reported that some of the remedies for serious ailments were prepared from a mixture of two or more species. In a study on management of female reproductive health conducted in Tana River County, Kaingu *et al.* (2013) found that more than a third of the remedies were prepared by mixing parts of the principal plant with those of one or more species.

Negligible costs incurred in using herbal remedies in treatment of diseases could be the reason why majority of the respondents resort to self treatment by using freely available and cultivated plant species such as *Cissampelos Pareira*, *Anacardium occidentale*, *Azadirachta indica*, *Passiflora edulis*, *Hoslundia opposita* and *Moringa oleifera*. However, whenever the conditions of patients worsen they chose to consult herbalists or conventional medical services as their last resort.

6.4.3 Traded medicinal species and their sources

Extraction of medicinal plants is one of the nature based income generating activity in the study area (RoK, 2013). Majority of traded species were derived from the forest, and most of them were reported to be rare. Similarly, Okello *et al.* (2010) and Pakia (2001) found that majority of the used medicinal plants by the Sabaot and the Kenyan coastal ethnic communities, respectively were obtained from the wild. According to Schippmann *et al*. (2002), cultivation of medicinal plants in farmlands could be a strategy to reduce pressure on the wild stocks, as well as a way of conserving important species to meet future demands. Cultivation of the most important medicinal plants is expected to reduce the pressure on the natural habitats and time spent by households in search of herbal plants.

Whereas Kimondo *et al.* (2015) reported high utilization of roots for treatment of various ailments, among the Maasai community of Kenya, Nanyingi *et al.* (2008) found that it was mainly the leaves that were used for theraupetic purposes among the Samburu community of Kenya. According to Kaigongi and Musila (2015), continuous harvesting of roots calls for conservation needs since it does not support sustainable utilization of plant resources.

The main actors in the trade of herbal products in the current study were found to be quite similar to those reported from South Africa by Dold and Cocks, (2002). This study has shown that some of the traded species were harvested from the farmlands, forest and while others were bought from collectors. Matiku *et al.* (2013) in a study to determine the impact of participatory forest management in Arabuko Sokoke forest found that there were household members who collected and sold herbal medicine to herbalists. Likewise, Pakia (2001) in an ethnobotanical study in two Kaya coastal forests of Kenya reported the collection of herbal material by non-healers as one form of income generating activity.

The simplicity of the marketing channel and the few actors in the trade corresponds to the findings of Belcher and Schreckenberg (2007) who noted that short and simple marketing chain is associated with the trade of non timber forest products, at the local level. Similar to the results of the current study, Belcher and Schreckenberg (2007) reported lack of storage and processing facilities, small markets, long distance to resource sites, poor transport infrastructure and unpredictable markets as the main constraints to herbal products trade. Furthermore, McMullin *et al.* (2014) noted that limited market information for medicinal plants is an additional bottleneck in the value chain.

6.5 CONCLUSION

This study has revealed high demand for and dependency on medicinal plants in surrounding areas of Arabuko Sokoke forest that put alot of pressure on the available resources, which could potentially lead to decline of some important forest species. This calls for efforts to promote both in situ and ex situ conservation of the key medicinal plant species, as well as interventions to improve the herbal products value chain for the purpose of enhancing benefits and promoting sustainable utilization of medicinal plants resources.

CHAPTER SEVEN
SUMMARY CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

- Species richness and diversity was higher in the mixed community compared to the brachystegia and cynometra community due to favorable edaphic and climatic conditions in the mixed community. The higher diversity in the disturbed sites compared to the undisturbed areas can be attributed to open canopies created by human interference which promotes the establishment and growth of understory species and sun-loving species.
- The decreasing number of species with increasing diameter size depicts high recruitment. Lower number of larger woody species in the disturbed than in the undisturbed area indicates targeting and preference of large trees by commercial loggers.
- Age of respondent, education of household head, main livelihood source and households' use of plant remedies were the key determinants of knowledge on medicinal plant resources. The results show that the change of lifestyle and formal education has negatively influenced ethnobotanical knowledge in the younger generation.
- Anthropogenic factors such as charcoal burning, forest clearing for cultivation, deforestation and commercialization of forest products contributed a considerable proportion of threat to medicinal plants. Generally, this may be due to fewer livelihood options in the area that results in overreliance on forest resources.
- The positive relationship between the species cultural and practical use indices implies that people use the species that are culturally important to them, indicating that species considered to be culturally valuable are used more frequently than those with less cultural

value. The results on use values provide an entry point for identifying important species that are of conservation concern.

- High proportion of households was found to use medicinal plants for the treatment of various diseases. Moreover, herbal species had positive contribution to households' primary health and income. This is through cost saved by use of free or cheap medicinal plants as opposed to modern medicine, as well as through income accruing to households from sales of herbal products.
- Majority of the marketed medicinal plants that are traded around ASF and those destined for far markets were obtained from Arabuko Sokoke forest, and most of them were considered rare species by the respondents. However, the trade of herbal products was reported to be constrained by poor market, scarcity of some species and lack of proper processing and storage facilities.

7.2 RECOMMENDATIONS

- High plant diversity in disturbed site implies that human activities are not always destructive and that with proper management plans, conservation can be achieved by ensuring that people use the forest resources responsibly and sustainably to the benefit of the ecosystem and people themselves.
- Lower number of larger trees in disturbed sites than in the undisturbed areas implies that there is selective exploitation of the larger trees. This calls for management plans to control commercial logging and ensure sustainable utilization in order to sustain the forest's ecological and functional integrity.

- The little ethnobotanical knowledge in the young generation is a red flag indicating the potential loss of the knowledge because it is confined to the elderly, and therefore the need to document and promote its transmission to the youth.
- High utilization of culturally valuable medicinal species and threats from anthropogenic activities calls for domestication of culturally valuable species and community awareness on sustainable forest utilization. This will ensure long term benefits accrue to people using the forest for subsistence purposes and perhaps more importantly the maintenance of forest integrity.
- The results indicate that majority of the marketed medicinal plants are obtained from the forest are rare and therefore conservation strategies should be focused on domestication and in situ conservation of these species. Poor markets and lack of proper processing technology calls for interventions aimed at improving market linkages and value addition to ensure maximum economic benefits accrue to the traders.

REFERENCES

Achard, F., Eva, H. D., Stibig, H. J., Mayaux, P., Gallego, J., Richards, T., and Malingreau, J. P. (2002). Determination of deforestation rates of the world's humid tropical forests. *Science, 297*(5583), 999-1002.

Addis, G., Asfaw, Z., and Woldu, Z. (2013). Ethnobotany of Wild and Semi-wild Edible Plants of Konso Ethnic Community, South Ethiopia. *Ethnobotany Research and Applications*, *11*, 121-141.

Agrawal, A., and Gibson, C. C. (1999). Enchantment and disenchantment: the role of community in natural resource conservation. *World development*,*27*(4), 629-649.

Aigbe, H.I. and Omokhua, G.E. (2015). Tree species composition and diversity in Oban forest reserve, Nigeria. *Journal of Agricultural studies, 3 (1), 10-24.*

Akankwasah, B., Agea, J. G., and Van Damme, P. (2012). Prioritizing wild medicinal and food plants with potential for commercialization and value chain improvement for livelihood enhancement and poverty reduction in Uganda.

Albuquerque, U. P., Lucena, R. F., Monteiro, J. M., Florentino, A. T., and Almeida, C. D. F. C. (2006). Evaluating two quantitative ethnobotanical techniques. Ethnobotany Research and Applications 4, 51-60.

Althof, A. J. (2005). Human impact on flora and vegetation of Kakamega forest, Kenya: structure, distribution and disturbance of plant communities in an East African rainforest. (Doctoral Thesis, Universität Koblenz-Landau).

ASFMT (2002). Arabuko-Sokoke strategic forest management plan, 2002–2027. Available at: www.kws.go.ke/download/file/fid/1459 *accessed on 25/8/2014.*

Barbour, M. G., Burk, J. H., Pitts, W. D., Gilliam, F. S., and Schwartz, M. W. (1999). Methods of sampling the plant community. *Terrestrial Plant Ecology, 3rd Edition. Wesley Longman,Inc., Don Mills, ON.*

Beentje, H., Adamson, J., and Bhanderi, D. (1994). Kenya trees, shrubs, and lianas. National Museums of Kenya.

Begossi, A., Hanazaki, N., and Tamashiro, J. Y. (2002). Medicinal plants in the Atlantic Forest (Brazil): knowledge, use, and conservation. *Human Ecology*, *30*(3), 281-299.

Belcher, B., and Schreckenberg, K. (2007). Commercialisation of Non-timber Forest Products: A Reality Check. *Development Policy Review*, *25*(3), 355-377.

Belcher, B., Ruíz-Pérez, M., and Achdiawan, R. (2005). Global patterns and trends in the use and management of commercial NTFPs: implications for livelihoods and conservation. *World development*, *33*(9), 1435-1452.

Benz, B. F., Cevallos, J., Santana, F., and Rosales, J. (2000). Losing knowledge about plant use in the Sierra de Manantlan biosphere reserve, Mexico. *Economic Botany*, *54*(2), 183-191.

Berkes, F., and Davidson-Hunt, I. J. (2006). Biodiversity, traditional management systems, and cultural landscapes: examples from the boreal forest of Canada. *International Social Science Journal*, *58*(187), 35-47.

Berkes, F., and Turner, N. J. (2006). Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. *Human Ecology*, *34*(4), 479-494.

Berkes, F., Colding, J., and Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological applications*, *10*(5), 1251-1262.

Birhanu, T., Abera, D., and Ejeta, E. (2015). Ethnobotanical Study of Medicinal Plants in Selected Horro Gudurru Woredas, Western Ethiopia. *Journal of Biology, Agriculture andHealthcare, 5*(1), 83-93.

Bjorå, C. S., Wabuyele, E., Grace, O. M., Nordal, I., and Newton, L. E. (2015). The uses of Kenyan aloes: an analysis of implications for names, distribution and conservation. *Journal of ethnobiology and ethnomedicine*, *11*(1), 1.

Bobo, K. S., Waltert, M., Sainge, N. M., Njokagbor, J., Fermon, H., and Mühlenberg, M. (2006). From forest to farmland: species richness patterns of trees and understory plants along a gradient of forest conversion in Southwestern Cameroon. *Biodiversity & Conservation*, *15*(13), 4097-4117.

Bonet, M. À., and Valles, J. (2002). Use of non-crop food vascular plants in Montseny biosphere reserve (Catalonia, Iberian Peninsula). *International Journal of Food Sciences and Nutrition*, *53*(3), 225-248.

Brandt, R., Mathez-Stiefel, S. L., Lachmuth, S., Hensen, I., and Rist, S. (2013). Knowledge and valuation of Andean agroforestry species: the role of sex, age, and migration among members of a rural community in Bolivia. *Journal of ethnobiology and ethnomedicine*, *9*(1), 1.

Britton, P.L., and Zimmerman, D.A. (1979). The avifauna of Sokoke forest,Kenya. *Journal of the East Africa natural history society and national museum*, 169, 1-15.

Brook, B. W., Sodhi, N. S., & Bradshaw, C. J. (2008). Synergies among extinction drivers under global change. *Trends in ecology & evolution*, *23*(8), 453-460.

Burgess, N. D., Butynski, T. M., Cordeiro, N. J., Doggart, N. H., Fjeldså, J., Howell, K. M., Kilahama, F.B., Loader, S.P., Lovett, J.C., Mbilinyi, B., Menegon, M., Moyer, D.C., Nashanda, E., Perkin, A., Rovero, F., and Stuart, S. N. (2007). The biological importance of the Eastern Arc Mountains of Tanzania and Kenya. *Biological conservation*, *134*(2), 209-231.

Burgess, N.D., Clarke, G.P., and Rodgers, W.A. (1998). Coastal forests of eastern Africa: status, endemism patterns and their potential causes. *Biological Journal of the Linnean society*, 64: 337-367.

Bussmann, R. W. (2006). Ethnobotany of the Samburu of Mt. Nyiru, South Turkana, Kenya. *Journal of Ethnobiology and Ethnomedicine*, *2*(1), 1.

Bussmann, R. W., Gilbreath, G. G., Solio, J., Lutura, M., Lutuluo, R., Kunguru, Wood, N., and Mathenge, S. G. (2006). Plant use of the Maasai of Sekenani Valley, Maasai Mara, Kenya. *Journal of ethnobiology and ethnomedicine*, *2*(1), 1.

Bussmann, R., Sharon, D., and Ly, J. (2008). From Garden to Market? The cultivation of native and introduced medicinal plant species in Cajamarca, Peru and implications for habitat conservation. *Ethnobotany Research and Applications*, *6*, 351-361.

Calixto, J. B. (2000). Efficacy, safety, quality control, marketing and regulatory guidelines for herbal medicines (phytotherapeutic agents). *Brazilian Journal of Medical and Biological Research*, *33*(2), 179-189.

Case, R. J., Pauli, G. F., and Soejarto, D. D. (2005). Factors in maintaining indigenous knowledge among ethnic communities of Manus Island. *Economic Botany*, *59*(4), 356-365.

CEPF, (2005). Ecosystem profile. Accessed on 25 April 2016 at www.cepf.net.

Chirchir, J., Mungai, G., and Kariuki, P. (2006). Indigenous knowledge and conservation of natural resources: resource medicinal plants utilisation in Eastern Africa. In *Proceedings* *of national museums of Kenya first scientific conference, 15th-17th Nov 2006* (pp. 106-111).

Cohen, J., Cohen, P., West, S. G., and Aiken, L. S. (2013). Applied multiple regression/correlation analysis for the behavioral sciences. Routledge.

Collins, S., Martins, X., Mitchell, A., Teshome, A., and Arnason, J. T. (2006). Quantitative ethnobotany of two East Timorese cultures. *Economic Botany*, *60*(4), 347-361.

Cox, P. A. (2000). Will tribal knowledge survive the millennium? *Science*, *287*(5450), 44-45.

Da Silva Sousa, R., Hanazaki, N., Lopes, J. B., and de Barros, R. F. M. (2012). Are Gender and Age Important in Understanding the Distribution of Local Botanical Knowledge in Fishing Communities of the Parnaiba Delta Environmental Protection Area?. *Ethnobotany Research and Applications*, *10*, 551-559.

De Lucena, R. F. P., Araújo, E. D. L., and De Albuquerque, U. P. (2007). Does the local availability of woody Caatinga plants (Northeastern Brazil) explain their use value?. *Economic Botany*, *61*(4), 347-361.

Dold, A. P., and Cocks, M. L. (2002). The trade in medicinal plants in the Eastern Cape Province, South Africa. *South African Journal of Science*, *98*(11/12), 589-597.

Fashing, P. J., and Mwangi Gathua, J. (2004). Spatial variability in the vegetation structure and composition of an East African rain forest. African Journal of Ecology, 42(3), 189-197.

Fashing, P. J., Forrestel, A., Scully, C., and Cords, M. (2004). Long-term tree population dynamics and their implications for the conservation of the Kakamega Forest, Kenya. *Biodiversity and Conservation*, *13*(4), 753-771.

Findlay, C. S., and Houlahan, J. (1997). Anthropogenic correlates of species richness in southeastern Ontario wetlands. *Conservation Biology*, *11*(4), 1000-1009.

Food and Agriculture Organization. (2010). *Global Forest Resources Assessment 2010 Main Report*. Article available at: http://www.fao.org/docrep/013/i1757e/i1757e.pdf accessed on 30/09/2014.

Foody, G. M., and Cutler, M. E. (2003). Tree biodiversity in protected and logged Bornean tropical rain forests and its measurement by satellite remote sensing. *Journal of Biogeography*, *30*(7), 1053-1066.

Gathirwa, J. W., Rukunga, G. M., Mwitari, P. G., Mwikwabe, N. M., Kimani, C. W., Muthaura, C. N., Kiboi, D.M., Nyangacha, R.M., and Omar, S. A. (2011). Traditional herbal antimalarial therapy in Kilifi district, Kenya. *Journal of ethnopharmacology*, *134*(2), 434-442.

Gathirwa, J. W., Rukunga, G. M., Njagi, E. N. M., Omar, S. A., Mwitari, P. G., Guantai, A. N., and Ndunda, T. N. (2008). The in vitro anti-plasmodial and in vivo anti-malarial efficacy of combinations of some medicinal plants used traditionally for treatment of malaria by the Meru community in Kenya. *Journal of ethnopharmacology*, *115*(2), 223-231.

Ghimire, S. K., McKey, D., and Aumeeruddy-Thomas, Y. (2005). Conservation of Himalayan medicinal plants: Harvesting patterns and ecology of two threatened species, Nardostachys grandiflora DC. and Neopicrorhiza scrophulariiflora (Pennell) Hong. *Biological Conservation*, *124*(4), 463-475.

Giday, M., Asfaw, Z., and Woldu, Z. (2009). Medicinal plants of the Meinit ethnic group of Ethiopia: an ethnobotanical study. *Journal of Ethnopharmacology*, *124*(3), 513-521.

Giday, M., Asfaw, Z., Elmqvist, T., and Woldu, Z. (2003). An ethnobotanical study of medicinal plants used by the Zay people in Ethiopia. *Journal of ethnopharmacology*, *85*(1), 43-52.

Giliba, R. A., Boon, E. K., Kayombo, C. J., Musamba, E. B., Kashindye, A. M., and Shayo, P. F. (2011). Species composition, richness and diversity in Miombo woodland of Bereku Forest Reserve, Tanzania. *Journal of Biodiversity*, *2*(1), 1-7.

Glenday, J. (2008). Carbon storage and emissions offset potential in an African dry forest, the Arabuko-Sokoke Forest, Kenya. *Environmental monitoring and assessment*, *142*(1-3), 85-95.

Godoy, R., Overman, H., Demmer, J., Apaza, L., Byron, E., Huanca, T., and Brokaw, N. (2002). Local financial benefits of rain forests: comparative evidence from Amerindian societies in Bolivia and Honduras. *Ecological Economics*, *40*(3), 397-409.

Gooch, M. (2007). Residents' attitudes towards Arabuko-Sokoke forest and ASSETS. ASSETS technical report.

Gray, A. N., and Spies, T. A. (1996). Gap size, within-gap position and canopy structure effects on conifer seedling establishment. *Journal of ecology*, 635-645.

Hamilton, A. C. (2004). Medicinal plants, conservation and livelihoods. *Biodiversity and Conservation*, *13*(8), 1477-1517.

Hanazaki, N., Tamashiro, J. Y., Leitão-Filho, H. F., and Begossi, A. (2000). Diversity of plant uses in two Caiçara communities from the Atlantic Forest coast, Brazil. *Biodiversity and Conservation*, *9*(5), 597-615.

Irl, S. D., Harter, D. E., Steinbauer, M. J., Gallego Puyol, D., Fernández-Palacios, J. M., Jentsch, A., and Beierkuhnlein, C. (2015). Climate vs. topography–spatial patterns of plant species diversity and endemism on a high-elevation island. *Journal of Ecology*, *103*(6), 1621-1633.

Irungu, B. N., Rukunga, G. M., Mungai, G. M., and Muthaura, C. N. (2007). In vitro antiplasmodial and cytotoxicity activities of 14 medicinal plants from Kenya. *South African Journal of Botany*, *73*(2), 204-207.

IUCN.(2015). IUCN Red list of threatened species. Version 2015-4. Accessed on 03 March 2016 at www.iucnredlist.org.

Jeruto, P., Lukhoba, C., Ouma, G., Otieno, D., and Mutai, C. (2008). An ethnobotanical study of medicinal plants used by the Nandi people in Kenya. *Journal of Ethnopharmacology*, *116*(2), 370-376.

Johns, T., Kokwaro, J. O., and Kimanani, E. K. (1990). Herbal remedies of the Luo of Siaya District, Kenya: establishing quantitative criteria for consensus. *Economic Botany*, *44*(3), 369-381.

Kaigongi, M. M., and Musila, F. M. (2015). Ethnobotanical study of medicinal plants used by Tharaka people of Kenya. *International Journal of Ethnobiology and Ethnomedicine*,1 (1), 1-8.

Kaingu, C. K., Mbaria, J. Oduma, J.A and Kiama, S. G. (2014). Ethnobotanical study of medicinal plants traditionally used in Tana River County for management of illnesses. *Asian Journal of Complementary and Alternative Medicine*, *2*(02), 01-05.

Kaingu, C. K., Oduma, J. A., and Kanui, T. I. (2011). Practices of traditional birth attendants in Machakos District, Kenya. *Journal of ethnopharmacology*, *137*(1), 495-502.

Kaingu, C. K., Oduma, J. A., Mbaria, J. M., and Kiama, S. G. (2013). Medicinal plants traditionally used for the management of female reproductive health dysfunction in Tana River County, Kenya. *Tang [humanitas medicine]*, *3*(2), 17-1.

Kala, C. P. (2000). Status and conservation of rare and endangered medicinal plants in the Indian trans-Himalaya. *Biological Conservation*, *93*(3), 371-379.

Kala, C. P. (2005). Indigenous uses, population density, and conservation of threatened medicinal plants in protected areas of the Indian Himalayas. *Conservation Biology*, *19*(2), 368-378.

Kala, C. P., Farooquee, N. A., and Dhar, U. (2004). Prioritization of medicinal plants on the basis of available knowledge, existing practices and use value status in Uttaranchal, India. *Biodiversity and Conservation*, *13*(2), 453-469.

Kenya indigenous forest conservation programme, (1995). Arabuko Sokoke forest and Mida creek: the official guide. Majestic Printing works limited, Nairobi, Kenya.

Kidane, B., van Andel, T., van der Maesen, L. J. G., and Asfaw, Z. (2014). Use and management of traditional medicinal plants by Maale and Ari ethnic communities in southern Ethiopia. *Journal of ethnobiology and ethnomedicine*, *10*(1), 1.

Kigen, G. K., Ronoh, H. K., Kipkore, W. K., and Rotich, J. K. (2013). Current trends of traditional herbal medicine practice in Kenya: a review. *African Journal of Pharmacology and Therapeutics*, *2*(1), 32-37.

Kigen, G., Maritim, A., Some, F., Kibosia, J., Rono, H., Chepkwony, Kipkore, W.,S., and Wanjoh, B. (2016). Ethnopharmacological survey of the medicinal plants used in Tindiret, Nandi County, Kenya. *African Journal of Traditional, Complementary & Alternative Medicines*, *13*(3).

Kimaro, J., and Lulandala, L. (2013). Human influences on tree diversity and composition of a coastal forest ecosystem: The case of Ngumburuni forest reserve, Rufiji, Tanzania. *International Journal of Forestry Research*, *2013*.

Kimondo, J., Miaron, J., Mutai, P., and Njogu, P. (2015). Ethnobotanical survey of food and medicinal plants of the Ilkisonko Maasai community in Kenya. *Journal of ethnopharmacology*, *175*, 463-469.

Kipkore, W., Wanjohi, B., Rono, H., and Kigen, G. (2014). A study of the medicinal plants used by the Marakwet Community in Kenya. *Journal of ethnobiology and ethnomedicine*, *10*(1), 24.

Kiringe, J. W. (2005). Ecological and anthropological threats to ethno-medicinal plant resources and their utilization in Maasai communal ranches in the Amboseli region of Kenya. *Ethnobotany Research and Applications*, *3*, 231-242.

Kufer, J., Heinrich, M., Förther, H., and Pöll, E. (2005). Historical and modern medicinal plant uses—the example of the Ch'orti 'Maya and Ladinos in Eastern Guatemala. *Journal of Pharmacy and pharmacology*, *57*(9), 1127-1152.

Kvist, L. P., Andersen, M. K., Hesselsøe, M., and Vanclay, J. K. (1995). Estimating use-values and relative importance of Amazonian flood plain trees and forests to local inhabitants. *The Commonwealth Forestry Review*, 293-300.

Ladio, A. H., and Lozada, M. (2004). Patterns of use and knowledge of wild edible plants in distinct ecological environments: a case study of a Mapuche community from northwestern Patagonia. *Biodiversity & Conservation*, *13*(6), 1153-1173.

Lange, D. (1998). Europe's medicinal and aromatic plants: their use, trade and conservation. Traffic International.

Lange, D. (2006). International trade in medicinal and aromatic plants: actors, volumes and commodities. *Frontis*, *17*, 155-170.

Larsen, H. O., and Smith, P. D. (2004). Stakeholder perspectives on commercial medicinal plant collection in Nepal: poverty and resource degradation. *Mountain Research and Development*, *24*(2), 141-148.

Liu, J.G., Linderman, M., Ouyang, Z.Y., An, L., Yang, J.,and Zhang, H.M. (2001). Ecological degradation in protected areas: The case of Wolong Nature Reserve for giant pandas. *Science*, 292, 98–101.

Martin, G. J. (1995). Ethnobotany: A methods manual. Chapman and Hall.

Matiku, P. (2005). The Coastal Forests of Kenya: Forests data, threats, socio-economic issues, values, stakeholders, challenges, strategies, investment and enabling environment--A national synthesis report for the development of the WWF-EARPO Eastern Africa Coastal Forests Ecoregion Programme.

Matiku, P., Caleb, M., and Callistus, O. (2013). The impact of participatory forest management on local community livelihoods in the Arabuko-Sokoke Forest, Kenya. *Conservation and Society*, *11*(2), 112.

Matu E. (2010). Good intentions, little action: national policies and legislations on traditional medicine in Africa. Plant Resources for Tropical Africa (PROTA) Newsletter 9.

Maundu, P., Berger, D., Ole Saitabau, C., Nasieku, J., Kipelian, M., Mathenge, S., Morimoto, Y., and Höft, R. (2001). Ethnobotany of the Loita Maasai. Unesco. Ethnobotany of the Loita Maasai: towards community management of the forest of the lost child experiences from the Loita Ethnobotany Project. UNESCO-Division of ecological sciences.

McGeoch, L., Gordon, I., and Schmitt, J. (2008). Impacts of land use, anthropogenic disturbance, and harvesting on an African medicinal liana. *Biological Conservation*, *141*(9), 2218-2229.

McMillen, H. (2012). Ethnobotanical Knowledge Transmission and Evolution: The Case of Medicinal Markets in Tanga, Tanzania1. *Economic Botany*, *66*(2), 121-131.

McMullin, S., Nieuwenhuis, M., and Jamnadass, R. (2014). Strategies for Sustainable Supply of and Trade in Threatened Medicinal Tree Species: A case study of genus Warburgia. *Ethnobotany Research and Applications*, *12,* 671-683.

Mesfin, F., Demissew, S., and Teklehaymanot, T. (2009). An ethnobotanical study of medicinal plants in Wonago Woreda, SNNPR, Ethiopia. *Journal of Ethnobiology and Ethnomedicine*, *5*(1), 1.

Mitchell, K. (2010). Quantitative analysis by the point-centered quarter method.

Mligo, C. (2015). Conservation of Plant Species Diversity Based on Richness and Evenness Criteria in the Coastal Forests of Tanzania. *Journal of Environment and Ecology*, *6*(1), 1-20.

Mugenda, O. M., and Mugenda, G., A. (1999). Research Methods: Quantitative and Qualitative Approaches.*African Centre of Technology Studies, Nairobi, Kenya*.

Mulliken, T., and Crofton, P. (2008). Review of the status, harvest, trade and management of seven Asian CITES-listed medicinal and aromatic plant species. *BfN-Skripten, Federal Agency for Natural Conservation, Bonn, Germany*.

Muposhi, V. K., Chademana, T. C., Gandiwa, E., and Muboko, N. (2016). Edge effects: impact of anthropogenic activities on vegetation structure and diversity in western Umfurudzi Park, Zimbabwe. *African Journal of Ecology*. Doi:10.1111/aje.12300.

Mwase, W. F., Bjørnstad, Å., Bokosi, J. M., Kwapata, M. B., and Stedje, B. (2007). The role of land tenure in conservation of tree and shrub species diversity in miombo woodlands of southern Malawi. *New Forests*, *33*(3), 297-307.

Mwitari, P. G., Ayeka, P. A., Ondicho, J., Matu, E. N., and Bii, C. C. (2013). Antimicrobial activity and probable mechanisms of action of medicinal plants of Kenya: Withania somnifera, Warbugia ugandensis, Prunus africana and Plectrunthus barbatus. *PloS one*, *8*(6), e65619.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., and Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, *403*(6772), 853-858.

Nagata, J. M., Jew, A. R., Kimeu, J. M., Salmen, C. R., Bukusi, E. A., and Cohen, C. R. (2011). Medical pluralism on Mfangano Island: use of medicinal plants among persons living with HIV/AIDS in Suba District, Kenya. *Journal of ethnopharmacology*, *135*(2), 501-509.

Nanyingi, M. O., Mbaria, J. M., Lanyasunya, A. L., Wagate, C. G., Koros, K. B., Kaburia, H. F., Munenge, R. W., and Ogara, W. O. (2008). Ethnopharmacological survey of Samburu district, Kenya. *Journal of Ethnobiology and Ethnomedicine*, *4*(1), 1.

Ndangalasi, H. J., Bitariho, R., and Dovie, D. B. (2007). Harvesting of non-timber forest products and implications for conservation in two montane forests of East Africa. *Biological Conservation*, *134*(2), 242-250.

Ndang'ang'a, P. K., Barasa, F. M., Kariuki, M. N., and Muoria, P. (2016). Trends in forest condition, threats and conservation action as derived from participatory monitoring in coastal Kenya. *African Journal of Ecology*, *54*(1), 76-86.

Njoroge, G. (2012). Traditional Medicinal Plants in Two Urban Areas in Kenya (Thika and Nairobi): Diversity of traded species and conservation concerns. *Ethnobotany Research and Applications*, *10*, 329-338.

Njoroge, G. N., and Bussmann, R. W. (2006). Herbal usage and informant consensus in ethnoveterinary management of cattle diseases among the Kikuyus (Central Kenya). *Journal of ethnopharmacology*, *108*(3), 332-339.

Njoroge, G. N., Kaibui, I. M., Njenga, P. K., and Odhiambo, P. O. (2010). Utilisation of priority traditional medicinal plants and local people's knowledge on their conservation status in arid lands of Kenya (Mwingi District). *Journal of ethnobiology and ethnomedicine*,*6*(1), 1.

Obiri, J., Lawes, M., and Mukolwe, M. (2002). The dynamics and sustainable use of high-value tree species of the coastal Pondoland forests of the Eastern Cape Province, South Africa. *Forest Ecology and Management*, *166*(1), 131-148.

Okello, S. V., Nyunja, R. O., Netondo, G. W., and Onyango, J. C. (2010). Ethnobotanical study of medicinal plants used by Sabaots of Mt. Elgon Kenya. *African Journal of Traditional, Complementary and Alternative Medicines*, *7*(1).

Omwenga, E. O., Hensel, A., Shitandi, A., and Goycoolea, F. M. (2015). Ethnobotanical survey of traditionally used medicinal plants for infections of skin, gastrointestinal tract, urinary tract and the oral cavity in Borabu sub-county, Nyamira county, Kenya. *Journal of ethnopharmacology*, *176*, 508-514.

Otieno, N. E., and Analo, C. (2012). Local indigenous knowledge about some medicinal plants in and around Kakamega forest in western Kenya. *F1000Research*, *1*.

Owuor, B. O., and Kisangau, D. P. (2006). Kenyan medicinal plants used as antivenin: a comparison of plant usage. *Journal of ethnobiology and ethnomedicine*, *2*(1), 1.

Oyugi, J. O., Brown, J. S., and Whelan, C. J. (2008). Effects of human disturbance on composition and structure of Brachystegia woodland in Arabuko-Sokoke Forest, Kenya. *African Journal of Ecology*, *46*(3), 374-383.

Pakia, M. (2001). Plant ecology and ethnobotany of two sacred forests (kayas) at the Kenya coast (Doctoral dissertation, University of Natal, Durban).

Pallant J. (2005). SPSS survival manual, a step by step guide to data analysis using SPSS for Windows 12. 2nd edition.

Pardo-de-Santayana, M., Tardío, J., Blanco, E., Carvalho, A. M., Lastra, J. J., San Miguel, E., and Morales, R. (2007). Traditional knowledge of wild edible plants used in the northwest of the Iberian Peninsula (Spain and Portugal): a comparative study. *Journal of Ethnobiology and Ethnomedicine*, *3*(1), 27.

Phillips, O., and Gentry, A. H. (1993a). The useful plants of Tambopata, Peru: I. Statistical hypotheses tests with a new quantitative technique. *Economic Botany*, *47*(1), 15-32.

Phillips, O., and Gentry, A. H. (1993b). The useful plants of Tambopata, Peru: II. Additional hypothesis testing in quantitative ethnobotany. *Economic Botany*, *47*(1), 33-43.

Phillips, O.L. (1996). Some Quantitative Methods for Analyzing Ethnobotanical Knowledge. In: Selected Guidelines for Ethnobotanical Research: A Field Manual. ed. M.N. Alexiades. Scientific Publications Department, The New York Botanical Gardens, Bronx, NY.

Pieroni, A. (2001). Evaluation of the cultural significance of wild food botanicals traditionally consumed in Northwestern Tuscany, Italy. *Journal of Ethnobiology*, *21*(1), 89-104.

Prance, G. T., Baleé, W., Boom, B. M., and Carneiro, R. L. (1987). Quantitative ethnobotany and the case for conservation in Amazonian. *Conservation Biology*, *1*(4), 296-310.

Rai, L. K., Prasad, P., and Sharma, E. (2000). Conservation threats to some important medicinal plants of the Sikkim Himalaya. *Biological conservation*,*93*(1), 27-33.

Republic of Kenya (2008b). Seeking Solutions for Traditional Herbal Medicine: Kenya Develops a National Policy. Policy Briefs Number 1 May, 2008.

Republic of Kenya (2014). Forest Policy, 2014.Ministry of environment, water and natural resources. Available at: http://www.environment.go.ke/wp-content/uploads/2014/03/forest-policy-2014. Accessed on 25/11/2014.

Republic of Kenya. (2008a). Kenya Vision 2030: First Medium Term Plan (2008-2012). Ministry of State for Planning, National Development and Vision 2030, Government of the Republic of Kenya.

Republic of Kenya. (2010). Kenya Population and Housing Census, 2009. Kenya National Bureau of Statistics, Nairobi, Kenya, 2010.

Republic of Kenya. (2013). Kilifi County, First County Integrated Development Plan 2013-2017 towards a globally competitive and prosperous Kenya. Kilifi County, Kenya.

Reyes-García, V., Huanca, T., Vadez, V., Leonard, W., and Wilkie, D. (2006). Cultural, practical, and economic value of wild plants: a quantitative study in the Bolivian Amazon. *Economic Botany*, *60*(1), 62-74.

Reyes-García, V., Vadez, V., Huanca, T., Leonard, W. R., and McDade, T. (2007). Economic development and local ecological knowledge: a deadlock? Quantitative research from a native Amazonian society. *Human Ecology*, *35*(3), 371-377.

Reyes-García, V., Vadez, V., Huanca, T., Leonard, W., and Wilkie, D. (2005). Knowledge and consumption of wild plants: a comparative study in two Tsimane' villages in the Bolivian Amazon.

Ribeiro, E., Arroyo-Rodríguez, V., Santos, B. A., Tabarelli, M., and Leal, I. R. (2015). Chronic anthropogenic disturbance drives the biological impoverishment of the Brazilian Caatinga vegetation. *Journal of Applied Ecology*, *52*(3), 611-620.

Robertson SA. (1999). Arabuko Sokoke Forest plant list. *Unpublished report*.

Salafsky, N., Salzer, D., Stattersfield, A. J., Hilton-Taylor, C., Neugarten, R., Butchart, S. Collen, S., Cox, N., Master, L., O'connor, S., and Wilkie, D. (2008). A standard lexicon for biodiversity conservation: unified classifications of threats and actions. *Conservation Biology*, *22*(4), 897-911.

Schippmann, U., Leaman, D. J., and Cunningham, A. B. (2002). Impact of cultivation and gathering of medicinal plants on biodiversity: global trends and issues. *Biodiversity and the ecosystem approach in agriculture, forestry and fisheries*.

Schippmann, U., Leaman, D., and Cunningham, A. B. (2006). A comparison of cultivation and wild collection of medicinal and aromatic plants under sustainability aspects. *Frontis*, *17*, 75-95.

Schrodt, F. (2005). Estimating distribution and habitat associations of theendangered aders' duiker (*Cephalophus adersi*):implications for research and conservation. (Masters thesis, University of Plymouth.

Shackleton, C. M., Shackleton, S. E., Buiten, E., and Bird, N. (2007). The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest policy and economics*, *9*(5), 558-577.

Shafie, T. (2010). Designed-based estimators for snowball sampling. Available at SSRN: http://ssrn.com/abstract=2471006. Accessed on 16/08/2016.

Shiracko, N., Owuor, B. O., Gakuubi, M. M., and Wanzala, W. (2016). A survey of ethnobotany of the AbaWanga people in Kakamega County, western province of Kenya. *Indian Journal of Traditional Knowledge*, *15*(1), 93-102.

Shrestha, K. B., Måren, I. E., Arneberg, E., Sah, J. P., and Vetaas, O. R. (2013). Effect of anthropogenic disturbance on plant species diversity in oak forests in Nepal, Central Himalaya. *International Journal of Biodiversity Science, Ecosystem Services and Management*, *9*(1), 21-29.

Sindiga, I. (1995). African ethnomedicine and other medical systems. *Traditional medicine in Africa*, 9966-46.

Sodhi, N. S., and Brook, B. W. (2006). *Southeast Asian biodiversity in crisis*. Cambridge University Press.

Stepp, J. R., and Moerman, D. E. (2001). The importance of weeds in ethnopharmacology. *Journal of Ethnopharmacology*, *75*(1), 19-23.

Sunderlin, W. D., Angelsen, A., Belcher, B., Burgers, P., Nasi, R., Santoso, L., and Wunder, S. (2005). Livelihoods, forests, and conservation in developing countries: an overview. *World development*, *33*(9), 1383-1402.

Sunil, C., Somashekar, R. K., and Nagaraja, B. C. (2011). Impact of anthropogenic disturbances on riparian forest ecology and ecosystem services in Southern India. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *7*(4), 273-282.

Tardío, J., and Pardo-de-Santayana, M. (2008). Cultural importance indices: a comparative analysis based on the useful wild plants of Southern Cantabria (Northern Spain) 1. *Economic Botany*, *62*(1), 24-39.

Taylor, J. L. S., Rabe, T., McGaw, L. J., Jäger, A. K., and Van Staden, J. (2001). Towards the scientific validation of traditional medicinal plants. *Plant Growth Regulation*, *34*(1), 23-37.

Ticktin, T. (2004). The ecological implications of harvesting non-timber forest products. *Journal of Applied Ecology*, *41*(1), 11-21.

Ticktin, T., and Johns, T. (2002). Chinanteco management of Aechmea magdalenae: implications for the use of TEK and TRM in management plans. *Economic Botany*, *56*(2), 177-191.

Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection.

Trotter, R. T. and Logan, M. H. (1986). Informant Consensus: A New Approach for Identifying Potentially Effective Medicinal Plants. Plants in Indigenous Medicine and Diet: Biobehavioral Approaches. Redgrave Publishing Company, New York.

Turner, N. J. (1988). "The importance of a rose": evaluating the cultural significance of plants in Thompson and Lillooet Interior Salish. *American anthropologist*, *90*(2), 272-290.

Uprety, Y., Asselin, H., Boon, E. K., Yadav, S., and Shrestha, K. K. (2010). Indigenous use and bio-efficacy of medicinal plants in the Rasuwa District, Central Nepal. *Journal of Ethnobiology and Ethnomedicine*, *6*(1), 1.

Uprety, Y., Poudel, R. C., Asselin, H., Boon, E. K., and Shrestha, K. K. (2011). Stakeholder perspectives on use, trade, and conservation of medicinal plants in the Rasuwa District of Central Nepal. *Journal of Mountain Science*, *8*(1), 75-86.

Vaglio Laurin, G., Hawthorne, W. D., Chiti, T., Di Paola, A., Cazzolla Gatti, R., Marconi, S., Noce, S., Grieco, E., Pirotti F., and Valentini, R. (2016). Does degradation from selective logging and illegal activities differently impact forest resources? A case study in Ghana. *iForest-Biogeosciences and Forestry*, 488.

Voeks, R.A. and Leony, A. (2004). Forgetting the Forest: Assessing Medicinal Plant Erosion in Eastern Brazil. *Economic Botany,* 284-S306.

Weiss, E. A. (1979). Some indigenous plants used domestically by East African coastal fishermen. *Economic Botany*, *33*(1), 35-51.

Wekesa, C., Ndalilo, L., Ongugo, P., Leley, N., and Swiderska, K. (2015). Traditional knowledge based innovations for adaptation and resilience to climate change: the case of coastal Kenya.

WHO (2002). WHO traditional medicine strategy 2002-2005.

World Bank (2003).World development report 2003: Sustainable development in a dynamic world: trans-forming institutions, growth, and quality of life. Washington, DC: The World Bank; New York: Oxford University Press.

WWF-EARPO (2006). The eastern Africa coastal forests ecoregion, Strategic framework for conservation (2005-2025).

APPENDICES

APPENDIX I: SOCIOECONOMIC, KNOWLEDGE AND UTILIZATION OF MEDICINAL PLANTS QUESTIONNAIRE

General Information
Date of interview: ……/……/……
Questionnaire serial number…………………
Name of enumerator: ………………..………………..
Location …………………………….. Village…………………….

Respondent Details

Name of respondent:

Sex: Male [ ] Female [ ]

Age: 1) Under 30 years [ ] 2) Between 30 and 60 [ ] 3) Above 60 years [ ]

1.0 Household attributes

1.1 Household's head 1) Male 2) Female
1.2 Age: 1) Under 30 years [ ] 2) Between 30 and 60 [ ] 3) Above 60 years [ ]
1.3 Education of the household's head: 1) None 2) Primary 3) Secondary 4) Post Secondary
1.4 Are you employed? Yes [ ] No [ ]
1.5 If yes, how much do you earn per month? …………………………………
1.6 Is any other member of your family is in the formal employment? Yes [ ] No [ ]
1.7 If yes, how much do he/she earn per month? ....
1.8 Household size

Adults		Children under 18		No. of children in School	Other dependants	Total No. of members
Husband and wife(s)	Children over 18 years	Boys	Girls			

1.9 Land tenure system: (1) Clan/family ownership (2) Old titled private land (3) Newlytitled private land (4) Squatter (5) Scheme settlement
1.10 How much acreage do you own? ....
1.11 What is the distance from your home to the nearest health centre? ....
1.12 What is the distance from your home to all-weather roads? ....
1.13 What is the distance from your home to the forest? ....
1.14 Sources of livelihood: (1) Livestock (2) Crop cultivation (3) Beekeeping(4) Business (5) Formal employment (6) Fishing (7) Others (specify)……………………………
1.15 Main livelihood source: 1) Agriculture 2) Employment and/or business

2.0 Sources of Income

2.1Which crops have you…………this season?

Item	Sold		Consumed at home Amount (kgs)
	Amount (Kegs)	Unit price (Kshs)	

2.2 How many animals have you………….this season?

Species	Sold		Slaughtered (Consumed)
	No.	Unit price (Kshs)	
Camel			
Cattle			
Goats			
Sheep			
Donkey			
Poultry			
Total			

2.3 How much have you received from the………….. of livestock products this season?

Species	Sold		Consumed at Home
	Amount	Unit price (Kshs)	
Meat			
Milk			
Eggs			
Manure			
Skins			
Others			
Total			

2.4 How many members of your family are employed elsewhere?

2.5 Do you receive any transfers from them? Yes [ ] No [ ]

2.6 How much do they bring back home?

No.	Amount brought (Monthly)
1.	
2.	
3.	
4.	

3.0 Information on Medicinal Plants

I am interested in knowing and documenting plants used for medicinal and other purposes

3.1 Do you use traditional medicines to treat diseases? Yes [ ] No [ ]

3.2 If yes; used for the treatment of ………… diseases.

Human [ ] Livestock [ ] Both [ ]

3.3 When did you decide to use medicinal plants and why?

………

3.4 From whom did you know or learn about medicinal plants? Explain

………

3.5 Why did you start using medicinal plants?

Reasons for using medicinal plants	

Codes for reasons: 1) Availability 2) Cheap 3) No side effects 4) Long distance to health centre 5) Efficacy 6) Others, specify………..

3.6 Do you collect medicinal plants for yourself or do you buy them from healers/vendors.

Self [ ] Buy [ ] Both [ ]

If others, specify…………………………………………………………………………………

3.7 If you buy, where do you buy from?

…………………………………………………………………………………………………
…………………………………………………………………………………………………

3.8 If you collect for yourself; where do you collect your medicinal plants?

Around the house and own farm [ ]

From the forest [ ]

Both Farm and forest [ ]

If others, specify……………………………………………………

3.9 Do you sell medicinal plants? Yes [ ] No [ ]

3.10 If yes, which medicinal plant species do you sell? List them.

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………………

3.10 How much did you earn from the sale of medicinal plants, last month? ....

4.0 Cultural component

4.1 Can you tell me the names of plant species that are used as medicine? What are its other uses?

Name of Species	USES					
	Medicine	Animal feed	Food	Construction	Fuel	Others

4.2 Do you know this species and do you use it? Does it face any threats and do you think or the species is conserved/ or is there any management strategy in place to conserve it?

Species	**Knowledge(Yes/No)**	**Utilization(Yes/No)**	**Threats(Yes/No)**	**Conservation(Yes/No)**

4.0 Practical component

4.1 How many times have you brought the species to the house, in the last (one day-food; seven days- animal feed, fuel; 90 days- medicine and 'other'; and six months for construction) and what was it used for?

Species	Number of Times Brought	Intended Uses

4.2 Which diseases did you experience in your family in the last six months and which mode of treatment did you use?

Disease	Medicine used			Source of M.P		Price of M.P purchased	Price of M.M Used	Part used (M.P)	Administration (M.P)	Days of medication	Did the medication worked (Yes/NO)	For how did the disease take before it disappeared (days)
	M.M	M.P	BOTH	Self collection	Purchased							

(M.M= Modern medicine, M.P = Medicinal Plant, Coll= collected)

<u>6.0 Threats to and conservation of medicinal plant species</u>

6.1If you used to collect medicinal plants in the past, do you still collect them now?
Yes [ ] No [ ]

6.2 If No, why?

……………………………………………………………………………………………………
……………………………………………………………………………………………………

6.3 If yes, why?

……………………………………………………………………………………………………
……………………………………………………………………………………………………
………………

<u>7.0 Conservation of Medicinal Plants</u>

7.1 Are there any forest species we have discussed growing in your farm? Yes [ ] No [ ]

7.2 If Yes, which ones?

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
………………………………

7.3 What do you think are the main threats to wild medicinal plants?

Threats	Measures undertaken to Conserve

Codes for threats: 1) Overharvesting 2) Overgrazing 3) Clearing for cultivation 4) Charcoal burning 5) Climate change 6) Commercialization 7) Breakdown of traditional institutions 8) Reduced sources of livelihood 9) Poverty 10) Others (specify)

Codes for measures undertaken to conserve: 1) Domestication 2) Groups that protect medicinal plants 3) Community scouts 4) Efforts by administrative officers e.g. chief 5) Rules governing use 6) Trainings on conservation 7) government/ county's conservation provisions 8) Others (specify)

APPENDIX II: CHECKLIST FOR FOCUS GROUP DISCUSSIONS AND KEY INFORMANT INTERVIEWS ON MEDICINAL PLANTS AND MARKETED SPECIES AROUND ARABUKO SOKOKE

1. **Marketed medicinal plant species**
   - I. Marketed species
   - II. Disease cured by each species
   - III. Part used
2. **Place of harvest (origin)**
   - I. Places of harvest (of specific species)
   - II. Collection (from wild collection/ cultivation)
   - III. Place of sale
   - IV. Availability of each wild medicinal plant species
3. **Actors in the trade**
   - I. List of actors in harvesting and trade
   - II. Their roles and interconnections
   - III. Any suppliers organizations/societies
4. **Value addition**
   - I. Any Forms of value addition and medicinal plant species
   - II. Who are involved
5. **Challenges in the trade**
   - I. Specific challenges in the trade and people involved
   - II. Where they are found in the marketing channel
   - III. Any management strategies in place

APPENDIX III: MEDICINAL PLANTS AND THEIR USES BY COMMUNITIES ADJACENT TO ARABUKO SOKOKE FOREST

	Local Name	Scientific Name	Plant Family	Part used	Preparation	Medicinal Use
1.	Mtundukula (Gir) Hudaa-hud'a (San)	*Ximenia americana L.*	Olacaceae	Roots Leaves Fruits	Boiling	Respiratory problems, Toothache, vomiting, diarrhea in children
2.	Mbundukwi, Mbunduki (Gir) Bunduki (San)	Bourreria petiolaris (Lam.) Thulin	Boraginaceae	Roots	Boiling	Female Reproductive disorder
3.	Mkayukayu (Gir) Horocha (San)	*Ozoroa obovata* (Oliv.) R & A. Fernandes	Anacardiaceae	Roots Bark	Boiling	Malaria, Dizziness
4.	Mvuma (Gir)	*Premna chrysoclada*(Bojer) Gürke	Lamiaceae	Roots Leaves	Boiling	Female Reproductive disorder, Malaria
5.	Mrori (Gir) Shilole (San)	*Uvaria acuminata* Oliv.	Annonaceae	Roots Leaves	Boiling Soaking	Gastrointestinal gas, Aphrodisiac, Rectal prolapsed, Menstrual cramps, Malaria, Female reproductive disorder
6.	Mdzalasimba (Gir) Shilole warsesa (San)	*Monodora grandidieri* Baill.	Annonaceae	Roots Leaves	Boiling Soaking	Aphrodisiac, Gastrointestinal gas, Reproductive disorder
7.	Mdhungu, Mjafari (Gir) Gadayu (San)	*Zanthoxylum chalybeum*Engl.	Rutaceae	Leaves Roots Bark	Soaking Boiling Chewing	Obesity, Reproductive disorder, Cough, Wounds
8.	Mdzaladowe (Gir) Shilole-korm (San)	*Uvaria lucida* Benth.	Annonaceae	Leaves Roots	Boiling Soaking	Reproductive disorder, Aphrodisiac
9.	Mwangajeni (Gir) Mangajini (San)	Polyathia stuhlmanii (Engl.) Verdc.	Annonaceae	Roots Bark	Burning Boiling	High Blood pressure, Typhoid, Obesity
10.	Mboho (Gir) Muki shakaa (San)	*Securidaca longipedunculata* Fresen.	Polygalaceae	Leaves Roots	Pounding Boiling	Vaginal discharge, Menstrual cramps,Infertility, Aphrodisiac

	Local Name	**Scientific Name**	**Plant Family**	**Part used**	**Preparation**	**Medicinal Use**
11.	Mdalamwaka (Gir)	*Deinbollia borbonica* Scheff.	Sapindaceae	Roots	Boiling	Gastrointestinal complaints
12.	Mshindaalume (Gir)	*Combretum illairii* Engl.	Combretaceae	Bark Leaves	Boiling	Malaria,female infertility
13.	Mbambakofi, Mwamba (Gir) Vaamicha (San)	*Afzelia quanzensis* Welw.	Fabaceae	Roots Bark	Boiling	Chest pain,Snake bite, increase in menses (female)
14.	Mbirandu (Gir) Boora (San)	*Oldfieldia somalensis*(Chiov.) Milne-Redh	Euphorbiaceae	Bark Roots	Boiling	Arthritis, Fatigue, Cough, Tuberculosis
15.	Mkulu (Gir) Qolathi (San)	*Diospyros cornii*Chiov.	Ebenaceae	Bark	boiling	Skin diseases, Respiratory problems
16.	Mkuha (Gir) Garse (San)	*Dobera glabra* (Forssk.) Juss. ex Poir	Salvadoraceae	Roots Branches	Boiling	Rheumatism, Gouts
17.	Mbathe (Gir) Kararacha (San)	*Diospyros consolatae* Chiov.	Ebenaceae	Roots Leaves	Chewing	Kidney problem, Gastrointestinal gas, Snakebite, Arthritis, Umbilical cord, Hernia, Veterinary medicine
18.	Mkuro (Gir) Muki bofaa korm (San)	*Toddaliopsis sansibarensis* (Engl.) Engl.	Rutaceae	Roots	Boiling	Reproductive disorder
19.	Mbarawa (Gir)	*Xylopia parviflora* (A. Rich.) Benth.	Annonaceae	Roots	Boiling	Aphrodisiac
20.	Mugurure (Gir) Mungule (san)	*Combretum schumanii*Engl.	Combretaceae	Bark	Boiling	Reproductive disorder , Swelling
21.	Mkone (Gir) Haroru (San)	*Grewia plagiophylla* K.Schum	Tiliaceae	Bark Leaves Roots	Soaking Boiling	Yellow fever, Malaria, Obesity, Skin diseases, Epilepsy
22.	Muhuhu (Gir)	*Brachylaena huillensis* O. Hoffm	Asteraceae	Roots Leaves	Boiling	Gastrointestinal complaints
23.	Chikuro	Toddalia asiatica (L.) Lam.	Rutaceae	Roots	Boiling	Gastrointestinal complaints, Respiratory problems

	Local Name	Scientific Name	Plant Family	Part used	Preparation	Medicinal Use
24.	Mhumba (Gir)	*Cassia abbreviata* Oliv.	Fabaceae	Roots Bark	Boiling	Menstrual cramps, Aphrodisiac, Venereal disease
25.	Muhowe (Gir)	*Thespesia danis* Oliver	Malvaceae	Roots Leaves	Boiling	Fibroids, Female sexual problems
26.	Mgore (Gir)	*Adenia gummifera* (Harv.) Harms	Passifloraceae	Roots	Boiling	Aphrodisiac, Diarrhea, female reproductive disorder
27.	Muyama/Myama (Gir) K'eetethi (San)	*Croton pseudopulchellus* Pax	Euphorbiaceae	Leaves Roots	Boiling Soaking	Convulsion, Snake bite, Rheumatism
28.	Mguji (Gir) Gorra (San)	*Capparistomentosa* Lam.	Capparaceae	Roots	Boiling	Female infertility, Menstrual problems
29.	Mnwa-madzi (Gir) Gale nooya (San)	*Rhoicissus tridentata* (L.f.) Wild & R.B. Drumm	Vitaceae	Secretion Roots	Squeezing	Skin diseases, Eye problem, Hydrocele
30.	Mkingiri (Gir, San)	*Dichrostachys cinerea* (L.) Wight and Arn	Fabaceae	Roots	Boiling	Malaria, Cold, Asthma, Toothache
31.	Mkipa (Gir,San)	*Euclea natalensis* A.DC F. White	Ebenaceae	Roots	Chewing Boiling	Constipation, Vaginal discharge, Toothache, Earache
32.	Mfudu (Gir) Muki-k'ufaa (San)	*Vitex ferruginea*	Lamiaceae	Fruits Root	Chewing Boiling	Appetite, Gastrointestinal complaint
33.	Mung'ambo (Gir) D'ooki (San)	*Manilkara sansibarensis* (Engl.) Dubard	Sapotaceae	Bark	Boiling	Rheumatism, Cough
34.	Mgome (Gir) B'udhe (San)	*Cassipourea euryoides* Alston	Rhizophoraceae	Bark	Boiling	Aphrodisiac, Rheumatism
35.	Mnyumbu (Gir) Handaraku (San)	*Lannea schweinfurthii* (Engl.) Engl.	Anacardiaceae	Bark Roots	Boiling	Heart problem, Malaria
36.	Mkonga (Gir) Badhana (San)	*Balanites wilsoniana* Dawe & Sprague	Zygophyllaceae	Bark, Leaves	Boiling	Insomnia, Amnesia
37.	Katsembeke (Gir)	*Tinnea aethopica* Kotschy ex Hook.f.	Lamiaceae	Whole	Boiling	Gastrointestinal complaints in children

	Local Name	Scientific Name	Plant Family	Part used	Preparation	Medicinal Use
38.	Mthema kwalala (Gir) Sooso korm (San)	*Pteleopsis tetraptera* Wickens	Combretaceae	Bark	Pounding Boiling	Venereal diseases, wounds, Vitality in men
39.	Mutola, Mtola (Gir) Warebi (San)	*Commiphora africanum* Endl.	Burseraceae	Bark Roots	Boiling	Wound, Burns
40.	Chaa, Kidhongodhongo (Gir) Rorogithi (San)	*Euphorbia candelabrium* Kotschy	Euphorbiaceae	Whole plant	Secretion	Hernia, Leprosy
41.	Mkwambawari, Mkwambasima (Gir) K'athe (San)	*Flueggea virosa* (Roxb.ex Willd) Voigt	Euphorbiacea	Leaves Roots	Boiling	Female Reproductive disorder, Aphrodisiac
42.	Mtambakiko (Gir) (Gururi)	*Carissa edulis* (Forssk.) Vahl.	Apocynaceae	Roots Fruits	Boiling	Gastrointestinal gas/ bloating, heartburn
43.	Muyama wa nyika (Gir) Keethethi korm (San)	*Croton menyhartii* Pax.	Eurphorbiaceae	Roots Leaves	Soaking Boiling	Female reproductive disorder, Vaginal discharge, Ulcers, Respiratory problem
44.	Muhalanda (Gir) Mtawanda (San)	*Fernandoa magnifica* Seem.	Bignoniaceae	Roots	Boiling	Female Reproductive disorder
45.	Mrusapungu (Gir) Thiro arbaa (San)	*Clerodendrum incisum* Klotzsch	Lamiaceae	Leaves Roots	Soaking Boiling	Vomiting(bile), Gastrointestinal gas, Cerebral malaria, Post-natal problems(Mothers)
46.	Mthurithuri (Gir) Kimanjala (San)	*Abrus precatorius* L.	Fabaceae	Leaves Roots	Boiling Mixing with body lotion	Asthma, Heart pain, Cough, Fever
47.	Mthakuma, Mtomoko tsaka (Gir) Bombo (San)	*Annona senegalensis* Pers.	Annonaceae	Roots Bark	Boiling	Liver and spleen problems, Headache, Dizziness
48.	Kazhalananyuma (Gir)	–	–	Leaves	Boiling Soaking	Gastric problems, constipation in children, labour pains,
49.	Mkula usiku (Gir) Thiro werebesaa (San)	*Clerodendron kirkii* Baker	Lamiaceae	Leaves Roots	Soaking Boiling	Intestinal worms, Respiratory problems, Reproductive disorder

	Local Name	Scientific Name	Plant Family	Part used	Preparation	Medicinal Use
50.	Kabaruthitsaka (Gir)	*Psilotrichum scleranthum* Thwaites.	Amaranthaceae	Small branches Leaves	Soaking	Aphrodisiac, smoothening skin
51.	Mjungumoto (Gir) Aadhe (San)	*Salvadora persica* L.	Salvadoraceae	Roots Bark	Pounding Boiling	Labor pain, Obesity, Hernia, Gastrointestinal gas, whitening teeth
52.	Mtsatsa mubomu (Gir) Orbis (San)	*Acalypha fruticosa* Forssk.	Eurphorbiaceae	Leaves Roots	Soaking Boiling	Gastrointestinal gas, labor pain
53.	Vuje ya tsi (Gir) Gururi korm (San)	*Pentarrhinum insipidum* E.Mey.	Apocynaceae	Roots	Boiling	Malaria, Eye problem, Reproductive disorder
54.	Musunduzi (Gir)	*Croton talaeporos* Radcl.-Sm.	Euphorbiaceae	Roots Leaves	Boiling	Typhoid, high blood pressure, Rheumatism
55.	Kadhimi kapala (Gir) Thiro-jarthi lagaa (San)	*Clausena anisata* (Willd.) Hook.f.ex Benth.	Rutaceae	Roots	Chewing Boiling	Chest pain, Respiratory problem, Cough, Malaria
56.	Mwalagakuku (Gir) Ule-durfaa korm (San)	*Turaea wakefieldii*	Meliaceae	Roots Bark Leaves	Boiling	Measles, chest pain, chicken pox, cough
57.	Mtomoko (Gir,San)	*Anonna sqaumosa L.*	Annonaceae	Fruits Roots Leaves	Chewing Boiling	Ulcers, Blood purifier, High blood pressure, Reproductive disorder, Dizziness
58.	Mpera (Gir)	*Psidia guajava* L.	Myrtaceae	Fruit Leaves Roots	Chewing Boiling	Ulcer, High blood pressure, Reproductive disorder
59.	Mhirihiri (Gir) Wonokoon (San)	*Warburgia stulhmanii* Engl.	Canellaceae	Bark Leaves	Chewing Boiling Inhalation	Cough, Malaria, Chest pain, Heart pain, Toothache, Antiditoxicant, Veterinary medicine
60.	Mtserere, Mtserezamoyo (Gir) Muserere (San)	*Hoslundia opposita* Vahl	Lamiaceae	Leaves Roots	Chewing Boiling	Diabetes, Wound, Blood purifier, Safe child delivery

	Local Name	Scientific Name	Plant Family	Part used	Preparation	Medicinal Use
61.	Mshomoro (Gir)	*Lantana camara*	Verbenaceae	Leaves Roots	Soaking Boiling	Removal of placenta, Veterinary medicine
62.	Mkilifi, Mzirikita, Mwarubaini (Gir)	*Azadirachta indica* A.Juss.	Meliaceae	Leaves Bark Roots	Boiling	Fatigue, Fever, Malaria, Gastrointestinal problems, Cough and cold, Veterinary medicine
63.	Kabanda kesi (Gir)	*Occimum spp.*	Lamiaceae	Leaves, flowers	Soaking	Diabetes, Blood purifier
64.	Kitozi (Gir) Hargesi (San)	*Aloe volkensii* Engl.	Aloaceae	Leaves	Chewed Boiling	Malaria, Wounds, Skin diseases, High blood pressure, Eye problems, Veterinary medicine
65.	Mpashoni, Mpesheni (Gir,San)	*Passiflora edulis* Sims.	Passifloraceae	Leaves	Chewing Soaking	Stomach ache
66.	Kasikiropaka (Gir)	*Cissampelos Pareira* L.	Menispermacea e	Leaves Roots	Chewing	Gastric complaints/ stomach ache
67.	Mkwaju (Gir) Roka (San)	*Tamarindus indica* L.	Fabaceae	Roots Fruits	Boiling Soaking	Snake bite, Diarrhea
68.	Mutsalafu/Mtsalafu (Gir, San)	*Senna occidentalis (L.) Link.*	Fabaceae	Leaves	Soaking	Malaria, Gastric complaints
69.	Mzungwi (Gir) Safarra (San)	*Moringa oleifera Lam.*	Moringaceae	Roots Leaves Seeds	Boiling	Reproductive disorder, High blood pressure, Malaria, Diabetes
70.	Mkorosho, Mkanju (Gir) Maibo (San)	*Anacardium occidentale* L.	Anacardiaceae	Leaves Roots	Boiling	Toothache, Child colic
71.	Mpapai, Mpapayu (Gir, San)	*Carica papaya* L.	Caricaceae	Roots	Boiling	Venereal diseases, Gastrointestinal problems
72.	Mwembe (Gir, San)	*Mangifera indica* L.	Anacardiaceae	Leaves Bark	Chewing Boiling	Cerebral Malaria, Toothache, Yellow fever, Stomach ache
73.	Mkapu, Mlimau (Gir, San)	*Citrus limon* (L.) Burm.f.	Rutaceae	Roots Leaves	Crushing Boiling	Infertility

	Local Name	Scientific Name	Plant Family	Part used	Preparation	Medicinal Use
74.	Mgomba (Gir) Warki (San)	*Musa sapientum*	Musaceae	Roots Bark	Boiling	Female infertility
75.	Mpilipili (Gir) Shifisho (San)	*Capsicum frutescens* L.	Solanaceae	Roots Fruits	Boiling	Tumours
76.	Mgamu (Gir, San)	*Eucalyptus grandis* W. Hill ex Maiden	Myrtaceae	Bark Leaves Roots	Boiling	Fever, Cold, Headache
77.	Mkode (Gir, San)	*Thaveitia spp*		Roots Bark	Pounding	Wounds, Skin disease, ringworms
78.	Mbuyu, Mkuluhazingwa (Gir)	*Adansonia digitata* L.	Malvaceae	Leaves Seeds	Soaking Boiling	Measles, Appetizer
79.	Mchungwa (Gir)	*Citrus sinensis* (L.) Osbeck.	Rutaceae	Fruit Leaves bark	Boiling	Eye ache, Flu
80.	Mukidhunya, Mpapura (Gir, San)	*Capparis sepiaria* L.	Capparaceae	Leaves Roots	Boiling	Malaria, Menstrual cramps
81.	Mnyanga kitswa (Gir) Kombachi (San)	*Allophylus pervillei* Blume	Sapindaceae	Roots Leaves	Crushing Boiling	Headache, Wounds, Fibroid, Female reproductive disorder
82.	Mtondo (Gir)	*Solanum incanum* L.	Solanaceae	Fruit Roots	External application Boiling Inhalation	Boil, Toothache, Snake bite, kidney problem
83.	Mbalazi (Gir)	*Cajanus cajan* (L.) Millsp.	Fabaceae	Leaves Roots	Chewing/squeezing Boiling	Eye and ear problems, Female infertility, Constipation
84.	Mbonokoma (Gir) Thaki-daa-diko (San)	*Jatropha carcus* L.	Euphorbiaceae	Leaves Roots	Pounding	Wounds, prevention of miscarriage
85.	Mnazi (Gir)	*Cocos nucifera* L.	Arecaceae	Fruit Leaves	Crushing	Asthma, Kidney problems, Wound
86.	Munga (Gir) Bura (San)	*Acacia nilotica* (L.) Willd. Ex Del.	Fabaceae	Roots	Boiling	Asthma, Malaria, fibroid, women infertility

	Local Name	Scientific Name	Plant Family	Part used	Preparation	Medicinal Use
87.	Mwanangira (Gir) Ngira mbiri (San)	*Synaptolepsis kirkii* Oliv.	Thymelaeaceae	Roots	Boiling	Female infertility, Hydrocele
88.	Mporojo (Gir)	*Albizia anthelmintica* (A.Rich.) Brongn.	Fabaceae	Roots Bark Leaves	Boiling Soaking	Helminthis, Asthma, Snakebite
89.	Mmbilimbi (Gir)	*Averrhoa bilimbi* L.	Oxalidaceae	Fruit	Chewing	Aphrodisiac, Appetizer, Food medicine
90.	Muarubaini nusu (Gir)	*Melia azedarach* L.	Meliaceae	Bark Leaves	Boiling	Malaria, Cold and flu, Fever
91.	Morya (Gir)	*Sterculia Africana* (Lour.) Fiori	Malvaceae	Bark Roots	Boiling	Heart problem, Dysentery, Rectal prolapse, Asthma
92.	Ria	*Pyrenacantha kaurabassana* Baill.	Icacinaceae	Tuber	Boiling	Aphrodisiac, Fetus development, Labor pain, Veterinary medicine
93.	Mujaji	*Strychnos madagascariensis* Poir.	Loganiaceae	Roots Fruit	Crushed and mixed with paraffin oil	Jiggers
94.	Mthupa	*Mundulea sericea* (Willd.) A. Chev.	Fabaceae	Bark Leaves	Crushed and mixed with oil	Jiggers

Note: Gir; Giriama and San; Sanya ethnic languages