CONSERVATION OF MEDICINAL PLANTS FOR MANAGING HIV/AIDS OPPORTUNISTIC INFECTIONS IN RUNGWE DISTRICT, MBEYA REGION, TANZANIA

SUMA FAHAMU KIBONDE

A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2019

EXTENDED ABSTRACT

The application of medicinal plants in primary health care for people living with HIV/AIDS is well acknowledged in Tanzania. However, the conservation status of medicinal plants is questionable. This study aimed at assessing the conservation status of medicinal plants used to manage HIV/AIDS opportunistic infections in Rungwe District, Mbeya Region, Tanzania. Specifically, this study sought to: identify and document medicinal plant species used to manage HIV/AIDS opportunistic infections in the study area, explore indigenous knowledge of conserving medicinal plants in the study area, assess the wild population status of medicinal plant species used to manage HIV/AIDS opportunistic infections and to propose a conservation framework for medicinal plant species in the study area. This study employed a cross sectional research design through which data were collected at a single point in time. Ethnobotanical data were collected using questionnaires, key informants' interviews, focus group discussions and field observations. Furthermore, the inventory was conducted to collect data on the wild population status of priority medicinal plant species. While quantitative data were analysed using descriptive and inferential statistics, qualitative data were analysed using content analysis method. Logistic regression models were developed to analyse the influence of socio-demographic factors of the respondents on ethnobotanical knowledge. Preference ranking method was used to obtain priority medicinal plant species used to manage HIV/AIDS opportunistic infections in the study area. Analysis of inventory data was done by using Microsoft Excel and QGIS software version 2.18 to analyse spatial data gathered on assessment of wild population status of priority medicinal plant species. Inventory data were further analysed for species structure and density. It was revealed that a total of 31 medicinal plant species belonging to 23 families were used to manage HIV/AIDS opportunistic infections in the study area. Compositae and Rosaceae were the

mostly extracted plant families (15%). With regards to plant parts, the study indicated that leaves were mostly extracted for medicine (44%) than others. Of the cited HIV/AIDS opportunistic infections, Tuberculosis utilized the largest share of the medicinal plant species (60%). The ethnobotanical knowledge of the respondents was independent of age and sex, but was significantly influenced by ethnic background and education levels of the respondents ($p=0.00$). In relation to indigenous knowledge on conservation, the study indicated that up to nine indigenous conservation practices were recorded. Out of the nine indigenous conservation practices, selective harvesting was the most popular to 94% of the respondents. Moreover, the study revealed that indigenous knowledge on conservation was significant among males than females ($p=0.031$) and adults than youth respondents ($p=0.002$). The study revealed up to seven priority medicinal plant species used by communities to manage HIV/AIDS opportunistic infections in the study area. The assessment of the wild population status of medicinal plant species was carried out on two species (*Hagenia abyssinica* and *Myrica salicifolia).* The findings on population status of priority medicinal plant species indicated that, both species were mostly distributed within 1950-2050 meters above sea level in the Poroto forest reserve and were linearly distributed adjacent rivers. The population structure of priority medicinal plant species showed *J*-shaped curves, most species were dominant in (>10cm) size class and few in the lowest size class (<10cm) for *Hagenia abyssinica* while there were no species of the lowest size class found for *Myrica salicifolia*. With regards to stem density, the findings revealed that *Hagenia abyssinica* had a total of 200 stems/ha whereas only 28 stems/ha density were found in *Myrica salicifolia*. Further, it was indicated that arable farming, logging, and animal grazing inside the forest reserve interfered the sustainability of medicinal plant species. To address those conservation challenges the respondents suggested approaches such as ex-situ (32%) and in-situ (23%). The findings from all objectives were scrutinized to arrive at proposing a

conservation framework suitable for medicinal plant species. The aim of the conservation framework is to attain sustainability of medicinal plants and ensuring improvement of health of the people. The framework proposed encompasses many variables such as: legal and institutional frameworks ex-situ and in-situ conservation and conservation knowledge (formal and/or indigenous). Other variables include suitable site selected for ex-situ conservation from which the properly prepared seeds/seedlings will be planted. With regards to in-situ conservation, it is required that seedlings for restoring the wild are properly prepared and they are left to grow under proper managed and protected environment. In conclusion, the communities in the study area are rich in ethnobotanical knowledge. This study recommends for preservation and transmission of ethnobotanical knowledge across generations by the elders to the youth. Based on the study findings, there is a necessity of taking urgent measures to address conservation challenges and safeguarding the medicinal plant species. The implementation of the proposed conservation framework requires government's responsible institutions such as the Tanzania Forest Service Agency (TFS), Tanzania Forest Research Institution (TAFORI) together with academic and other research institutions, environmental policy makers and conservationists, local authorities and all stakeholders interested in the medicinal plants sector to work cooperatively.

DECLARATION

I, **SUMA FAHAMU KIBONDE**, do hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my original work done within the period of registration and that it has neither been submitted or being concurrently submitted to any other institution for degree award.

_____ _____

Suma Fahamu Kibonde **Date**

(PhD Candidate)

The above declaration is confirmed by;

_____ _____

Dr. Suzana Augustino **Date**

(Supervisor)

_____ _____

Dr. Faith Mabiki **Date**

(Supervisor)

COPYRIGHT

ACKNOWLEDGEMENTS

First of all, I thank the Lord Jesus Christ, my Saviour, for His Guidance, Protection and Mercy throughout the PhD years. I am also deeply grateful to my supervisors Dr. Suzana Augustino and Dr. Faith Mabiki for their patience, and valuable contributions made towards the completion of this study.

I also express my heartfelt thanks to Prof. Robinson Mdegela who provided me a sponsorship opportunity in the project under his leadership. His academic advice and financial care made my PhD journey smooth.

I deeply appreciate the assistance extended to me by the late Dr. Sijaona Msigala, especially for his support in data collection. He died without seeing me graduating, but, his moral and material support will remain in my heart.

I further extend my special appreciations to my lovely husband Gerion Mwankenja who tolerated a lonely life during the entire period of my study and encouraged me to take heart when I felt down. Also to my lovely children, Gladness Gerion, Gavriel Gerion and Gaddiel Gerion, you deserve my compliments.

I acknowledge my beloved parents, the late Mtambwege Kibonde my father and the late beloved mother Ezelina Mbungu for bringing me on earth. I am equally thankful to my brothers: Angetile Kibonde (late), Asumwisye Kibonde (late), Daimon Kibonde, Hezron Kibonde, Ambwene Kibonde (late) and Lusajo Kibonde and my sister Atwisile Kibonde.

I am indebted to the Regional Initiative in Science and Education- African Natural Product Research Network (RISE-AFNNET) and Carnegie Corporation CR-AFNNET) for granting me three years PhD scholarship. Conversely, I acknowledge my employer, Sokoine University of Agriculture (SUA) for granting me study leave permission, via the principals; Prof. Patrick Mwang'ingo and Prof. Allen Malisa. I also thank Dr. C. Mjema and Dr. P. Mtoni my Heads of Department for the former Physical Sciences and now department of Geography and Environmental Studies.

Lastly, but not least, I thank the Rungwe District administrators and village leaders for offering me a research permit. I am grateful to the support and cooperation I received from officials of the forests in Rungwe including Rungwe Nature Reserve and Poroto Forest Reserve, Makandana District Hospital and the respondents that facilitated my fieldwork.

DEDICATION

This thesis is dedicated to my late and beloved mama mdogo (aunt) Elizabeth Mbungu, who sacrificed her energy, time and needs for my interest since when I was a 4-years child. It was very hard for me to go through without your presence and precious love, but God strengthened me, it’s all good with my Soul.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

AfDB	African Development Bank
AIDS	Acquired Immune Deficiency Syndrome
ART	Anti-Retroviral Therapy
ARVs	Antiretrovirals
CBD	Convention for Biological Diversity
CC	City Council
COP	Country Operation Plan
CTCs	Care and Treatment Centres
DBH	Diameter at Breast Height
DC	District Council
ERDB	Ecosystems Research and Development Bureau
FAO	Food and Agriculture Organization
GACP	Good Agricultural and Collection Practices
ha	hectare
HBC	Home-based care
HIV	Human Immunodeficiency Virus
ibid.	Latin, short for ibidem, meaning "in the same place"
IBT	Island Biogeography Theory
ICS	International Centre for Science and High Technology
ICSU	International Council for Science
IK	Indigenous knowledge
ITM	Institute of Traditional Medicine
IUCN	International Union for Conservation of Nature
masl	metres above sea level

MAT	Medical Association of Tanzania
MDGs	Millennium Development Goals
MPs	Medicinal plants
NBSAP	National Biodiversity Strategy and Action Plan
NIMR	National Institute for Medical Research
NRC	National Research Council
NSGRP II	National strategy for growth and reduction of poverty
OIs	Opportunistic Infections
PEPFAR/T	President's Emergency Plan for AIDS Relief -Tanzania
PhD	Doctor of Philosophy
REDD	Reducing Emissions from Deforestation and Forest Degradation
RISE-AFNNET	Regional Initiative in Science and Education- African Natural Product Research Network
SCBD	Secretariat of the Convention on Biological Diversity
SDGs	Sustainable Development Goals
TAFORI	Tanzania Forest Research Institute
TB	Tuberculosis
TCAM	Traditional, Complementary and Alternative Medicine
TFS	Tanzania Forest Services Agency
THs	Traditional Healers
UNAIDS	United Nations Programme on HIV and AIDS
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
URT	United Republic of Tanzania

USA	United States of America
WHO	World Health Organisation
WIPO	World Intellectual Property Rights
WWF	World Wildlife Fund

LIST OF PUBLICATIONS

Kibonde, S. F., Augustino, S., Mabiki, F. K. and Mdegela, R. (2018). Ethnobotanical study of medicinal plants used to manage HIV/AIDS opportunistic infections in Rungwe, Mbeya Region, Tanzania. *Journal of Medicinal Plants Research* 12(2): 32-41.

CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 Background Information

In recent years, the role of medicinal plants in enhancing the health of the rural people has become a topical and widely recognized issue (WHO, 2009; Ekor, 2014). In this context there is a growing body of literature related to medicinal plants' contribution to health through reduction of excessive mortality, morbidity and disability due to diseases such as HIV/AIDS, malaria, tuberculosis, diabetes, sickle cell and mental disorders (Kloos *et al.*, 2013; Savina, 2015). However, to what extent the existing medicinal plants are conserved and continuously being identified in our day to day life does not yet have an easily clear road map in many communities.

Medicinal plants include all plants with useful properties which can be used in preventing or managing diseases such as HIV/AIDS and its opportunistic infections (Nwachukwu *et al*., 2010; Shahidullah and Haque, 2015; Verma *et al*., 2015 and Savina, 2015). Some of the common known HIV/AIDS opportunistic infections include but not limited to insomnia, dermatological disorders, Tuberculosis (TB), Herpes zoster (Shingles), Herpes simplex (Genital herpes), Oral candidiasis, and Cryptococcal meningitis (Kisangau *et al.*, 2007; Orisatoki and Oguntibeju, 2010). However, this study was confined to HIV/AIDS opportunistic infections including Tuberculosis (TB), Herpes zoster, Herpes simplex, Oral candidiasis, chronic cough and chronic diarrheal.

The reasons for much reliance on traditional medicine include: its affordability among the poor and/or marginalized rural communities, imbalance of trained doctors and the high rate of population growth among African countries (Rukangira, 2004). Some

studies like that of Aladele and Omobuwajo (2011) have reported that many people's interest in utilizing medicinal plants is influenced by limited access to modern health care systems and have huge amount of trust in traditional medicines in effectively handling modern day life style based diseases such as cancer, diabetes and HIV/AIDS (Batugal *et al*., 2004; Msuya and Kideghesho, 2009; Verma *et al.*, 2015). However, communities use medicinal plants based on their indigenous knowledge about the common existing species in their localities (Abbas *et al*., 2017). Since indigenous knowledge is transmitted from one generation to another, it is obvious that only the former medicinal plants species are maintained while new medicinal plants species necessary for the current health challenges are likely to be depleted unnoticed (Chen *et al*., 2016). In this scenario identification of medicinal plants used to manage HIV/AIDS opportunistic infections existing in the localities especially forests becomes crucial for their sustainability. According to Verma *et al.* (2015), there are thousands of plants known and unknown that yield to medicine. However, the current scenario shows that knowledge of this science is handed over from one generation to another but some of the plants and knowledge of their medicinal value is going down amongst the people and by this way these plants are being neglected.

Indigenous knowledge (IK) of medicinal plants and their use by indigenous cultures are beneficial for conservation of cultural traditions and biodiversity, healthcare and drug development in the present and future day (Tamiru *et al*., 2013). However, it is reported that through destruction of habitats, numerous species are lost from the wild unrecorded (Savina, 2015). Different reasons for the loss of these species have been highlighted by different scholars, they include: pressure and threats due to high rate of anthropogenic activities such as extension of farms, demand for construction materials, and animal grazing. Roberson (2008) and Chen *et al*. (2016), state that the stress which is exerted on

plants like that of deforestation makes about 15 000 medicinal plant species' extinction. As the result the earth is losing one potential major drug every two years. This may in the end become catastrophic to the populations especially in the developing world who rely on these plants (Kasagana and Karumuri, 2011 and Bukuluki *et al*., 2014).

A study by Boafo (2013) highlighted that the rate of deforestation in Africa is estimated to be about 3 000 000 hectares/year. Therefore, identification of other species not only helps for sustainability of the MPs but also it helps in treating other diseases found or prevalent in the developed and developing countries for which no medicines are available or inaccessible (Trivedi, 2009). This study takes into consideration this fact of identifying the available species, indigenous knowledge of conserving them and how this knowledge is influenced by the socioeconomic factors.

The use of medicinal plants for treating various diseases including HIV/AIDS and its opportunistic infections in Tanzania is not new. Current findings reveal that about 60% of the population depend on traditional practitioners as the first point of choice in seeking medical consultation (Nahashon, 2013; Bukuluki *et al.*, 2014; Institute of Traditional Medicine (ITM, 2015). At most, HIV patients are reported to use traditional medicine concurrently with anti-retrovirals (ARVs) (Augustino, 2006; Orisatoki and Oguntibeju, 2010; Chinsembu and Hedimbi, 2010; Bukuluki *et al*., 2014; Chinsembu, 2016). This is why the significance of medicinal plants in the primary health care system within Tanzania is acknowledged in several studies (Kisangau *et al*., 2007; Amri and Kisangau, 2012; Nahashon, 2013; Augustino *et al*., 2014 and Nondo *et al*., 2015).

The importance of medicinal plants to the Tanzanians cannot be over emphasised because various studies such as Langwick (2008) who said nowhere in Tanzania where

modern medicine has been able to cater for the health needs of the entire population. Similarly, ITM (2015) expresses that traditional healers are the first, among health providers, to be consulted by patients due to many challenges including the existing imbalance of the ratio of medical service providers to the patients. By 2011, the ratio of doctor-patient in Tanzania was about 1:20 000 (WHO, 2009). Goodell *et al*. (2016) reveal similar findings that the ratio of physicians to patients by 2012 was 1:30 000. Generally, the country has lower ratio of doctors to patients than the WHO recommended ratio of 1:1000 (Deo, 2016). With regards to traditional healer services in Tanzania, a study by Wenzel (2011) and ITM (2015) reveal that there is one traditional medicine practitioner for every 350 to 450 people. These reports confirm the importance of traditional medicine and traditional practitioners to the majority of Tanzanians. Despite the extensive experiences on the usefulness of medicinal plants in traditional medicine, Tanzania is reported to lose 400 000 ha per annum due to anthropogenic activities as it is the case in other countries (Kideghesho, 2015; Fernqvist, 2016; Francis *et al*., 2016; URT, 2016; Drakenberg *et al*., 2016; AfDB, 2016).

To overcome these challenges, Tanzania has taken some measures towards biodiversity conservation initiatives. For example, the country is a member of the Convention on Biological Diversity (CBD) of 1992 after ratifying it in 1996. The measure has made the country a fully-fledged member to the convention in response to the international obligations of protecting and conserving biodiversity as a global resource. At the national level, a functional policy and legislative framework ensure international, regional and national obligations are met at all levels. To fulfil these requirements, the National Biodiversity Strategy and Action Plan (NBSAP), which provides guidance towards the realisation and promotion of sustainable utilisation and conservation of biodiversity in general, was established in 2001 (URT, 2015). However, in view of the importance,

medicinal plant species especially those dealing with HIV/AIDS opportunistic infections require not only specific conservation framework than what is existing now to ensure sustainability of these medicinal plant species, but also integrated conservation efforts of medicinal plants to save lives of the majority of people living with HIV/AIDS. Statistics show that in 2011 about 1.6 million people lived with HIV/AIDS in Tanzania, and majority of these were in the productive and reproductive age (Kassile *et al*., 2014). Recent reports show that there were about 1.4 million people in Tanzania who were living with HIV in 2015 (UNAIDS, 2017) with the annual prevalence rate of 4.7%. In the same year, there were about 54 000 new cases of people with HIV/AIDS, and among these, 36 000 died of HIV/AIDS opportunistic diseases.

This study was conducted in Rungwe District because the district is reported to have the HIV prevalence rate of about 9.1% which is higher than the nation rate of 5% (PEPFAR/T, 2016). However, only 0.3% density of health facilities has been allocated to serve people living with HIV/AIDS in the District (NIMR, 2011). Fortunately, the District is rich in plant resources and many of these are claimed to be medicinal (URT, 2011; Tilumanywa, 2013; Ndyamkama *et al*., 2013; Maregesi and Mwakalukwa, 2015). However, the exact species that are used to manage HIV/AIDS opportunistic infections are scantly documented. At the same time most important medicinal plants are within the reserves which are threatened by anthropogenic activities. The effect means even those deemed useful in managing HIV/AIDS opportunistic infections are likely to be threatened. In this regard, medicinal plants deserve urgent attention to ensure that their conservation is accorded high priority by all stakeholders including local communities in the district. Therefore, this study was set to identify and assess conservation status of medicinal plants which are used in managing HIV/AIDS and its opportunistic infections in Rungwe district, Mbeya Region-Tanzania. To achieve this general objective, the study

thought to answer the following questions (i) What are the available medicinal plant species used for managing HIV/AIDS opportunistic infections? (ii) How knowledgeable are the people on conservation of medicinal plants for managing HIV/AIDS opportunistic infections? (iii) What is the population status of the priority medicinal plants for managing HIV/ AIDS opportunistic infections in the study area? and then (iv) How conservation framework could be developed and put in place to manage medicinal plants to suit conservation of priority medicinal plants for managing HIV/AIDS opportunistic infections in the study area?

1.2 Statement of the Problem

There has been a continuous acknowledgement of the important roles played by medicinal plants in managing HIV/AIDS opportunistic infections worldwide and Rungwe district in particular. However, conservation status of medicinal plant species is uncertain. Tanzania has taken various measures to ensure medicinal plants are conserved among measures taken include establishment of institution responsible for international trade in medicinal plants, participatory forest management framework, establishment of Forest Act of 2002 which provides a legal basis for communities, groups and individuals to own, manage or co-manage forests and establishment of National Biodiversity Strategy and Action Plan (URT, 2001; ProFound, 2014). Although these measures have been put in place yet, majority of potential medicinal plants are being neglected and some depleted in the forests and such situation cannot be ignored (Kideghesho, 2015). Tanzania is has experiencing increased loss of important species which is caused by deforestation and trading (Msuya and Kideghesho, 2009). As the case in Rungwe, despite the usefulness of medicinal plants in managing HIV/AIDS opportunistic infections among communities, the conservation status of the medicinal plant species used for that purpose is uncertain. There is insufficient documentation of species of

medicinal plants used to manage HIV/AIDS opportunistic infections including the indigenous knowledge of conserving medicinal plants in the district. Nonetheless, the population status of medicinal plant species has not been assessed. Lastly, the existing conservation framework for medicinal plant species in Rungwe is lacking. Therefore, this study aimed to assess the conservation status medicinal plant species in the study area. Specifically, the study first, identified and documented the available medicinal plant species used for managing HIV/AIDS opportunistic infections, secondly, the study explored available indigenous knowledge on conservation of medicinal plants, thirdly, the study assessed the population status of priority medicinal plant species and fourthly, developed and proposed a conservation framework necessary to suit the medicinal plant species in the study area and outside.

1.3 Significance of the Study

This study is important as the results provide additional information from which the country's health sector could develop novel drugs. For the revealed indigenous knowledge, the conservationists will be furnished with basic information to be integrated into scientific conservation plans of medicinal plants. Moreover, information on population status of medicinal plants informs the environmentalists and other policy makers of what is taking place in the forest for action. The need of the conservation framework will not only contribute to the process of formulating conservation policies but also act as a stimulating factor for community-based natural resource conservation. Generally, conservation framework serves as a tool of ensuring sustainability of the valuable medicinal plant species and hence improving the health as well as the livelihood of people who depend on them in the country.

The study is in line with the National Health Policy of 2017, in recognizing indigenous knowledge and traditional medical practices and the development vision 2025 which emphasizes on, among other things, the role and the need of sustainably using and conserving medicinal plants. Also, the study is in line with the Regional Initiative of Science and Education- African Natural Product Research Network (RISE-AFNNET) which promotes among others, conservation and value addition on natural products in Africa**.**

1.4 Objectives of the Study

1.4.1 Overall objective

The overall objective of this study was to assess the conservation status of medicinal plants used in managing HIV/AIDS opportunistic infections in Rungwe District, Mbeya Region, Tanzania.

1.4.2 Specific objectives

Specifically, the study was designed to do the following:

i. To identify and document medicinal plant species used for managing HIV/AIDS opportunistic infections in the study area.
ii. To explore indigenous knowledge of conserving medicinal plants for managing HIV/AIDS opportunistic infections in the study area.
iii. To assess the population status of the selected priority medicinal plants for managing HIV/AIDS opportunistic infection in the study area, and
iv. To develop conservation framework for priority medicinal plant species in the study area.

1.4.3 Research questions

The study was guided by the following key questions:

i. What are the medicinal plants used to manage HIV/AIDS opportunistic infections in their area?
ii. How knowledgeable are the people on conservation of medicinal plants for managing HIV/AIDS opportunistic infections?
iii. What is the population status of the priority medicinal plants for managing HIV/ AIDS opportunistic infections in the study area?
iv. What could be the conservation framework to assist in preserving the medicinal plants in the study area?

1.5 Theoretical Frameworks

The theoretical foundation of this study relies on the fact that globally plants are the major sources of traditional medicines. In this case, people prefer to use medicinal plants because they are assumed to be freely and indefinitely available (Savina, 2015). This is why despite the increase in the use of medicinal plants; concerted efforts of ensuring their sustainability are minimal. Coupled with the present and projected climate variability and change, there is explosion of human population resulting in the expansion of farm lands for more plant goods and services but on the expense of medicinal plants (Mwakosya and Mligo, 2016). The fact that every two years the world loses one potential medicinal plant, indicates that the health of millions of people especially those living with HIV/AIDS is at risk (Edwards, 2009 and Chen *et al*., 2016). There is a need of promoting the conservation of medicinal plant species to curb the threats of extinction. In addressing this problem, this study reviewed two theories namely; Island Biogeography (IBT) and the Knowledge-practice-belief system.

1.5.1 The Theory of Island Biogeography (IBT)

As human destruction of natural resources increase, biologists and conservationists have thought of reserving more areas for what is regarded as endangered species. Theories which are crucial in giving conservation concepts to practitioners have been formulated to guide these management strategies. Thus, MacArthur and Wilson (1967) developed the IBT that has been responsible for the formation of reserves in the form of islands inside human impacted landscapes. The reserves are regarded as conservation tools (Williams, 1984; Triantis and Bhagwat, 2011), because they are protected from human interference, except for tourism activities, research and education purposes. This theory links to the evolution of forest reserves in countries such as Tanzania. Through guidelines provided in the theory, the reserved patches of plants have rescued some species of interests from threats of extinction although medicinal plants are not prioritized. As it is the case with national parks and nature reserves, which are preserved for conspicuous species, there is a need of having such arrangement for priority medicinal plant species. The theory of island biogeography is adopted in this study and is used to explain the presence of nature and forest reserves in the study area.

1.5.2 Theory of knowledge-practice-belief system

This theory by Gadgil *et al*. (1993) explains about people and their long time resource-use practices; which then provide them with a broad knowledge base of the behaviour of multifaceted ecological systems in their own localities. According to the theory, local people are well aware of their dependence on biological diversity for their livelihood including medicine. Their reliance on the environment compels them to manage and conserve resources for future use. Their biodiversity conservation practices are grounded in a series of rules of thumb which are apparently derived through a trial and error process over a long historical time period. This theory justifies the need for the

recognition of people's knowledge in the ecosystems and biodiversity sustainable management. Conserving traditions of the community would be most appropriately accomplished through promoting the community-based resource-management systems.

1.6 Conceptual Framework

The conceptual framework for this study draws on two theories namely; Theory of Island Biogeography (IBT) and Theory of knowledge-practice-belief system as detailed in section 1.5. The main assumption of IBT is that forest reserves should be gazetted and conserved. While the Theory of knowledge practice-beliefs assumes that as far as people live in their localities with different resources use and practice, they are likely to accumulate potential skills related with biological dependence and diversity. Therefore, this study extends on the two theories to explain the relationships and interrelationships among variables so as to arrive at the main objective which is conservation of medicinal plants for managing HIV/AIDS opportunistic infections. It shows the process of identifying species that are in use with their related attributes such as: how many species in total were identified, from what plant families do they belong, from which plant parts is the medicine obtained, and what are the life forms of these plants. The knowledge people hold towards conservation of medicinal plants in their locality is confirmed by Theory of knowledge practice beliefs to play an important role on conservation practices as influenced by experience and belief systems. It also shows how socio-demographic characteristics relate with an individual's knowledge on conservation. This is because knowledge determines the population status of the medicinal plants in the study area as knowledge that people hold towards conservation correlates with the situation in the field. The prioritization of the conceived important species from the total species also is an important aspect because the prioritized species population were assessed for their structure, density and distribution pattern in the Poroto forest reserve. Since

anthropogenic activities such as agriculture, over grazing, logging and timber extraction seem to affect the sustainability of both species, and then the need for suitable conservation framework becomes crucial. However, for the developed conservation framework to work smoothly, there must be enabling polices to govern the process. By doing so it is expected that improved medicinal plants population status, ensured availability of medicinal plants and improved management of HIV/AIDS opportunistic infections will be achieved (Fig. 1.1).

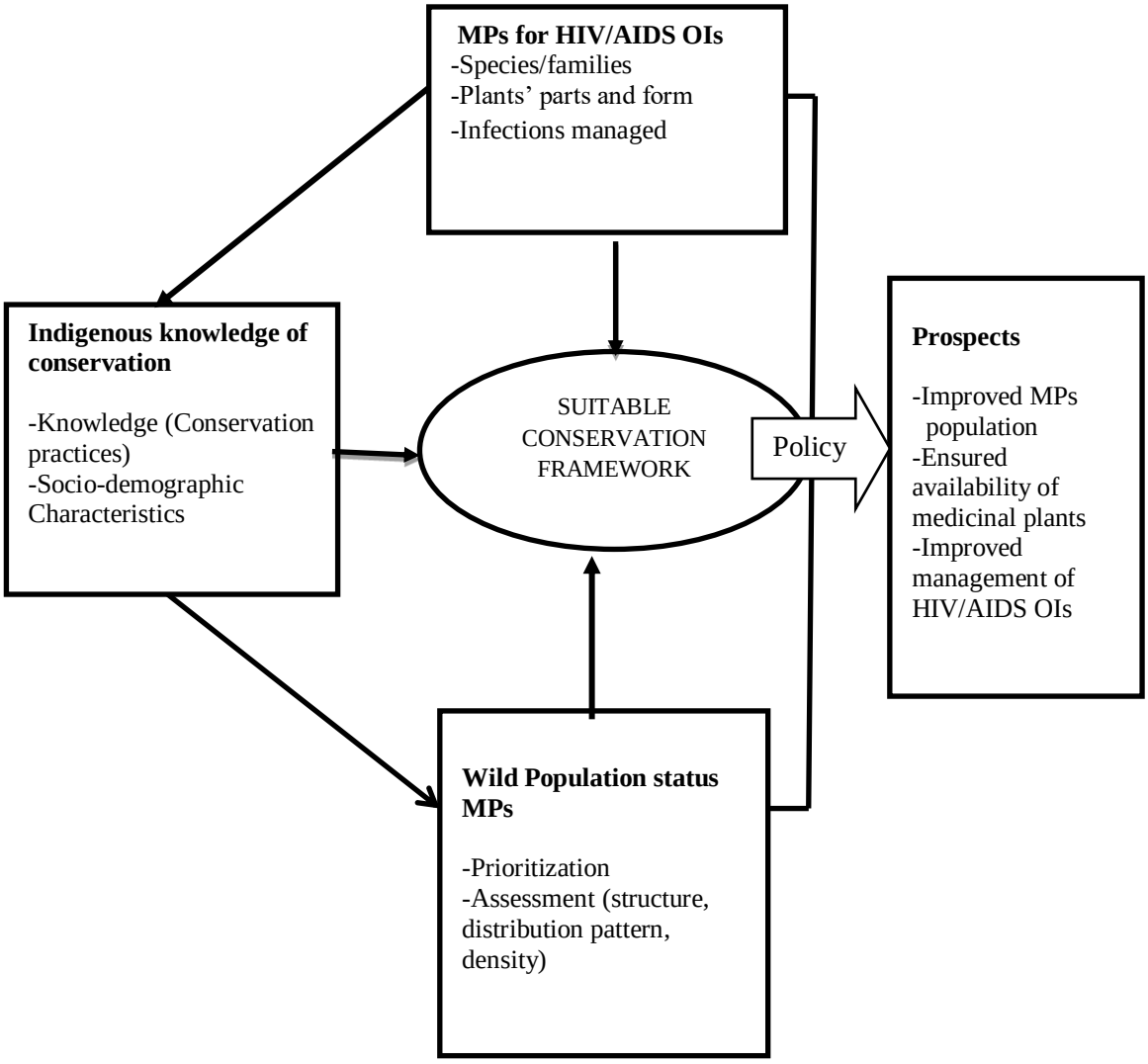

Figure 1.1: Conceptual framework for assessing conservation status of medicinal plants for managing HIV/AIDS OIs in Rungwe District

1.7 Limitations of the Study

The researcher was encountered with the following limiting factors:

First, the nature of the study demanded the researcher to deal with HIV/AIDS patients and traditional health practitioners, both being considered as hidden groups from which under certain circumstances it was difficult to verify the gathered information. But, this limitation was controlled by the use of volunteers of home based care for the patients. To overcome, the problem of getting information from traditional practitioners, the researcher convinced them through declaring that the study had no intention of utilizing their knowledge for any other benefit apart from academics.

The second limitation was inaccessibility to some areas such as villages being located around the forests with difficulties in terms of access due poor roads. For example, Ngumbulu village is far away and can only be reached using motorcycle transport. The researcher and the assistants used motorcycles to reach the village and managed to collect data.

1.8 Ethical Approval

Ethical approval to carry out this research was obtained from the ethical review committee of the National Institute for Medical Research (NIMR) of Tanzania. Besides, the study participants were asked for consent and their information were maintained confidential by the researcher.

1.9 Structure of the Thesis

This thesis is organized in form of publishable manuscripts format where each manuscript represents its own chapter. The thesis consists of six chapters; Chapters two to five are made up of four manuscripts developed from the entire study. In the first

chapter the background of the study followed by the statement of the research problem and justification of the study are presented. This is followed by the presentation of general, specific objectives as well as the major study questions and the theoretical and conceptual framework which guided the study.

The first manuscript covering objective one is presented in chapter two. The manuscript identifies a variety of medicinal plants which are commonly used to manage HIV/AIDS opportunistic infections in the study area as well as fidelity index ranking for every species used in managing the conditions and the documentation of the medicinal plant species which are commonly used to manage HIV/AIDS opportunistic infections in the study area. Chapter three presents the second manuscript that explores indigenous knowledge on the conservation of medicinal plants for managing HIV/AIDS opportunistic infections in the study area. Different conservation practices were covered in this manuscript.

Chapter four is a third manuscript that covers the population status of the selected priority medicinal plants which are used to manage HIV/AIDS opportunistic infections in Poroto forest reserve. Chapter five comprises the manuscript on development of conservation framework. Chapter six presents the overall conclusion and recommendations. The chapter draws conclusion from the previous chapters and provides recommendations for policy makers, conservationists, and medical professional. Lastly the chapter presents recommendations for further research.

References

Abbas, Z., Khan, S. M., Alam, J., Khan, S. W. and Abbasi, M. S. (2017). Medicinal plants used by inhabitants of the Shigar Valley, Baltistan region of Karakorum range-Pakistan. *Journal of Ethnobiology and Ethnomedicine* 2017: 13-53.

African Development Bank Group. (2016). $REDD^{+}$ in Africa context, challenges and next steps of $REDD^{+}$ mechanisms in the continent. 8pp.

Amri, E. and Kisangau, D. P. (2012). Ethnomedicinal study of plants used in villages around Kimboza forest reserve in Morogoro, Tanzania. *Journal of Ethnobiology and Ethnomedicine* 8(1): 1-9.

Augustino, S. (2006). Medicinal Plant Resources of Urumwa, Tabora region, Tanzania: Thesis for Award of Doctor of Philosophy Degree at University of Wales, Bangor. 270pp.

Augustino, S., Hall, J. B., Makonda F. B. S. and Ishengoma R. C. (2014). Medicinal plant parts and practices used by communities around the Miombo woodlands of Urumwa, Tanzania. *Journal of Medicinal Plant Research* 8(15): 599–606.

Augustino, S. and Gillah, P. R. (2015). Medicinal Plants in Urban Districts of Tanzania: Plants, Gender Roles and Sustainable Use. 13pp. Available at: [https://www. researchgate. net/publication] site visited on 26/2/2017.

Batugal, P. A, Jayashree, K., Lee, S. Y. and Jeffrey, T. O. (eds). (2004). *Medicinal Plants Research in Asia*, Volume 1: The Framework and Project Workplans. International Plant Genetic Resources Institute. 221pp.

Boafo, J. (2013). The impact of deforestation on forest livelihoods in Ghana. Africa Portal a project of the Africa initiative: 6pp. Available at [www.africaportal.org backgrounder No. 49 January 2013] site visited on 26/22/2017.

Bukuluki, P., Luwangula, R. and Walakira, E. J. (2014). Harvesting of Medicinal Plants in Uganda: Practices, Conservation and Implications for Sustainability of Supplies. *International Journal of Medicinal Plant Research* 3(1): 1–10.

Chen, S. L., Yu, H., Luo, H. M., Wu, Q., Li, C. F. and Steinmetz, A. (2016). Conservation and sustainable use of medicinal plants, problems, progress and prospects. *Chinese Medicine* 11(37): 1–10.

Chinsembu, K. C. and Hedimbi, M. (2010). An ethnobotanical survey of plants used to manage HIV/AIDS opportunistic infections in Katima Mulilo, Caprivi region, Namibia. *Journal of Ethnobiology and Ethnomedicine* 6(1): 1-25.

Chinsembu, K. C. (2016). Ethnobotanical Study of Plants Used in the Management of HIV/AIDS-Related Diseases in Livingstone, Southern Province, Zambia. *Evidence-Based Complementary and Alternative Medicine* 2016: 1–14.

Deo, M. G. (2016). Time to Revisit Recommendations on Doctor to Population Ratio in India. *Journal of The Association of Physicians of India* 64: 1-3.

Drakenberg, O., Göran, E. K. and Fernqvist, K. W. (2016). Environmental and Climate Change Policy Brief Tanzania. 30pp.

Edwards, R. (2009). Medicinal plants on verge of extinction. New Scientist. [Available at: https://www.newscientist.com/article/mg20126903.200-medicinal plants-on-verge-of-extinction/] site visited on 26/2/2017.

Ekor, M. (2014). The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. *Frontiers in Neurology* 2014: 1–10.

Fernqvist, K. W. (2016). Environmental and Climate Change Policy Brief Tanzania. Tanzania Country Climate Change Risk Assessment Report. 46pp.

Francis, J., Edwin, K., Abiud, N. and Freddy, K. (2016). International Journal of Asian Social Science Analysis of Drivers and Agents of Deforestation and Forest

Degradation in Masito Forests, Kigoma, Tanzania Contribution/ Originality. *International Journal of Asian Social Science* 6(2): 93–107.

Gadgil, M., Berkes, F. and Folke, C. (1993). Indigenous Knowledge for Biodiversity Conservation. *Ambio* 22(2–3): 151–156.

Goodell, A. J., Kahn, J. G., Ndeki, S. S., Kaale, E., Kaaya, E. E. and Macfarlane, S. B. J. (2016). Modeling solutions to Tanzania's physician workforce challenge. *Global Health Action* 2016(9): 1-11.

Kasagana, V. N. and Karumuri, S. S. (2011). Conservation Of Medicinal Plants (Past, Present and Future Trends). *Journal of Pharmaceutical Sciences and Research* 3(8): 1378–1386.

Kassile, T., Anicetus, H., Kukula, R. and Mmbando, B. P. (2014). Health and social support services to HIV/AIDS infected individuals in Tanzania : employees and employers perceptions. *BMC Public Health* 14(630): 1–9.

Kayombo, E. J. (2013). Indigenous Knowledge and HIV/AIDS Prevention and Management in Local Communities in Africa South of the Sahara. *Pharmaceut Anal Acta* 4(204): 1-5.

Kideghesho, J. R. (2015). Realities on Deforestation in Tanzania — Trends, Drivers, Implications and the Way Forward [http://dx.doi.org/10.5772/61002] site visited on 27/8/2016.

Kisangau, D. P., Lyaruu, H. V. M., Hosea, K. M. and Joseph, C. C. (2007). Use of traditional medicines in the management of HIV/AIDS opportunistic infections in Tanzania: a case in the Bukoba rural district. *Journal of Ethnobiology and Ethnomedicine* 3(1): 1-9.

Kisangau, D. P., Herrmann, T. M., Lyaruu, H. V. M., Hosea, K. M., Joseph, C. C., Mbwambo, Z. H. and Masimba, P. J. (2011). Traditional Knowledge, Use

Practices and Conservation of Medicinal Plants for HIV/AIDS Care in Rural Tanzania. *Ethnobotany Research and Applications* 9: 043-057.

Kloos, H., Mariam, D. H., Kaba, M. and Getnet Tadele, G. (2013). Traditional medicine and HIV/AIDS in Ethiopia: Herbal medicine and faith healing: A Review. *Ethiop. J. Health Dev.* 27(2): 141-155.

Langwick, S. A. (2008). Articulate(d) bodies: Traditional medicine in a Tanzanian hospital. *American Ethnologist* 35(3): 428–439.

MacArthur and Wilson. (1967). *Island Biogeography*.Princeton University Press, Princeton: 224pp.

Maregesi, S. M. and Mwakalukwa, R. (2015). Ethnopharmacological Study on Medicinal Plants used to treat infectious diseases in the Rungwe District, Tanzania. *International Journal of Medicinal Plants and Natural Products* 1(3): 15–22.

Msuya, T. S. and Kideghesho, J. R. (2009). The role of traditional management practices in enhancing sustainable use and conservation of medicinal plants in West Usambara Mountains. *Open Access Journal-Tropical Conservation Science* 2(1): 88–105.

Institute of Traditional Medicine (2015). Muhimbili University of Health and Allied Sciences.

Mwakosya, J. and Mligo, C. (2016). The impacts of disturbance on plant species composition in.*African Journal of Science and Research* 1(5): 47–56.

Nahashon, M. (2013). Conservation of Wild-harvested Medicinal Plant Species in Tanzania Conservation of Wild-harvested Medicinal Plant Species in Tanzania. Thesis for Award of Master at Uppsala University, Uppsala: 67 pp.

National Institute for Medical Research (2010). NIMR at 30 : History, Development, Achievements and Success Stories. October, Vol. 30.

Ndyamkama, M. W., Mutabazi, K. and Silayo, D. A. (2013). Economic Implication of REDD^{+} Initiative on Food Security of Farmers in Rungwe District, Tanzania. *In Proceedings of the International Conference on Reducing Climate Change Challenges Through Forestry and Other Land Use Practices* 1: 1-24.

Nondo, R. S. O., Moshi, M. J., Erasto, P., Zofou, D., Njouendou, A. J., Wanji, S. and Titanji, V. P. K. (2015). Evaluation of the cytotoxic activity of extracts from medicinal plants used for the treatment of malaria in Kagera and Lindi regions, Tanzania. *Journal of Applied Pharmaceutical Science* 5(04): 7–12.

Nwachukwu C. U., Umeh C. N. and Kalu I. G. (2010). Identification and traditional uses of some common medicinal plants in Ezinihitte Mbaise L.G.A. of Imo State, Nigeria. Report and Opinion 2010 2(6): 1-8.

Oladele, A. T., Alade, G. O. and Omobuwajo, O. R. (2011). Medicinal plants conservation and cultivation by traditional medicine practitioners (TMPs) in Aiyedaade Local Government Area of Osun State, Nigeria. *Agriculture and Biology Journal of North America* 2(3): 476–487.

Orisatoki, R. O. and Oguntibeju, O. O. (2010). The role of Herbal Medicine use in HIV / AIDS treatment. *IMedPub Journals* 1(3): 1–4.

ProFound (2014). Wild-Collected Botanicals and the EU market. 112 pp. Available at [http://www.This Is ProFound. com] site visited on 30/05/2016.

Roberson, E. (2008). Nature's Pharmacy, Our Treasure Chest: Why We Must Conserve Our Natural Heritage, A Native Plant Conservation Campaign Report: 16pp.

Rukangira, E. (2004). Medicinal Plants and Traditional Medicine in Africa. Constraints and Challenges. Sustainable Development International. 179-184.

Savina, A. (2015). Nutri-medicinal plants used in the management of HIV/AIDS opportunistic infections in western Uganda: documentation, phytochemistry and bioactivity evaluation. Thesis for Award of Doctor of Philosophy Degree

at Royal Institute of Technology, SE-100 44 Stockholm, Sweden. 81pp.

Shahidullah, A. K. M. and Haque, C. E. (2015). Medicinal Plants Conservation Strategies for Primary-Healthcare and Livelihood at Local Level. An Examination of Initiatives in South Asia. *Springer Science+Business Media Dordrecht* 1: 74–111.

Smith-Hall, C., Larsen, H. O. and Pouliot, M. (2012). People, plants and health: a conceptual framework for assessing changes in medicinal plant consumption. *Journal of Ethnobiology and Ethnomedicine* 8: 1-43.

Tarimo, G. B. (2012). Delay in seeking care among Tuberculosis patients attending Tuberculosis clinics in Rungwe District, Tanzania. **T**hesis submitted for the Award of Master of Public Health at Muhimbili University of Health and Allied Sciences, Tanzania. 71pp.

Tamiru, F., Terfa, W., Kebede, E., Darbessa, G., Kumar, R. R. and Sorsa, M. (2013). Ethnoknowledge of plants used in veterinary practices in Dabo Hana District, West Ethiopia. *J. Med. Plant. Res.* 7(40): 2960-2971.

Tilumanywa, V. T. (2013). Land use and Livelihood changes in the Mount Rungwe Ecosystem, Tanzania. Thesis for Award of Doctor of Philosophy Degree at Stellenbosch University, Stellenbosch. 272pp.

Triantis, K. A. and Bhagwat, S. A. (2011). Applied Island Biogeography. In; Richard Ladle., Robert J. and Whittaker, R. J. (Ed.), *Conservation Biogeography*. Blackwell Publishing Ltd: 320 pp.

Trivedi, P. C. (2009). Medicinal Plants Utilization and Conservation 2nd Revised and Enlarged Edition. **A**avishkar Publishers, Distributors 807, Vyas Building, Chaura Rasta, India: 542pp.

United Nations Programme on HIV and AIDS (2017). HIV and AIDS in Tanzania. 11pp.

United Republic of Tanzania (2016a). President's Emergency Plan for AIDS

Relief/Tanzania. Data for Local Impact Innovation Challenge. Available at: [https://reliefweb.int/report/world/pepfar-innovation-challenge-reduce-hivaids-africa-awards-aiddata-two-year-project] Site visited on 24/11/2017.

United Republic of Tanzania (2016b). President's Emergency Plan for AIDS Relief/ Tanzania. Country Operational Plan (COP) 2016 Strategic Direction Summary. 75pp. Available at [https://tz.usembassy.gov/wp-content/uploads/sites/258/2017/07/TZ-COP-2017-SDS-FINAL-Update-29June2017.pdf] Site visited on 1/9/2018.

United Republic of Tanzania, Ministry of Natural Resources and Tourism (2011). Management Plan for Mount Rungwe Nature Reserve 2011/12 to 2015/16: 150pp.

United Republic of Tanzania (2001). National Biodiversity Strategy and Action Plan. 148pp.

United Republic of Tanzania (2016). Tanzania's Forest reference emission level submission to the UNFCCC. 32pp.

Verma, A. C., Hingora, I. and Namratadubey, S. (2015). Identification and Traditional uses of certain Medicinal Plants and its Conservation in Kawardha area, Chhattisgarh State, India. *Journal of Environmental Science, Toxicology and Food Technology* 1(1): 6–20.

Wenzel, T. L. (2011). Western and Traditional Medicine Use Practices in Shirati, Tanzania. *Spring* 2011: 1-17.

Williams, G. R. (1984). Has Island Biogeography Theory any relevance to the design of biological reserves in New Zealand ? *Journal of the Royal Society of New Zealand* 4(1): 1869-1971.

World Health Organization (2009). *Selected Medicinal Plants* (Vol. 4): 456pp.

CHAPTER TWO

2.0 Ethnobotanical study of medicinal plants used to manage HIV/AIDS opportunistic infections in Rungwe, Mbeya Region, Tanzania

Vol. 12(2), pp. 32-41, 10 January, 2018 DOI: 10.5897/JMPR2017.6476

Article Number: 674B41C55605 ISSN 1996-0875 Copyright © 2018

http://www.academicjournals.org/JMPR

Journal of Medicinal Plants Research

Full Length Research Paper

CHAPTER THREE

3.0 Indigenous knowledge of conserving medicinal plants for managing HIV/AIDS opportunistic infections in Rungwe District, Tanzania

Suma F. Kibonde[1*], Suzana Augustino[2], Faith P. Mabiki[3], and Robinson Mdegela[4]

[1] Department of Geography and Environmental Studies, Solomon Mahlangu College of Science and Education, Sokoine University of Agriculture, P.O. Box 3038, Chuo Kikuu, Morogoro, Tanzania

[2] Department of Forest Engineering and Wood Sciences, College of Forestry, Wildlife and Tourism, Sokoine University of Agriculture, P.O. Box 3014 Chuo Kikuu,Morogoro, Tanzania

[3] Department of Chemistry and Physics, Solomon Mahlangu College of Science and Education, Sokoine University of Agriculture, P.O. Box 3038, Chuo Kikuu, Morogoro, Tanzania

[4]Department of Public Health, College of Veterinary and Biomedical Sciences Sokoine University of Agriculture, P.O. Box 3021 - Chuo Kikuu, Morogoro, Tanzania

[*]Corresponding author:kibondesuma9@yahoo.com

3.1 Abstract

Indigenous knowledge and its role on conservation has been widely recognised in literature. However, little has been done to search for indigenous knowledge of conserving medicinal plants in Rungwe. This study aimed at exploring the indigenous knowledge on conservation of medicinal plants used in managing HIV/AIDS opportunistic infections in Rungwe District, Mbeya Region, Tanzania. To achieve this objective, the study firstly documented the possessed indigenous knowledge on conservation of medicinal plants used to manage HIV/AIDS opportunistic infections, secondly the study established the influence of social-demographic characteristics on

indigenous knowledge of conserving medicinal plant species in the study area. The study was guided by the Knowledge-practice-belief system theory. A total of 293 households were randomly sampled and data were collected using semi-structured questionnaire. Descriptive and inferential statistics were used to analyse the responses with respect to indigenous knowledge on conservation of medicinal plant species. Up to nine indigenous conservation practices were documented in the study area including: selective harvesting, domestication, sacredness of plants/forests, secrecy of use and location for medicinal plant species, collection of only dead/fallen wood, selective morals of the harvester, the use of local energy saving stoves and restrictive time and seasons to harvest medicinal plant species. Results revealed that selective harvesting of medicinal plant parts was popular by 94% of the respondents, followed by domestication of medicinal plant species (84%). The least scored practice was restrictive times and seasons for harvesting (57%). The study findings indicated that adults revealed significantly higher knowledge than youth ($p=0.002$) and the knowledge was significantly higher among male respondents than females ($p=0.031$). Conclusively, the respondents showed to possess sound indigenous knowledge on conservation and their knowledge varied based on their socio-demographic attributes. In view of these findings, the study recommends for preservation and promotion of indigenous knowledge of conservation across the community. Likewise, there is a need to transmitting of the indigenous knowledge on conservation by the elders to the youth.

Key words: Conservation, indigenous knowledge, sacred forest, conservation strategy

Targeted journal: International Journal of Biodiversity and Conservation

3.2 Background Information

The role played by indigenous knowledge on the conservation of medicinal plants is well acknowledged in Tanzania (Gadgil et al., 1993; Mokuku and Mokuku, 2004; Msuya and Kideghesho, 2009; Nimachow et al., 2010). Several studies argue that conservation of medicinal plants should be a community centred through using their experiences that have been developed and transmitted over time involving verbal expressions and valuable practices on sustainable conservation of medicinal plants.

Traditional medicines are believed to be the most affordable solution for about 80% of the world's population as well as 75% of people living with HIV/AIDS in Africa (WHO, 2003; Mahomoodally et al., 2004). In Tanzania, traditional medicine serves up to 60% of primary healthcare (Tabuti et al., 2012; Bukuluki et al., 2014). According to Anyangwe and Mtonga (2007) Africa bears more than 24% of the worldwide burden of diseases, with only 3% of the health workers; and less than 1% of finance invested in health matters.

The imbalance ratio of medical doctors to the population in Africa is one of the factors that promote the use of traditional medicine. For example, by 2010, the ratio of medical doctors to population was 1:40 000 while that of traditional healers to population was 1: 500 (WHO, 2013; Meremo et al., 2016). The recent data indicate that about 44% of WHO member states have less than one doctor per 1 000 population (WHO, 2015). Other factors that promote the use of traditional medicines include perceived effectiveness of traditional medicine in dealing with infections and/ or diseases, cultural preferences by communities and belief that traditional medicine can easily offset side effects caused by using Antiretroviral therapies (Orisatoki and Oguntibeju, 2010; Chinsembu, 2016).

In this view, integration of the indigenous knowledge on conservation of medicinal plants for managing HIV/AIDS opportunistic infections is paramount. This is due to the fact that reliance on plants for disease management and other livelihood strategies leave plants prone to depletion and extinction which in turn will cause misery to the large percentage of rural people who depend on them (Kasagana and Karumuri, 2011; Bukuluki et al., 2014). According to Roberson (2008) and Chen et al. (2016), about 15 000 medicinal plant species worldwide are under threats of extinction, implying that the earth loses at least one potential major drug species every two years.

Other factors contributing to medicinal plants depletion include deforestation, which in Africa is reported by Boafo (2013) to be about 3 000 000 hectares/year. Tanzania in particular loses up to 150 000 hectares of forests annually (FAO, 2010). As most medicinal plant species are mostly found in the wild (Nahashon, 2013), thus, conservation measures are urgently needed.

In addressing conservation challenges, different sets of recommendations have been drawn. They include calling international conferences at Chiang Mai, Thailand, in 1988 and Bangalore, India, in 1998 (Hamilton, 2004) which draw recommendations on in-situ and ex-situ strategies and inclusion of community and gender perspectives in the development of policies and programs. Other recommendations include: the need for more information on the medicinal plant trade, the establishment of systems for inventorying and monitoring the status of medicinal plants and the development of sustainable harvesting practices (Hamilton, 2004). However, little has been achieved on these recommendations especially in the field of medicinal plants because of the likely limited inclusion of indigenous knowledge.

This study addresses the knowledge gap surrounding the use of indigenous knowledge on conservation of medicinal plants to ensure their sustainability. In achieving this objective, the study borrows World Intellectual Property Rights (WIPO, 2005)' concepts such as: the traditional knowhow, innovations, information, practices and skills in its uses of the term indigenous knowledge.

3.3 Theoretical Framework

This study was guided by Knowledge-practice-belief systems Theory (Gadgil et al., 1993). In this regard, knowledge is defined by many options including practices or strategies as well as belief systems that help conserve certain species (Nimachow et al., 2011). In other words, the community has some beliefs and traditions that serve as recipes for sustainable utilization of biodiversity such as medicinal plants. These beliefs and traditions have been preserved as knowledge and practices of conservation among communities (Gadgil et al., 1993). Moreover, the theory explains about complex relationships of knowledge, management practices and beliefs existing in the communities thereof.

3.4 Methodology

3.4.1 Study area

This study was conducted in Rungwe District, Mbeya Region, Tanzania. The district was selected because it is among the districts in the country endowed with rich natural resources such as many forests in which medicinal plants are found. The District is one among other areas which are affected by HIV/AIDS and people use medicinal plants for their primary health care including treatment of opportunistic infections. Therefore, through their interaction with the environmental resources they have developed a particular inherent knowledge towards conservation of natural resources.

3.4.2 Research design and sampling techniques

This study adopted a cross section research design in which data were collected once in a time. According to literature the design is helpful in the gathering data on health attributes of the population using various data collection methods such as questionnaire, interviews, and field observations (Driscoll et al., 2007; Carlson and Morrison, 2009; Sedgwick, 2014; Meremo et al., 2016). Data were collected from 293 respondents at households (5.2%) which are considered adequate for such kind of studies (Boyde *et al.*, 1984). The respondents were obtained through random sampling technique to ensure equal representation of the sample.

3.4.3 Data collection methods

Data were collected by means of semi-structured questionnaire composed of both closed and open-ended questions to collect quantitative information such as socio-demographic characteristics and indigenous knowledge on conservation; while focus group discussions (FGDs) and key informant interviews were used to collect qualitative data for information triangulation. A total of two FGDs were conducted in two villages whereby each group was comprised by 8 participants and the criteria for selecting them were a person has sound knowledge on medicinal plants and or a person who is involving in traditional medicines. The key informants' interview involved village leaders whereby seven participants were interviewed in this study.

3.4.4 Data analysis

Descriptive statistics were used to analyse the responses regarding indigenous knowledge on conserving medicinal plants. To explore the conservation knowledge of the community, the respondents were required to show their level of agreement on the nine statements based on five responses "Strongly agree, agree, strongly disagree,

disagree and neutral". To establish the relationship between demographic parameters and the level of knowledge on conservation of medicinal plants individual score was established based on nine statements of Likert scale. The total scores were used as the proxy for the level of knowledge regarding conservation of medicinal plants. Based on the nine Likert scale statements the cut off score of 27 was established, below which a person is considered having a low indigenous knowledge with respect to conservation of medicinal plants, and above which a person is considered as having high indigenous knowledge regarding conserving medicinal plants. The Individual scores were summed up to obtain maximum and minimum scores whereby mean scores were computed based on sex, age group and education level to establish the relationship between demographic characteristics of an individual and indigenous knowledge on conservation of medicinal plants.

3.5 Results

3.5.1 Indigenous conservation knowledge

The study findings indicated that people in the study area were highly knowledgeable about the traditional fundamentals of medicinal plant conservation. The analysis performed revealed about nine practices that could help in conserving medicinal plant species. Out of the nine indigenous conservation practices, selective harvesting was the most popular in the study area, while, restrictive seasons and times of collecting medicinal plant species was lastly approved by the respondents (Table 3.1).

Table 3.1: Documented indigenous knowledge on conservation

	Knowledge	Responses	Percentage
1.	Selective harvesting	274	94
2.	Planting /domesticating some medicinal plants	245	84
3.	Conservation through sacred plants/forests	243	83
4.	Keeping names, location and use of some plants secret	242	83
5.	Collecting only dead and fallen wood for fuel	237	81
6.	Need of having selective morals for harvesters	214	73
7.	Using local energy saving stoves	210	72
8.	Planting medicinal plants at burial sites	201	69
9.	Restrictive seasons and times of collecting medicinal plants	168	57

From the study findings, it was indicated that more than half of the respondents were knowledgeable of a particular indigenous way of conserving medicinal plant species. This shows that the knowledge, practices and beliefs, have all been highly adopted across generations through cultural transmission and in that case, a combination of knowledge has been considered as vital with regards to preserving medicinal plant species in the study area.

3.5.2 Factors affecting indigenous knowledge on conservation

Most times it is perceived that the socio-demographic characteristics of respondents such as age, sex, and education levels could recount for any kind of knowledge on conservation that an individual possesses. Customarily, there has been strong links between age, sex and education level of the person and the indigenous knowledge one has on conservation of medicinal plant species (Nakashima and Bridgewater, 2000). Relating to this study finding it was showed that age and sex significantly influenced

indigenous knowledge on conservation of medicinal plants. However, education levels of the respondents indicated to have no strong relationship with the respondents' indigenous knowledge on conservation (Table 3.2).

Table 3.2: Socio-demographic attributes and indigenous knowledge on conservation

Category	Mean score	N	Significance	
			F	P
Age group				
18-45	36.4496	129		
Above 45	39.0549	164	9.682	.002**
Total	**37.9078**	**293**		
Sex				
Male	38.8889	129	4.681	.031*
Female	37.0696	164		
Total	**37.9078**	**293**		
Education level				
None	36.9600	25		
Educated	37.9963	268	.470	.493
Total	**37.9078**	**293**		

3.6 Discussion

The sound indigenous knowledge on conservation that was shown by the respondents in Rungwe suggests their awareness of their environment. Similarly, it implies that their long time living in the environment has equipped them with experience that is useful in conservation of medicinal plants. The findings are similar to Mapara (2009) who explain indigenous knowledge systems as a body of knowledge of particular geographical areas which people have survived on for a very long time.

The relatively higher knowledge score revealed by selective harvesting as a conservation practice could be associated with the advantage the method offers as it allows plants to continue budding. Likewise selective harvesting practice are credited for many areas as indicated in literature such as Msuya and Kideghesho (2009) in West Usambara Mountains' communities, Nankaya (2014) among the Maasai communities and

Nimachow et al. (2011) among the Akas tribal group in India. These scholars found almost similar responses that among many practices, selective harvesting was found as the most suitable conservation practice.

Domestication/cultivation of medicinal plant species which came second was attributed by the fact that the practice aids in reducing reliance of medicinal plants on the wild. In support of this study findings reports by Cunningham (1993), Wiersum et al. (2006) and Chen et al. (2016) commend that cultivation/domestication of medicinal plants are essential in ensuring sustainability of the resources for the present and future generations.

With respect to sacred places and plants, the study indicated that the presence of very strict traditional rules and norms could help to maintain vegetation cover in their areas (sacred places are areas where rituals and sacrifices of a particular community take place). For example, during one of the key informant interviews conducted with one of the traditional elders, the communities in the study area believed on sacredness of forest patches (locally known as *masyeto/matongo*). If any person interfered with such will result into unexpected heavy rains confined to an area where the offence has been committed. Hence, the elders would search for the criminal and whoever is found guilty is punished by paying a fine of chicken. As a result, these places and plants within are often intact compared to free entry zones. Similar findings associated with respecting sacred areas/plants and its impact on conservation of plants are confirmed by other scholars (Anthwal et al., 2006; Rajendran and Agarwal, 2007; Nimachow et al., 2011) who conducted studies in Himalaya and India.

It was indicated that traditional healers and others with knowledge on medicinal plant species have a tendency of concealing information about the plants they know. However,

this practice tendency has both negative and positive impacts on conservation. While it could minimize harvesting of the plants since only few people know about these species, it is easy for these few people to destroy the species completely out of ignorance. Studies by Msuya and Kideghesho (2009) in Western Usambara and Panghal et al. (2010) in Saperas community of Khetawas-India, report similar negative consequences of concealing knowledge about indigenous medicinal plants. The implication of keeping secrets on information about medicinal plants may lead to knowledge disappearance and hence loss to the future generation in the conservation context.

Moreover, the practice of restricting/providing special season for harvesting the plant species was preferred by (57%) of the many respondents as it provides the plant with ample time to regain its earlier potential or to mature. Although there were no evidence of such species during the survey, the effectiveness of temporary limitations in the gathering of natural products are common to safeguard medicinal plant species (Msuya and Kideghesho, 2009; Kisangau et al., 2011; Nimachow et al., 2011; Andarge et al., 2015).

Selective morals for harvesters were also found to score relatively high. Their supporting arguments were around species such as *Berberis holstii* (locally known as *Rungwe*) which was claimed to require specific morals of the person who want to harvest it. Another belief was on harvesting plant *Emilia discifolia* (locally known as *Ikuwizya)* was conserved through a taboo where it is unacceptable for a menstruating woman to touch or walk near unless the woman is under certain rituals administered by cultural leaders. The findings are supported by the knowledge- practice-belief system theory which explains how believing in something may lead to its preservation. Similar findings are

also reported by Nimachow et al. (2011) who noted the role of taboos on biodiversity conservation in India.

Generally, the study indicated that indigenous knowledge on conservation was highly contributed by the respondents' age increase. The elders revealed relatively higher knowledge to a wider conservation practices than was the case with the youths. This may be attributed to the elders' long-term experience that has been acquired through cultural conservation practices. Further, more than half of the population in the communities in the study area were elders (45 years and above). As perceived to be the main custodians and instructors of cultural practices (Nakashima and Bridgewater, 2000) a similar situation could apply to elders in the study area. Therefore, having larger proportion of elders might guarantee rich indigenous knowledge on conservation and a need to transfer that knowledge to young generations.

Moreover, it was found that females had lower scores in terms of indigenous knowledge on conservation than was the case with males. However, these results are contrary to the beliefs that traditionally women in rural areas have been thought to be closer to the nature in their daily activities and so they are able to perceive and express more concern about the environment than males (Loughland et al., 2003). A low knowledge score in females might suggest that the passage of indigenous conservation knowledge favour males than females. But also, in some traditions the knowledge is accompanied by practical experience about the wild environment where females may have limitations because the wild environment is hardly accessible and risky. Despite that, domestication approach may have high influence on the conservation of medicinal plants among females hence a gender balanced conservation approach is encouraged.

The indigenous knowledge on conservation was not attributed to education levels held by the community. This might be due to the fact that indigenous knowledge is not

acquired from modern education setup rather through cultural practices and experiences. This suggests that the knowledge is adopted by means of passing it orally from generation to generation. These findings are in contrast with observation of Badola et al. (2012) who found education as an important factor influencing indigenous knowledge on conservation. The implication of this finding is that, since formal education may provide people with new discoveries and innovations, there is the possibility of blending the indigenous knowledge with formal training and/or technologies. The two could be instrumental in ensuring a sustained environment for medicinal plant resources.

3.7 Conclusions and Recommendations

Based on the study findings it can be concluded that the community in the study area were rich in indigenous knowledge on conservation of medicinal plant species as they could mention up to nine conservation practices. The conservation practices seemed to be fundamental in conservation of medicinal plant species in the study area. However, the possession of indigenous knowledge of conservation was diverse. The variation of indigenous knowledge revealed by the respondents in Rungwe was influenced by age and sex. Due to these evidences, the study recommends for preservation and promotion of indigenous knowledge on conservation among community members. Further, the study urges for transferring of the knowledge by the elders to the youth.

3.8 Acknowledgements

The authors acknowledge the Carnegie Regional Initiative in Science Education- African Natural Products Network (CR-AFNNET) for the financial support that facilitated the execution of this study. Authors are highly indebted to Rungwe District Council Officers, District Medical Officers, Forest Officers, Local Government leaders, and community members especially the traditional practitioners and all other informants consulted, for their hospitality, advice, guidance, and cooperation during this study.

References

Andarge, E., Shonga, A., Agize, M. and Tora, A. (2015). Utilization and conservation of medicinal plants and their associated Indigenous Knowledge (IK) in Dawuro Zone: An ethnobotanical approach. *International Journal of Medicinal Plant Research* 4(3): 330–337.

Anthwal, A., Ramesh, C., Sharman, R. C. and Archana S. (2006). Sacred Groves: Traditional Way of Conserving Plant Diversity in Garhwal Himalaya, Uttaranchal. *The Journal of American Science* 2(2): 12pp.

Badola, R., Barthwal, S. and Hussain, S. A. (2012). Attitudes of local communities towards conservation of mangrove forests: A case study from the east coast of India. *Estuarine, Coastal and Shelf Science* 96: 188–196.

Boafo, J. (2013). *The Impact of Deforestation on Forest Livelihoods in Ghana.* Africa Portal a project of the africa initiative. 6pp.

Boyd, H. K., Westfall, R. and Stasch, S. F. (1981). Marketing research texts and cases. Richard D., Illinois. 675 pp.

Bukuluki, P., Luwangula, R. and Walakira, E. J. (2014). Harvesting of Medicinal Plants in Uganda: Practices, Conservation and Implications for Sustainability of Supplies. *International Journal of Medicinal Plant Research* 3(1): 1–10.

Carlson, M. D. A. and Morrison, R. S. (2009). A User's Guide to Research in Palliative Care Study Design, Precision, and Validity in Observational Studies. *Journal of Palliative Medicine* 12(1): 77-82.

Chen, S. L., Yu, H., Luo, H. M., Wu, Q., Li, C. F. and Steinmetz, A. (2016). Conservation and sustainable use of medicinal plants: problems, progress and prospects. *Chinese Medicine* 11(37): 1–10.

Chinsembu, K. C. (2016). Ethnobotanical Study of Plants Used in the Management of HIV/AIDS-Related Diseases in Livingstone, Southern Province, Zambia. Evidence-Based Complementary and Alternative Medicine. 1–14.

Cunningham, A. B. (1993). African medicinal plants: setting priorities at the interface between conservation and primary health care. People and Plants working paper 1. Paris. UNESCO. 53pp.

Driscoll, D. L., Salib, P. and Rupert, D. J. (2007). Merging Qualitative and Quantitative Data in Mixed Methods Research: How To and Why Not. *Ecological and Environmental Anthropology* 3(1): 18–28.

Food and Agriculture Organization (2010). Global Forest Resources Assessment. MainReport. United Republic of Tanzania. 191pp.

Gadgil, M., Berkes, F. and Folke, C. (1993). Indigenous Knowledge for Biodiversity Conservation. *Ambio* 22(2–3): 151–156.

Hamilton, A. C. (2004). Medicinal plants, conservation and livelihoods. Biodiversity and Conservation. Kluwer Academic Publishers. *Netherlands* 13: 1477–1517.

Harris, L. and Brown, G. (2010). Mixing interview and questionnaire methods: Practical problems in aligning data. *Practical Assessment Research* 15(1): 1–19.

Kasagana, V. N. and Karumuri, S. S. (2011). Conservation Of Medicinal Plants: Past, Present and Future Trends. *Journal of Pharmaceutical Sciences and Research* 3(8): 1378–1386.

Kisangau, D. P., Herrmann, T. M., Lyaruu, V. M., Hosea, K. M., Joseph, C. C., Mbwambo, Z. H. and Masimba, P. J. (2011). Traditional Knowledge, Use Practices and Conservation of Medicinal Plants for HIV/AIDS Care in Rural Tanzania. *Ethnobotany Research and Applications* 9: 43–58.

Loughland, T., Reid, A., Walker, K. and Petocz, P. (2003). Factors influencing young people's conception of environment. *Journal of Environmental Education Research* 9(1): 3–20.

Mahomoodally, M. F., Fakim, A. and Subratty, A. H. (2004). A kinetic model for in-vitro intestinal uptake of L-tyrosine and D (+)- glucose across rat everted gut

sacs in the presence of Momordica charantia, a medicinal plant used in traditional medicine against diabetes mellitus. *Journal of Cell and Molecular Biology* 3: 39–44.

Mahomoodally, F. M. (2013). Traditional Medicines in Africa: An Appraisal of Ten Potent African Medicinal Plants. *Evidence-Based Complementary and Alternative Medicine* 2013. 14pp.

Mapara, J. (2009). Indigenous knowledge systems in zimbabwe: Juxtaposing postcolonial theory. *The Journal of Pan African Studies* 3: 139-155.

Meremo, A., Mboya, B., Ngilangwa, D. P., Dulle, R., Tarimo, E., Urassa, D. and Ilako, F. (2016). Barriers to accessibility and utilization of HIV testing and counseling services in Tanzania: Experience from Angaza Zaidi programme. *Pan African Medical Journal* 23: 1–12.

Mokuku, T. and Mokuku, C. (2004). The Role of Indigenous Knowledge in Biodiversity Conservation in the Lesotho Highlands: Exploring indigenous epistemology. *Southern African Journal of Environmental Education* 21: 1-13.

Msuya, T. S. and Kideghesho, J. R. (2009). The role of traditional management practices in enhancing sustainable use and conservation of medicinal plants in West Usambara Mountains. *Journal-Tropical Conservation Science* 2(1): 88–105.

Nahashon, M. (2013). Conservation of Wild-harvested Medicinal Plant Species in Tanzania Conservation of Wild-harvested Medicinal Plant Species in Tanzania. Thesis for Award of Master Degree at Uppsala University, Uppsala. 62pp.

Nakashima, D., Prott, L. and Bridgewater, P. (2000). Tapping into the world's wisdom.monthly information magazine of the UNESCO. 23pp.

Nankaya, J. (2014). The Salient Traditional Medicinal Plants and Conservation Strategies of the Loita Maasai of Kenya. Thesis for Award of Master Degree at Clemson University, USA. 74pp.

Nimachow, G., Joshi, R. and Dai, O. (2011). Role of indigenous knowledge system in conservation of forest resources; A case study of the Aka tribes of Arunachal Pradesh. *Indian Journal of Traditional Knowledge* 10(2): 276–280.

Orisatoki, R. O. and Oguntibeju, O. O. (2010). The role of Herbal Medicine use in HIV/AIDS treatment. *IMedPub Journals* 1(3): 1–4.

Panghal, M., Arya, V., Yadav, S., Kumar, S. and Yadav, J. P. (2010). Indigenous knowledge of medicinal plants used by Saperas community of Khetawas, Jhajjar. *Ethnobiology and Ethnomedicine* 6(4): 1–11.

Roberson, E. (2008). Nature's Pharmacy, Our Treasure Chest: Why We Must Conserve Our Natural Heritage, A Native Plant Conservation Campaign Report. 16 pp.

Rajendran, S. M. and Agarwal, C. (2007). Medicinal plants conservation through sacred forests by ethnic tribals of Virudhunagar district, Tamil Nadu. *Indian Journal of Traditional Knowledge* 6(2): 328–333.

Sedgwick, P. (2014). Cross sectional studies. Advantages and Disadvantages. *Bmj* 348: 2236-2276.

Tabuti, J. R. S., Kukunda, C. B., Kaweesi, D. and Kasilo, O. M. J. (2012). Herbal medicine use in the districts of Nakapiripirit, Pallisa, Kanungu, and Mukono in Uganda. *Journal of Ethnobiology and Ethnomedicine* 8(35): 1–15.

Wiersum, K. F., Dold, A. P., Husselman, M. and Cocks, M. (2006). Cultivation of medicinal plants as a tool for biodiversity conservation and poverty alleviation. In; the Amatola Region, South Africa. Medicinal and Aromatic Plants. 15pp.

World Health Organization (2003). Traditional medicine Report by the Secretariat. 4pp.

World Health Organization (2013). WHO Traditional Medicine Strategy. 78pp.

World Health Organization (2015). World health statistics. *World Health Organization* 2015(46): 164-175.

World International Property Organization (2005). Intellectual property and traditional knowledge. WIPO Publication: 36pp.

CHAPTER FOUR

4.0 Population status of medicinal plants used to manage HIV/AIDS opportunistic infections in Rungwe District, Tanzania: A Reflection from *Hagenia abyssinica* and *Myrica salicifolia*

Suma F. Kibonde[1*], Suzana Augustino[2], Faith P. Mabiki[3] and Robinson Mdegela[4]

[1] Department of Geography and Environmental Studies, Solomon Mahlangu College of Science and Education, Sokoine University of Agriculture, P.O. Box 3038, Chuo Kikuu, Morogoro, Tanzania

[2] Department of Forest Engineering and Wood Sciences, College of Forestry, Wildlife and Tourism, Sokoine University of Agriculture, P.O. Box 3014 Chuo Kikuu, Morogoro, Tanzania

[3]Department of Chemistry and Physics, Solomon Mahlangu College of Science and Education, Sokoine University of Agriculture, P.O. Box 3038, Chuo Kikuu, Morogoro, Tanzania

[4]Department of Public Health, College of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, P.O. Box 3021 - Chuo Kikuu, Morogoro, Tanzania

*Corresponding author: kibondesuma9@yahoo.com

4.1 Abstract

Assessment of population status of medicinal plants is fundamental in conserving valuable plants in order to sustain those with minor or threatened populations and to ensure availability of resources to users. However, despite the usefulness of medicinal plants in managing HIV/AIDS opportunistic infections in Rungwe district, their wild population status has not been assessed. This study therefore, aimed at prioritizing

medicinal plants used to manage HIV/AIDS opportunistic infections and assessing their population status. Data to obtain priority medicinal plant species were collected using focus group discussions while inventories were conducted to collect data on population status of priority medicinal plant species. Preference ranking and Microsoft Excel were used to analyse data on priority medicinal plant species. QGIS software version 2.18 was used to analyse spatial data of the priority medicinal plants. The study findings indicated that there were seven priority medicinal plant species used to manage HIV/AIDS opportunistic infections in Rungwe. The assessment of wild population status of the priority medicinal plant species was carried out on two species, *Hagenia abyssinica* and *Myrica salicifolia*. The study findings revealed the dominance of the two medicinal plant species between 1950 to 2050 metres above the sea level. Both species displayed linear pattern distribution adjacent rivers. With regards to population structure, the species revealed *J*- shaped curves. Findings on species density showed that *Hagenia abyssinica* had 200/ha *while Myrica salicifolia* had only 28/ha. Conclusively, the respondents attached more values to some medicinal plant species indicating their recognition of the species usefulness. The presence of species in those altitudes indicates that they are of afro-montane habitat, and growing adjacent water sources indicated that the species probably require soils with high moisture content. Moreover, the *J*-shaped curves observed in both species imply that the species had poor recruitment of young plants and this could determine that the species are unsustainable. The study recommends for urgent conservation plans especially on the two priority medicinal plant species. There is a need also to ensure strict measures are put in place to safeguard the medicinal plant species to ensure their sustainability.

Key words: Spatial distribution, sustainability, priority, medicinal plants, Rungwe

Targeted journal: International Journal of Biodiversity

4.2 Introduction

Since time immemorial traditional medicines are acknowledged for their potential in the prevention and cure of various diseases worldwide (Otang et al., 2012; Maregesi and Mwakalukwa, 2015). Globally, plants form the largest part of traditional medicine (Vasisht and Kumar, 2004; Rahman et al., 2013; Bukuluki et al., 2014; Agisho et al., 2014) of which 80-90% are wild (Hamilton, 2004; Lakey and Dorji, 2016). Medicinal plants are important for managing HIV/AIDS related infections, and have been widely used by HIV/AIDS patients (Msuya and Kideghesho, 2009; Otang et al., 2012; Gyasi et al., 2013). By 2010's the HIV patients were reported to constitute one billion people who partly relied on medicinal plants (Ndah et al., 2013), adding more pressure on the wild population of medicinal plants (Hamilton, 2004; Lakey and Dorji, 2016).

In Tanzania, more than 60% of population depend on traditional medicine for primary health care (Lindh, 2015). For HIV patients, medicinal plants are mostly used as a solution to multiple related opportunistic infections. The trend of using plant medicine is associated with their availability all year long and affordability, both of which are not the case with modern drugs (Kayombo et al., 2017). This has increased the extractive activities of most medicinal plants which contribute to alteration of their population status in the wild (Lakey and Dorji, 2016).

According to Ambasta et al. (2016) report, 21% of the world plants are under threat of extinction. While, Africa loses about 3.4 million hectares of forests (FAO, 2010; AfDB, 2016), Tanzania is estimated to lose 0.3% hectares of her forests annually due to conversion and over exploitation of plant resources (FAO, 2015). Though data on the loss are not specific to medicinal plants, it is likely that there is a large percentage of medicinal plants which are depleted (Hamilton, 2004), something which calls for urgent

suitable conservation plans to guarantee their sustainable utilization (Mahunnah, 2002; Hamilton, 2004; Ndah et al., 2013; Souza et al., 2017).

Numerous ethnobotanical studies have been conducted across the country including Msuya and Kideghesho (2009); Nahashon (2013); Augustino et al. (2014); Kayombo et al. (2017). However, these studies focused on the identification of species and their use in managing various diseases. In Rungwe particularly Poroto forest reserve, most of the studies conducted focused on gathering information mostly on general plants use and the presence of medicinal plant species in the area. Good example of these studies are a study by Mwakisunga (2017) who confirmed Poroto forest to be rich in diverse plant species and a study by Joseph (2016) who related Poroto reserve's thick vegetation with the plenty of rainfall in the area and the adjacent communities that rely on the forest for livelihood including medicine. A study by Briggs and Wildman (2009) reported on the vegetation of Poroto forest reserve and the associated powerful ancestral spirits of Lake Ngozi with a special potency of most medicinal plants collected in the reserve.

Besides the confirmed use of medicinal plants among the HIV patients in Rungwe district (Kibonde et al., 2018), priority medicinal plant species are not documented. Also, limited studies have assessed the population status of the medicinal plants for managing HIV/AIDS opportunistic infections. This study was carried out to assess the population status of selected priority medicinal plant species used in the managing HIV/AIDS opportunistic infections in the Poroto forest reserve. Specifically, the study documented the priority medicinal plant species used to manage HIV/AIDS opportunistic infections and determined population structure, spatial distribution pattern, and population density to reveal its sustainability. These findings may benefit conservationists in their activities, the policy makers at all levels and the community at grassroots.

4.3 Methodology

4.3.1 Description of the study area

The study was conducted in Poroto forest reserve, Rungwe district, Mbeya region, Tanzania. Poroto forest reserve is located between Latitude 8°58' and 9°05' South and Longitude 33°26' and 33°36' East (Fig. 4.1). The forest trans-bordering Rungwe and Mbeya Rural district has an area of about 9332 ha with the altitude ranging from 1750-2620 masl (Mwakisunga, 2017).

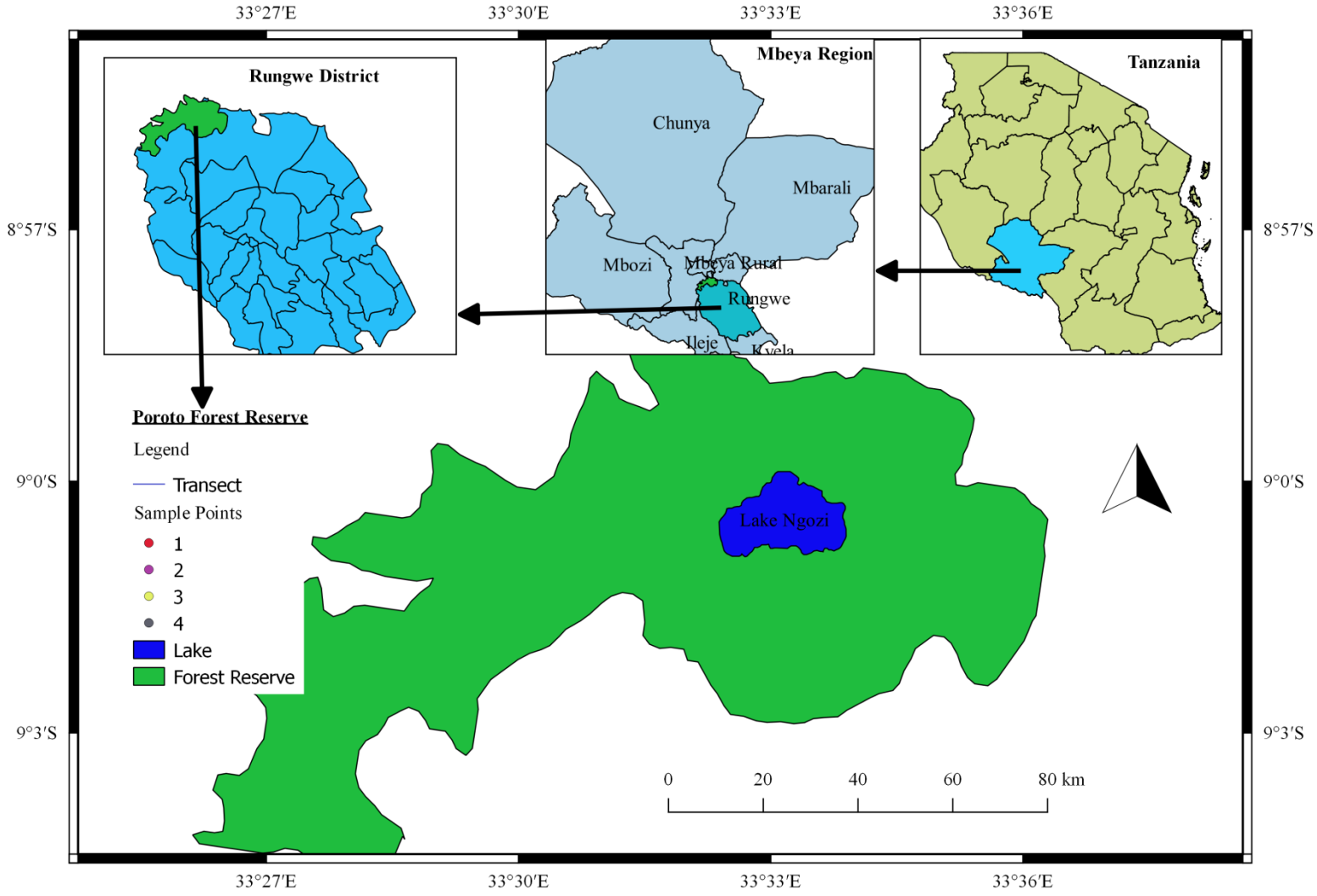

Figure 4.1: Map of the study area

4.3.2 Rationale for selection of Poroto Forest Reserve

Poroto forest reserve harbours many plant species which are documented in the District as being used in managing HIV/AIDS opportunistic infections. Poroto forest reserve was selected because it is one of the forests managed by central government and communities living adjacent have rights to access for livelihood. Moreover, the two priority medicinal plant species were found to grow in the Poroto forest reserve.

4.3.3 Climate and vegetation cover of Poroto Forest Reserve

Being part of the mountainous district, the area receives cool temperature ranging from 16 degrees Celsius in July as the minimum temperature and 21 degrees Celsius in November as the maximum temperature while average rainfall is 50 mm in September as the minimum rainfall and 606 mm in April as the maximum rainfall (Nyunza and Mwakaje, 2012; Mwakisunga, 2017). The climate around the reserve has greatly influenced the vegetation cover where almost 80% of the forest reserve is covered by humid montane vegetation types (URT, 2011). This reserve is an origin of a number of permanent and seasonal streams that provide water to the local community for domestic purposes (Josephat, 2016).

4.3.4 Topography and soil of Poroto Forest Reserve

The altitude of Poroto ranges between 1750-2620 masl. Almost 80% of the reserve is covered by upper montane forest, grassland and bamboo (URT, 2011). The soil of the Poroto forest reserve is typically volcanic soil with high amount of humus which allows growth of different food and cash crops such as maize, and potatoes (both sweet and Irish potatoes).

4.3.5 Social economic activities

The main socio-economic activities of communities around the reserve involve agriculture whereby the main crops grown include irish potatoes and maize as food and cash crops with varieties of fruits and vegetables (URT, 2011).

4.4 Data Collection Methods

4.4.1 Approach of prioritizing medicinal plants

Data on priority medicinal plant species used for managing HIV/AIDS opportunistic infections were collected through focus group discussions with traditional healers and people with sound ethnobotanical knowledge. Participants of the focus group discussions were purposively selected with the help of local government leaders as recommended by Uprety et al. (2012) and Kunwar et al. (2014). Sixteen (16) participants were obtained from two villages (Swaya and Mbeye One) whereby each village was represented by eight participants and one focus group discussion was conducted in each of the selected villages. In the first place, members in the (FGDs) were asked to prioritize medicinal plant species based on their uses/ importance (Dudney et al., 2015; Taline Cristina da Silva et al., 2018). Guidelines for group discussions were developed to facilitate the collection of information. The group discussions were conducted to gather data on species' local and scientific names, and the infections they deal with. A checklist was used to record all the information provided based on mentioned priority species. In this study traditional healers are recognized as people with sound knowledge on MPs and diseases as their role was that of key informants to supplement and verify information in the study.

4.4.2 Population status assessment

Data on selected two priority medicinal plant species in managing HIV/AIDS opportunistic infections were collected using plot method (Phillips et al., 2003). Systematic sampling technique was used to obtain samples. Transects were laid on the sites where local people (traditional healers) guided the area with availability of these two species in abundance. Each transect was located by a global positioning systems (GPS) and transects were separated by 500 metres each measured 1 kilometre long. A total of 44 circular sample plots were established along transects with 15 cm diameter radius and 100 metres apart. Diameter at Breast Height (DbH) was measured at 1.3 m above the ground. Information collected from plots included transect number, plot number, geographical coordinates of plots and species, elevation, species names, number of species in the plot and DBH (Appendix 7).

4.4.3 Data analysis

Preference ranking following Cotton (1996) and Microsoft Excel were used to obtain priority medicinal plant species as well as to determine population structure. QGIS software version 2.18 was used to analyse and describe the spatial data on the priority medicinal plants. Data on species' diameter breast height (DBH) were summarized in DBH size classes to determine population structure of the two species. This study adopted and modified Phama et al. (2014)'s classification of trees which are in three classes to two. Trees were counted as seedlings if they had (<10cm) and mature if they fell in (>10cm) class. Density in terms of the number of individual plants in a given area and one factor in determining sustainability was used to calculate density of the medicinal plant species used to manage HIV/AIDS opportunistic infections as follows:

$$N = \frac{n_i}{a_i} \quad \text{.....(1)}$$

Where *N* is the number of trees per ha; *n* is the number of trees in plot *i* and *a* is the plot area *I* (Global, 2019).

4.5 Results

4.5.1 Priority medicinal plants

Results from preference ranking showed seven medicinal plant species to be priority in managing HIV/AIDS opportunistic infections in the study area as shown in Table 4.1. However, the assessment of population status of priority medicinal plants was performed on two medicinal plant species only, which were H*agenia abyssinica* and *Myrica salicifolia.* The assessment was performed on two species because these species were reported to have other uses more than medicinal. Their multiple uses could have led to their depletion hence, assessment of their population status was vital so as to be able to determine their sustainability.

Table 4.1: Results of Direct Matrix Ranking for Priority Medicinal Plants in the study area

Scientific Name	Family	Local Name	Form	Infections managed							
				CD	**Hz**	**Hs**	**TB**	**OC**	**CC**	**Total**	**Rank**
Dissotis phaeotricha (Hochst.) Hook. f.	Melastomataceae	Kyumika	Shrub	14	10	12	0	10	11	57	**2nd**
Berberis holstii Engl.	Berberidaceae	Rungwe	Shrub/ Tree	16	9	10	14	11	13	73	**1st**
Myrica salicifolia Hochst. ex A. Rich.	Myricaceae	Nsibhisibhi	Tree	16	0	0	14	13	15	66	**3rd**
Hagenia abyssinica (Bruce ex Steud.) J.F.Gmel.	Rosaceae	Ntululunga	Tree	14	14	13	14	0	16	73	**1st**
Eriobotrya japonica (Thunb.) Lindl.	Rosaceae	Nsongwa	Tree	16	3	0	14	0	0	33	**5th**
Aloe sp.	Xanthorrhoeaceae	Mwalovela	Herb	10	12	6	8	0	0	36	**4th**
Rubia cordifolia L.	Rubiaceae	Idadauzi	Climber	14	0	13	0	0	0	27	**6th**

Key: Cd = Chronic diarrhoea; Hz = Herpes zoster; Hs = Herpes simplex; Oc = Oral candidiasis; Cc = Chronic cough;

TB = Tuberculosis

4.5.2 Distribution of *Hagenia abyssinica* and *Myrica salicifolia* by elevation

Both *Hagenia abyssinica* and *Myrcia salicifolia* preferred growing within the range of 1950 and 2050 m above the sea level (Fig. 4.2). This implies that the two species are of high altitudes therefore, any conservation approach that involve replanting or planting of these species outside their habitat should consider elevation aspects.

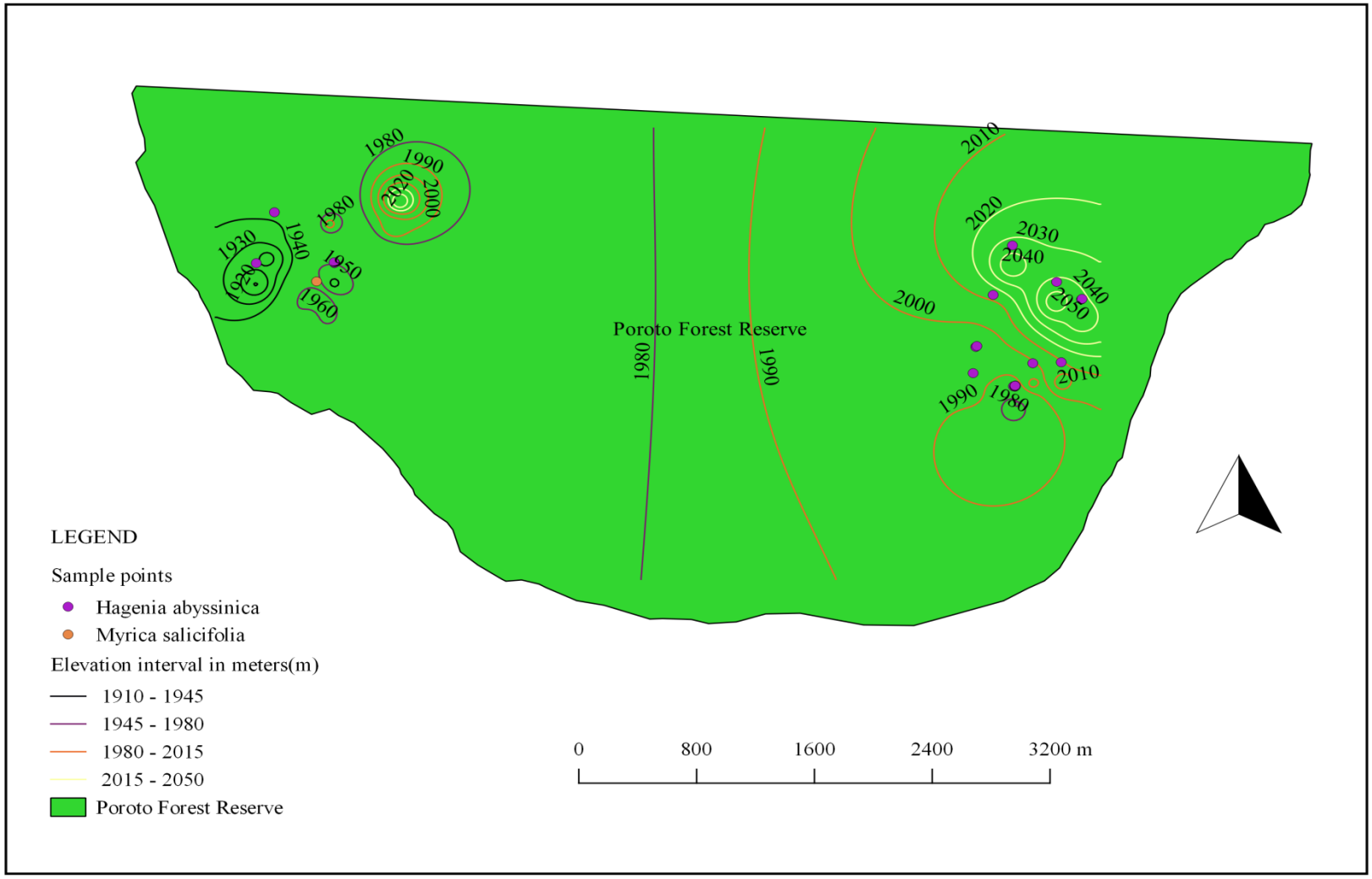

Figure 4.2: **Distribution of priority medicinal plants by elevation**

4.5.3 Distribution pattern of *Hagenia abyssinica* and *Myrica salicifolia*

These two priority medicinal plant species, *Hagenia abyssinica* and *Myrica salicifolia* were found to grow within 450m from water sources especially rivers (Fig. 4. 3). The Poroto forest reserve contains a number of permanent and seasonal rivers which probably provide favourable environment for the priority medicinal plant species and the forest ecosystem at large.

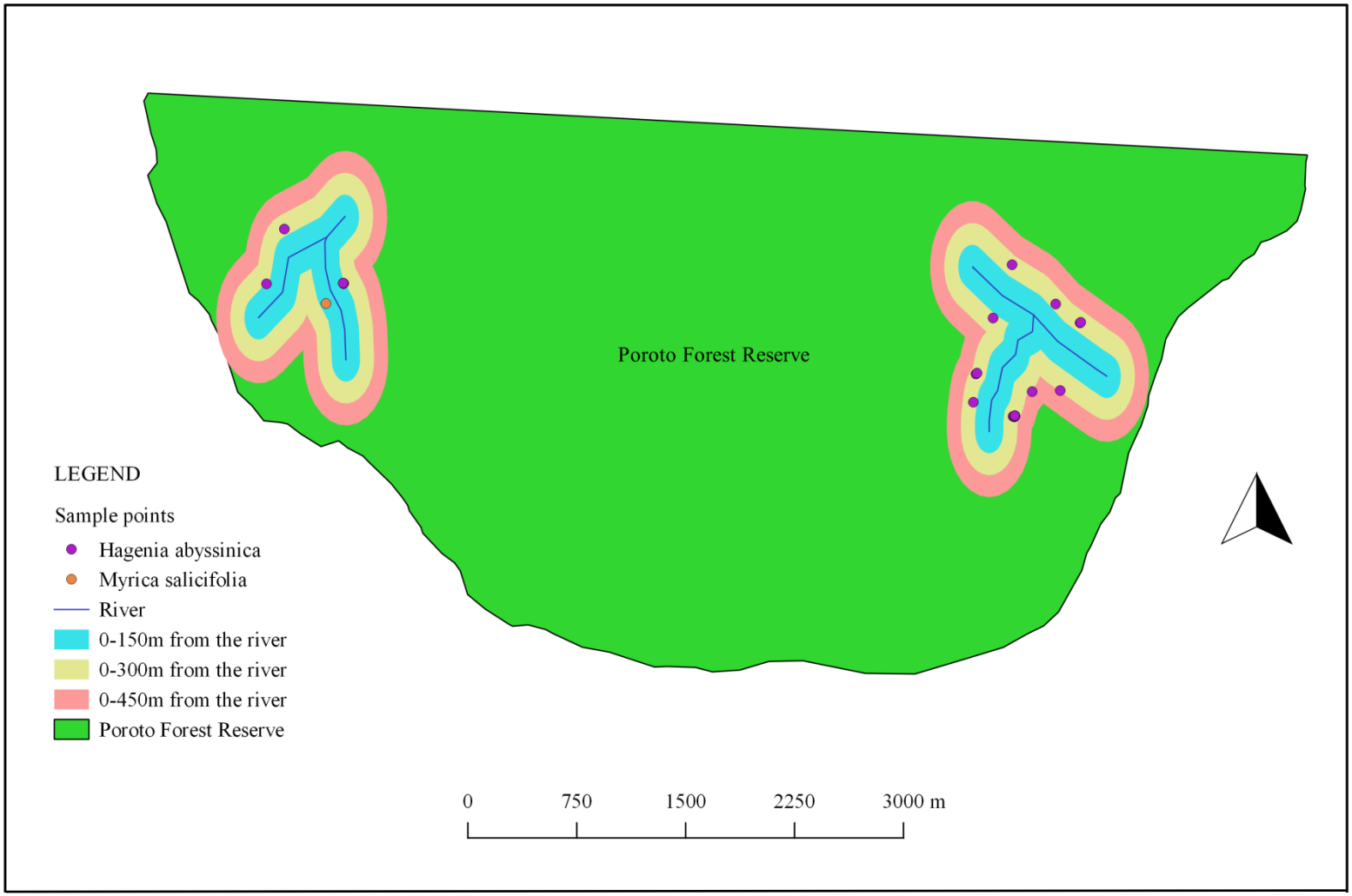

Figure 4.3: Species distribution pattern in Poroto Forest Reserve

4.5.4 Population structure of the species by diameter size classes

The population structures of *Hagenia abyssinica* and *Myrica salicifolia* in Poroto forest reserve were represented as mature trees with DBH classes (>10cm). The lowest class that included plants with (<10cm) known as seedlings, were poorly represented to indicate poor recruitment of the species. The worst scenario was observed on *Myrica salicifolia* as the species was not represented by trees in the lowest diameters (<10cm) (Fig.4.4 and 5).

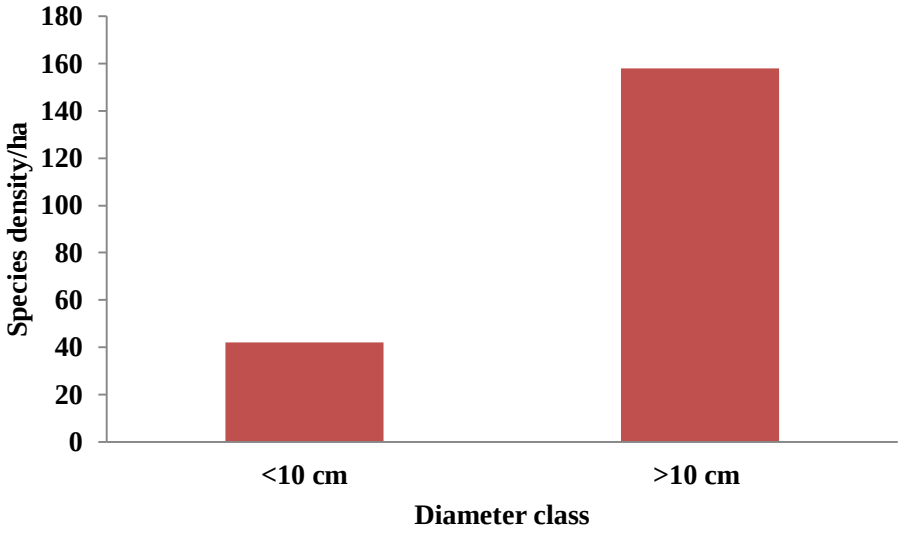

Figure 4.4: Population structure of *Hagenia abyssinica*

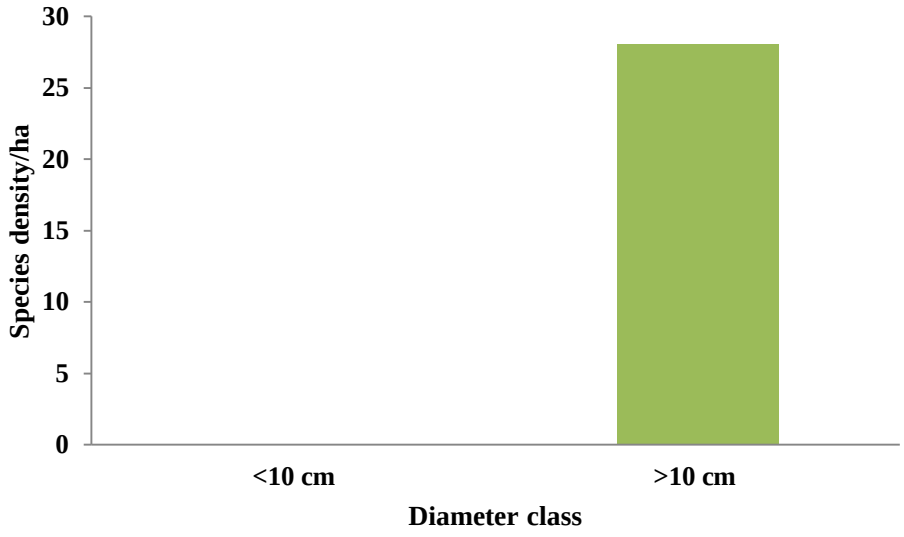

Figure 4.5: Population structure of *Myrica salicifolia*

4.5.5 Population density of *Hagenia abyssinica* and *Myrica salicifolia*

The density of the two priority medicinal plant species encountered in the Poroto forest reserve was 228 stems per ha. *Hagenia Abyssinica* contributed the largest share as compared to *Myrica salicifolia*. From the overall density, the individual species densities the stem per ha, of the two medicinal plants, *Hagenia abyssinica* and *Myrica salicifolia* are presented in Table 4.2.

Table 4.2: Density Distribution of selected Priority Medicinal Plants

Diameter Classes (cm)	Species Density (stems/ha)	
	Hagenia abyssinica	***Myrica salicifolia***
<10	42	0
10-20	104	14
>20	54	14
Total	**200**	**28**

4.6 Discussions

The communities interviewed in the study area seemed to be knowledgeable on the priority medicinal plant species as they mentioned up to seven of them in dealing with HIV/AIDS opportunistic infections. The prioritized species implies that they may contain bioactive ingredients as stated in literature by Trotter and Logan, (1986) and Kala et al. (2004). The literature reveals that if plants are repeatedly used for the same purpose they are likely containing active ingredients. The medicinal plant species that were prioritized in this study have also been reported as priority species in other areas, for example *Berberis holstii* by Maliwichi-nyirenda et al. (2011) in Malawi. *Hagenia abyssinica* and *Myrica salicifolia* by Assefa et al. (2010 and Teklay et al. (2013) in Ethiopia.

The two priority medicinal plant species revealing their distribution in higher altitudes indicate they are afro-montane habitat. The findings from this study are supported by studies conducted by Assefa et al. (2010) and Ayele et al. (2017) which showed similar species growing in higher altitudes. However, the species tended to decrease as the altitudes were getting to the peak, which is probably due to poor edaphic factors and prevailing high soil erosions. Therefore, in order to implement conservation strategies of *Hagenia abyssinica* and *Myrica salicifolia* in the study area or other places, efforts should focus on among others physiological factors and identifying favourable altitude thresholds. The altitudinal range reported in this study was considered favourable due to its thicker soils and low soil erosion as compared to steeper slopes.

Moreover, the tendency of species displaying linear pattern adjacent rivers may indicate that these plants require high soil moisture content and that in drier areas these species survival could be uncertain. These findings relate to those reported by Fen (2018) who associated the growth of *Hagenia abyssinica* with fertile and moist soils. Also, similar findings are reported in studies conducted in Ethiopia which confirm that *Myrica salicifolia* was found to be highly threatened by prolonged drought although other factors including anthropogenic activities contributed as well (Teklay et al., 2013; Agisho et al., 2014).

The implication of *J*-shaped curves revealed by both species is that, the future of medicinal plants is uncertain. This is because both plants missed or had few younger plants (seedlings) to succeed the mature plants which signal for unsustainability medicinal plant species. According to Malik and Bhatt (2016), the proportion of plant population in the seedling (young) stage determines a predictable plant population at mature stage. A study conducted by Berhan and Bekele (2006) indicated that similar

species *(Hagenia abyssinica* and *Myrica salicifolia)* missing representation in the lowest DbH class sizes (seedlings). Other studies have reported on *Hagenia abyssinica* and *Myrica salicifolia* being utilized for various purposes other than medicine such as house construction, furniture making and fuel wood, hence, threatening the species (Agisho, 2014). This implies the species have multiple uses and thus highly demanded to probably require conservation measures to ensure sustainability in future.

Generally, the density of the two species especially for the lowest Dbh size class indicated that these species could be threatened. The threats might have been caused by factors such as fuel wood extraction, farming activities and animal grazing as they were observed during the survey in the forest reserve. The findings relate to what Amsalu et al. (2018) stated that activities such as farm size expansion, extraction of wood for furniture and construction materials posed threats to the survival of *Myrica salicifolia* in Ethiopia.

4.7 Conclusions and Recommendations

The respondents in the study area were revealed to attach values to some species than others. These species are the most species people living with HIV/AIDS use or once used to manage the HIV/AIDS related infections. The population assessment performed on the two priority species (*Hagenia abyssinica* and *Myrica salicifolia*) growing in the Poroto forest reserve revealed that the species were unsustainable as the young plants were poorly represented. The study findings inform the policy makers and other stakeholders interested in medicinal plants of what is taking place in the forest reserve. Likewise the study urges for joint efforts among policy makers, conservationists, local authorities, people at grassroots and other stake holders interested in medicinal plants to safeguard the medicinal plant species.

4.8 Acknowledgements

The authors acknowledge the Carnegie Regional Initiative in Science Education- African Natural Products Network (CR-AFNNET) for financial support which facilitated execution of this study. Authors are highly indebted to Rungwe District Council Officers, District Medical Officers, Forest Officers and Local Government leaders, community members especially the traditional practitioners and all other informants consulted, for their hospitality, advice, guidance and cooperation during this study.

Reference

African Development Bank Group (2016). REDD^{+} in Africa. 54pp. [https://www. afdb.org ›AfricanDevelopmentBankClimateChangeAction Plan 2016-2020] site visited on 14/12/2015.

Agisho, H., Osie, M. and Lambore, T. (2014). Traditional medicinal plants utilization, management and threats in Hadiya Zone, Ethiopia. Journal of Medicinal Plants Studies 2(2): 94–108.

Ambasta, S. K., Kumari, S., Yadav, A. K., Trivedi, I., Prasad, B. and Sinha, U. K. (2016). European of Biomedical and Pharmaceutical sciences Medicinal plants of Bihar and its neighbouring region which needs. *E*uropean Journal of Biomedical and Pharmaceutical Sciences 3(4): 544–550.

Amsalu, N., Bezie, Y., Fentahun, M., Alemayehu, A. and Amsalu, G. (2018). Use and Conservation of Medicinal Plants by Indigenous People of Gozamin Wereda, East Gojjam Zone of Amhara Region, Ethiopia: An Ethnobotanical Approach, Evidence-Based Complementary and Alternative Medicine. 1-23.

Assefa, B., Glatzel, G. and Buchmann, C. (2010). Ethnomedicinal uses of *Hagenia abyssinica* (Bruce) J. F. Gmel. among rural communities of Ethiopia. Journal of Ethnobiology and Ethnomedicine 6(1): 1–10.

Augustino, S., Hall, J. B., Makonda F. B. S. and Ishengoma R. C. (2014). Medicinal plant parts and practices used by communities around the Miombo woodlands of Urumwa, Tanzania. Journal of Medicinal Plant Research 8(15): 599–606.

Ayele T.B., Gailing O., Finkeldey R. (2017). Spatial distribution of genetic diversity in populations of *Hagenia abyssinica* (Bruce) J.F. Gmel from Ethiopia. *Ann. For. Res.* 60(1): 1-16.

Berhan, G. and Bekele, T. (2006). Population structure and spatial distribution of four woody medicinal plant species in Bonga Forest, Ethiopia. Ethiopian Journal of Natural Resources 8(1): 19–38.

Briggs, P. and Wildman, K. (2009). Tanzania with Zanzibar, Pemba and Mafia.The Globe Pequot Press Inc. Goose Lane. USA. 592pp.

Bukuluki, P., Luwangula, R. and Walakira, E. J. (2014). Harvesting of Medicinal Plants in Uganda: Practices, Conservation and Implications for Sustainability of Supplies. Online International Journal of Medicinal Plant Research 3(1): 1–10.

Cotton, M. C. (1996). Ethnobotany, Principles and Applications, John Wiley and Sons Ltd., Chichister, England. 91-108.

Dudney, K., Warren, S., Sills, E. (2015). How Study Design Influences the Ranking of Medicinal Plant Importance: A Case Study from Ghana, West Africa, Econ Bot 4(69): 306-317.

Food and Agriculture Organization (2010). Global forest resources assessment. Country Report. United Republic of Tanzania. 378pp.

Food and Agriculture Organization (2015). Global Forest Resources Assessment 2015: 253 pp.

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.

Global Rangelands (2019). Access Thousands of Rangeland Resources. 1pp. Available at [https://globalrangelands.org/inventorymonitoring/cover]. Site visited on 21/10/2018.

Gyasi, R. M., Tagoe-darko, E. and Mensah, C. M. (2013). Use of Traditional Medicine by HIV/AIDS Patients in Kumasi Metropolis, Ghana: A Cross-sectional Survey.

Hamilton, A. C. (2004). Medicinal plants, conservation and livelihoods. Biodiversity and Conservation. Kluwer Academic Publishers, Netherlands 13: 1477-1517.

Hamilton, A. C. (editor) (2008). Medicinal plants in conservation and development: case studies and lessons learnt. Plantlife International, Salisbury, UK. 85pp.

Josephat, S. (2016). Geothermometry and Quantifying of Mixing and Water-Rock Interactions in the Ngozi Geothermal Field, SW-Tanzania. Reports 2016 Number 18: 22pp.

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: 453–469.

Kayombo, E. J. (2013). Indigenous Knowledge and HIV/AIDS Prevention and Management in Local Communities in Africa South of the Sahara. Pharmaceut Anal Acta 4(204): 1-5.

Kibonde, S.F., Augustino, S., Mabiki, F.K. and Mdegela, R. (2018). Ethnobotanical study of medicinal plants used to manage HIV/AIDS opportunistic infections in Rungwe, Mbeya Region, Tanzania. Journal of Medicinal Plants Research 12(2): 32-41.

Kunwar, R. M., Pandey, L. M., Kunwar, L. M. and Bhandari, A. (2014). Medicinal plants and ethnomedicine in peril: a case study from Nepal Himalaya. Hindawi 2014: 1-7.

Lakey and Dorji, K. (2016). Ecological status of high altitude medicinal plants and their sustainability: Lingshi, Bhutan. BMC Ecol. 15(45): 1-14.

Lindh, H. (2015). Mothers, markets and medicine. The role of traditional herbal medicine in primary women and child health care in the Dar es Salaam region, Tanzania. Thesis for Award of Bachelor Degree at Uppsala University, Uppsala: 57pp.

Lutz, J. A., Larson, A. J., Swanson, M. E. and Freund, J. A. (2012). Ecological Importance of Large-Diameter Trees in a Temperate Mixed-Conifer Forest. PLoS ONE 7(5): 15pp.

Mahunnah, R. L. A. (2002). Ethnobotany and conservation of medicinal plants in africa : the way forward in the next. In; Meeting of the Inter-African Experts Committee on African Traditional Medicine and Medicinal Plants, Arusha, Tanzania. 9pp.

Malik, A. Z. and Bhatt, A. B. (2016). Regeneration status of tree species and survival of their seedlings in Kedarnath Wildlife Sanctuary and its adjoining areas in Western Himalaya, India. Tropical Ecology 57(4): 677-690.

Maliwichi-nyirenda, C. P., Maliwichi, L. L. and Franco, M. (2011). Medicinal uses of *Berberis holstii* Engl. (Berberidaceae) in Malawi, the only African endemic barberry. Journal of Medicinal Plants Research 5(8): 1367–1373.

Maregesi, S. M. and Mwakalukwa, R. (2015). Ethnopharmacological Study on Medicinal Plants used to treat infectious diseases in the Rungwe District, Tanzania. International Journal of Medicinal Plants and Natural Products (IJMPNP) 1(3):15–23.

Morgan, D. L. (2002). Focus group interviewing. In Gubrium, J.F. and Holstein, J.A. (Eds.). Handbook of interviewing research: Context and Method. Sage Publications Inc. Thousand Oaks, CA.141-159.

Msuya, T. S. and Kideghesho, J. R. (2009). The role of traditional management practices in enhancing sustainable use and conservation of medicinal plants in West

Usambara Mountains. Tropical Conservation Science 2 (1): 88–105.

Mwakisunga, B. (2017). Forest Biomass Management Challenges in Commercially Exotic Tree Plantation Areas: A Case Study from the Rungwe Volcanic Province (Southern Highlands of Tanzania). Journal of Geoscience and Environment Protection 2017(5): 67-75.

Phama, J. O., Panagos, M. D., Myburgh, W. J. and Pfab, M. F. (2014). The population status of the endangered endemic plant Aloe peglerae: Area of occupancy, population structure, and past population trends. South African Journal of Botany 93 (2014): 247-251.

Phillips, O. L., Martı´nez, R. V., Vargas, P. N., Monteagudo, A. L., Chuspe Zans, M., Sa´nchez, W. G., Cruz, A.P., Timana, M., Markku Yli-Halla, M. and Sam Rose, S. (2003). Efficient plot-based floristic assessment of tropical forests. Journal of Tropical Ecology (2003) 19: 629–645.

Nahashon, M. (2013). Conservation of Wild-harvested Medicinal Plant Species in Tanzania Conservation of Wild-harvested Medicinal Plant Species in Tanzania. Thesis for Award of Master at Uppsala University, Uppsala: 67 pp.

Ndah, N. R., Andrew, E. E. and Bechem, E. (2013). Species composition, diversity and distribution in a disturbed Takamanda Rainforest, South West, Cameroon. African Journal of Plant Science 7(12): 577–585.

Nyumba, T. O., Wilson, K., Christina J. Derrick, C. J. and Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. Methods Ecol Evol. 2018(9): 20-32.

Nyunza, G. and Mwakaje, A. E. G. (2012). Analysis of Round Potato Marketing in Tanzania: The Case of Rungwe District, Tanzania. International Journal of Business and Social Science 3(23): 1-11.

Otang, W. M., Grierson, D. S. and Ndip, R. N. (2012). Ethnobotanical survey of medicinal plants used in the management of opportunistic fungal infections in HIV/AIDS patients in the Amathole District of the Eastern Cape Province,

South Africa. Journal of Medicinal Plants Research 6(11): 2071–2080.

Rahman, H., Rahman, M., Islam, M. and Reza, S. (2011). The importance of forests to protect medicinal plants: a case study of Khadimnagar National Park, Bangladesh. International Journal of Biodiversity Science, Ecosystem Services and Management 7(4): 283–294.

Souza, A. S, Albuquerque, U. P., Nascimento, A. L., Santoro, F. R., Torres-Avilez, W. R., Lucena, F. P. and Monteiro, J. M. (2017). Temporal evaluation of the Conservation Priority Index for medicinal plants. Acta Botanica Brasilica 31(2): 169-179.

Taline, Cristina da Silva., Josilene Marinho da Silva., and Marcelo, A. R. (2018). What Factors Guide the Selection of Medicinal Plants in a Local Pharmacopoeia? A Case Study in a Rural Community from a Historically Transformed Atlantic Forest Landscape. Evidence-Based Complementary and Alternative Medicine (2018): 1-10.

Teklay, A., Abera, B. and Giday, M. (2013). An ethnobotanical study of medicinal plants used in Kilte Awulaelo District, Tigray Region of Ethiopia. Journal of Ethnobiology Ethnomedicine 9(1): 1-23.

Trotter, R. T. and Logan, M. H. (1986). Informants consensus: a new approach for identifying potentially effective medicinal plants," In: Plants in Indigenous Medicine and Diet. Redgrave Publishing Company, Bedford Hill, NY, USA, 1986: 91-112.

United Republic of Tanzania (2011). Ministry of Natural Resources and Tourism. Management Plan for Mount Rungwe Nature Reserve 2011/12 to 2015/16: 150pp.

United Republic of Tanzania (2017). Mount Rungwe Nature Forest Reserve Management Plan. 133pp.

Uprety, Y. and Asselin, H. (2012). Review article Contribution of traditional knowledge to ecological restoration : Practices and applications. Écoscience 19(3): 225–

237.

Vasisht, K. and Kumar, V. (2004). Compendium of Medical and Aromatic plants. Volume 1: Africa. ICS - UNIDO. Trieste. 23–56.

CHAPTER FIVE

5.0 Conservation framework for medicinal plants used in managing HIV/AIDS opportunistic infections in Rungwe District, Mbeya Region, Tanzania

Suma F. Kibonde[1*], Suzana Augustino[2], Faith P. Mabiki[3] and Robinson Mdegela[4]

[1]Sokoine University of Agriculture, Solomon Mahlangu College of Science and Education, Department of Geography and Environmental Studies, P.O. Box 3038, Chuo Kikuu, Morogoro, Tanzania

[2]Sokoine University of Agriculture, College of Forestry, Wildlife and Tourism, Department of Forest Engineering and Wood Sciences, P.O. Box 3014 Chuo Kikuu, Morogoro, Tanzania

[3]Sokoine University of Agriculture, Solomon Mahlangu College of Science and Education, Department of Chemistry and Physics, P.O. Box 3038, Chuo Kikuu, Morogoro, Tanzania

[4]Sokoine University of Agriculture, College of Veterinary Medicine and Biomedical Sciences, Department of Public Health, P.O. Box 3021- Chuo Kikuu, Morogoro, Tanzania

*Corresponding author: kibondesuma9@yahoo.com

5.1 Abstract

Rungwe District has the highest percentage of HIV/AIDS prevalence than the nation. Due to several constraints associated with the antiretrovirals, HIV patients in the district use medicinal plants to manage HIV/AIDS opportunistic infections. Despite the reliance on medicinal plants by people living with HIV in Rungwe, there is no specific framework to suit their conservation. This study aimed at developing and proposing a

conservation framework for conserving medicinal plants in the area. Specifically, the study determined conservation challenges and documented conservation approaches before proposing a conservation framework that may help in conservation of medicinal plant species. The Island Biogeography and Knowledge-Practice-Belief system Theory were reviewed as the basis for the study. Data on conservation challenges facing medicinal plants and conservation approaches were gathered using questionnaire. In puts for conservation framework were obtained from the findings from; ethnobotanical study, explored indigenous knowledge on conservation, assessment of population status and findings from conservation challenges and conservation approaches. The proposed conservation framework was made up consisting different of variables such as; legal and institutional frameworks, ex-situ conservation, in-situ conservation, conservation knowledge (formal and/or indigenous). Further, site selection for ex-situ conservation with proper seedlings preparation and proper management of restored in-situ medicinal plants. The study recommends for implementation of the proposed conservation framework through involvement of communities as the custodian the resources, conservationists, environmental policy makers, academic and research institutions, agencies such as Tanzania Forest Services Agency (TFS), Tanzania Forest Research Institution (TAFORI) and all stake holders interested in medicinal plants.

Key Words: Conservation framework, medicinal plants, conservation challenges, Rungwe District

Target journal: Journal of Landscape Ecology

5.2 Introduction

The prevalence of HIV/AIDS presents a challenge to the poorly invested health systems of the developing countries, a situation that has intensified the use of medicinal plants

(Batugal *et al*., 2004; Peltzer, 2009; Orisatoki and Oguntibeju, 2010; Haile *et al*., 2017). Plants which are the largest constituent of traditional medicine, serve between 80 – 90% of people worldwide and they originate from different species found in the world (Smith-Hall *et al*., 2012).

About 25% plant species in Tanzania are reported to be medicinal, which serve up to 60% of the population (Langwick, 2008; URT, 2015). Therefore, medicinal plants are crucial in the health care system in Tanzania especially to people living with HIV/AIDS (Kisangau *et al.,* 2007). However, yearly degradation of forest resources due to various factors such as; settlements establishment, arable farming, frequent forest fires, tree felling for timber, wood fuel, construction materials and farm tools have been threatening sustainable availability of some medicinal plants in the country (Francis *et al*., 2016; URT, 2016; Drakenberg *et al*., 2016).

In acknowledging the role played by medicinal plants on human health, various endeavours have taken place worldwide. For example; During the Chiang Mai, Thailand (1988) conference, the participants prepared and issued "The Chiang Mai Declaration – Saving Lives by Saving Plants" – which insists on the importance of medicinal plants and calls on the United Nations, its agencies and Member States, as well as other international organizations, to take action for the conservation of medicinal plants. The guidelines to provide a framework for the conservation and sustainable use of plants in medicine were drafted: to study traditional knowledge on the use of plants in health care, to identify the medicinal plants, outline their distributions and assess their abundance, wherever possible, to cultivate the medicinal plants as the source of supply, to ensure that any collection from the wild is sustainable, to improve techniques for harvesting, storage and production, to conserve populations of medicinal plant species in natural

habitats, to conserve populations of medicinal plant species ex-situ and to build public support for the conservation of medicinal plants through communication and cooperation (WHO, IUCN and WWF, 1993).

Moreover, recognizing that medicinal plants are world treasure to be fostered for the future benefits, a Global Strategy for Plant Conservation by the Parties to the Convention on Biological Diversity (CBD) was adopted in April 2002, whereby over 175 countries of the world ratified the strategy. CBD was formed to provide the background for sustainable use and for equitable sharing of benefits arising from the exploitation of medicinal plants. With regards to conservation of medicinal plants the Strategy set out 16 outcome-oriented global targets for 2010 which supported the work of the IUCN Species Survival Commission through the Specialist Groups and the Red List Programme (IUCN, 2017).

Likewise, Zimbabwe established a Conservation and Sustainable use of Traditional Medicinal Plants to promote the conservation, sustainable use and cultivation of endangered medicinal plants. The project achieved the following outputs: the National Herbarium and Botanical Gardens, the University of Zimbabwe School Of Pharmacy, the Southern Alliance for Indigenous Resources (SAFIRE), a regional NGO, and the Attorney General's Office. To achieve goals, the project used a community-based approach through which local communities were involved in project implementation (Chapeyama, 2009).

Generally, various developed country specific conservation frameworks on medicinal plants exist (SCBD, 2009; WB, 2004) and target at avoiding extinction of the valuable medicinal plants through implementing different conservation strategies including

restrictive harvesting, protecting specific niche with abundant medicinal plants and ensuring regeneration of medicinal plants through implementing propagation of medicinal plants. All the frameworks developed targeted at reducing impacts brought by different human activities including excessive harvesting of plants, pollution and forest fires that negatively impact plant population.

Tanzania has taken some steps towards conservation initiatives. For example, the country is a member to the Convention on Biological Diversity (CBD) of 1992 after ratifying in 1996, the step made the country a fully-fledged party to the convention in response to international obligations to protect and conserve its biodiversity as a global resource. At national level a functional policy and legislative framework serves to ensure that international, regional and national obligations are met at all levels from central government to the individual level. To implement the requirements, a National Biodiversity Strategy and Action Plan (NBSAP) were established in 2001, the organ guides realisation and promotion of sustainable utilisation and conservation of biodiversity in general (URT, 2015).

The country also has research institutions such as Tanzania Forest Research Institute (TAFORI) and Sokoine University of Agriculture having the mandate to conduct research. Moreover, Tanzania has formulated policy and legislation on traditional medicine and established a section in the Ministry of Health and Social Welfare. None the less, in each and every district there is council to deal with matters pertaining to Traditional, Complementary and Alternative Medicine (TCAM). More importantly, the Institute of Traditional Medicine (ITM) of the Muhimbili University of Health and Allied Sciences, National Institute for Medical Research (NIMR), perform research tasks

on safety, efficacy, phytochemical studies as well as herbal product formulations (Moshi and Mhame, 2013).

However, issues related to conservation and sustainable uses of medicinal plant species have been down looked. No specific initiatives have been developed to ensure cultivation of medicinal plants to relieve pressure on the wild medicinal resources (Moshi and Mhame, 2013). In this regard, specific conservation plans for the medicinal used in managing HIV/AIDS are needed due to opportunities these materials offer. Therefore, this study was carried out to develop and propose a conservation framework for priority medicinal plants used in managing HIV/AIDS opportunistic infections in Tanzania. In this study, the term conservation framework (CF) is used to mean a tool that enables collaboration between government and non-government, resource managers and other practitioners to guide medicinal conservation. It follows some guidelines such as, to prioritize species that require conservation under constrained resources before determining the most appropriate and effective management actions to be taken.

5.3 Theoretical background

This study is built on two theories, Island Biogeography and Knowledge-practice-belief system. The theory of island biogeography was reviewed as one of the tool that countries have used so as to safeguard natural resources. The theory has been a foundation of protected areas such national parks and nature reserves where there is a controlled interference by communities. According to East and Williams (1984), the aim of conservation is usually to preserve certain species or groups of species rather than entire species communities. The study was conducted in the areas around forest reserves with an expectation that medicinal plants that this study was built on are among resources

safeguarded. Moreover, this study intended to acknowledge the contribution of the people in the local contexts when it comes to take care of resources using their own experiential knowledge. Based on this, the theory of knowledge-practice-belief system was incorporated.

5.4 Methodology

5.4.1 Study area

This study was conducted in Rungwe District, Mbeya Region, Tanzania. The district is rich in forest resources which are important to people's livelihood including medicine (Ndyamukama *et al*., 2013). Rungwe was chosen because of the presence of protected forests such as Rungwe nature reserve and Poroto forest reserve but, are said to be encroached by communities around. Hence, the study was conducted so as to find out conservation challenges and what conservation framework suits the priority species with reference to Poroto forest reserve.

5.4.2 Data collection

Data to develop a conservation framework were gathered from findings on ethnobotanical knowledge which yielded up to 31 medicinal plant species being used to manage HIV/AIDS opportunistic infections in the study area. The findings from indigenous knowledge for conserving medicinal plants were also included. Further, findings from assessment of wild population status of the selected priority medicinal plants for managing HIV/AIDS opportunistic elements to be included in developing the conservation framework. Finally, the findings on conservation challenges of medicinal plants and perceived suitable conservation approaches as suggested by the respondents were important elements for conservation framework.

5.4.3 Data analysis

Descriptive analysis methods were employed to analyse data on conservation challenges of medicinal plants and conservation approaches as perceived by respondents.

5.5 Results

5.5.1 Conservation challenges of medicinal plants in Rungwe District

The findings revealed four major challenges that are perceived as threats on the regeneration capacity of medicinal plants (Fig. 5.1). Young plant species were likely more affected by those challenges such as overgrazing which could lead to browsing of the species. The mature medicinal plant species were likely to be targeted for timber and wood fuel extraction. All these challenges were evidenced in the Poroto forest reserve.

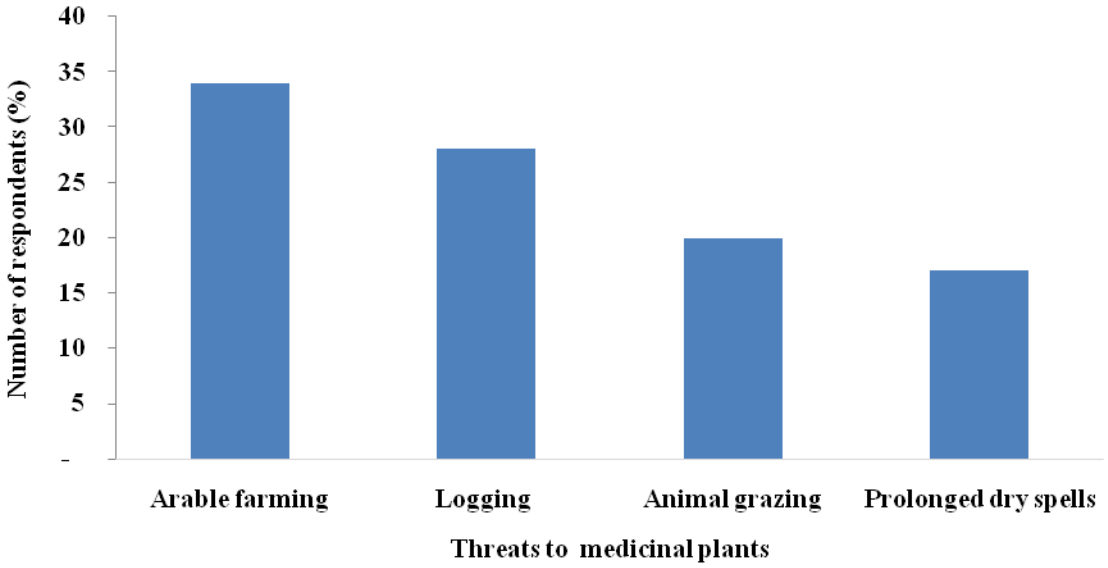

Figure 5.1: Conservation challenges of medicinal plants in the study area

5.5.2 Conservation approaches by communities in Rungwe District

The findings showed that 32% of households in the study villages would prefer ex-situ[1] conservation approach to preserve the two species because it reduces pressure on forest as the availability of medicine outside the forest is guaranteed. Further assessment on gender preference showed that both males and females were interested in the two approaches. About 14% of the households indicated that a policy on promotion of medicinal in the villages was required. This implies that the respondents are aware that institutional legal frameworks are important factors for the conservation of medicinal plant species.

Nevertheless, about 30% of the households' respondents indicated being not aware of any conservation approaches of medicinal plants. This situation is linked to low sensitization and/or initiatives on the conservation of medicinal plants and the need to safeguard medicinal plants is urgently suggested. In line with these findings concerning conservation approaches, the following were the excerpts from key informant interviews: "*…the community should be educated on the importance of medicinal plants so that they may help in their conservation…" (A traditional healer from Syukula village).*

Another quotation was: "... Communities should be involved in conservation activities through their labour power and guards so as to foster conservation effort…" (A forest officer from Tanzania Forest Service Agency- Rungwe District).

5.5.3 Assumptions of the proposed conservation framework

The proposed conservation framework (Fig. 5.2) links a variety of possible conservation variables. The integration of these variables is expected to lead to conservation of

[1] Ex-situ conservation is the process of protecting an endangered species of plant outside its natural habitat Dulloo *et al.* (2010).

priority medicinal plants for managing HIV/AIDS opportunistic infections. When the conservation of medicinal plants is attained and sustained, community health and ecosystem services are expected to be improved. For conservation of medicinal plants to be successful and ultimately improving the health of the people and livelihood in general, the following assumptions are generated: First, legal and institution framework must strive in enabling the environment for establishing ex-situ and in-situ conservation, for example issues pertaining to land ownership must be clear in the frameworks. Secondly, the legal and institutional frameworks have to involve provision of education on conservation to communities for their smooth participation. The knowledge stipulated in this study involves both formal and indigenous as far as they contribute to conservation of medicinal plants. Thirdly, ex-situ conservation requires suitable site selection before its implementation, this study considered elevation and moisture as important factors for medicinal plants' growth. Also it is important that seeds/seedlings are carefully selected for better yields. Fourth, there must be suitable seeds/seedlings so as to restore species that are threatened or lost in the wild. Finally, in-situ conservation is the approach which must be associated with proper management to control species degradation, hence total protection is required.

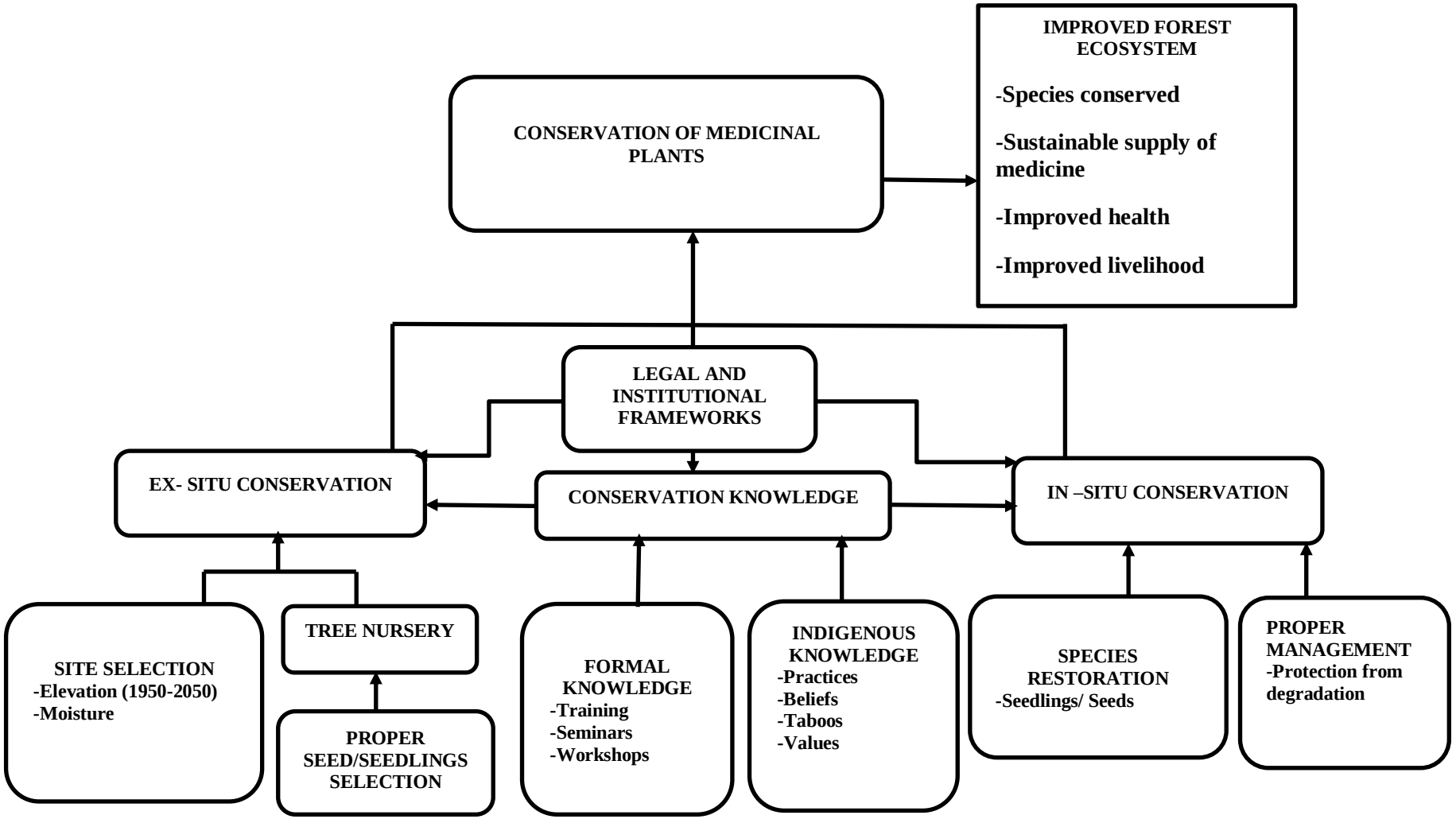

Figure 5.2: Conservation framework for medicinal plants in the study area

5.6 Discussions

The interference of human activities such as arable farming which involved expansion of crop fields, logging and overgrazing was the probable cause of observed conservation challenges of the priority medicinal plant species in the Poroto forest reserve. The challenges correlate with observations by Agisho *et al*. (2014) who reported on the usability of plant species and how the species were affected by anthropogenic activities especially wood extraction and farm extensions. The implication is that if nothing takes place to curb the situation, the sustainability of medicinal plants will be unreliable. Although the International Union for Conservation of Nature (IUCN, 2019) indicates that *Hagenia abyssinica* and *Myrica salicifolia* have not been evaluated for their conservation status, the findings in the study area and those from Ethiopia call for attention.

The choice of ex-situ over in-situ in conservation of medicinal plants indicates that the respondents were aware of the advantages that might accrue from these approaches. The findings are similar to Chen *et al*. (2016) who report on the same approaches being recommended to the conservation of medicinal plants. Likewise Abdela and Sultan (2018) encourage conserving medicinal plants in genebanks and botanical gardens, the two are form of ex-situ conservation.

The proposed conservation framework postulates on the need to conserve medicinal plants species in the study area and wherever used, reverse destructive anthropogenic activities posed on these resources well as other ecological threats posed. It abides to the WHO, IUCN and WWF (1993) and the WHO (2003) guidelines on the conservation of medicinal plants, since it assumes integration of both indigenous and modern knowledge on conservation of plants.

Indigenous knowledge unique to a culture or society has been the basis for many activities including conservation across the world (Nakashima *et al.*, 2000). Indigenous knowledge that is embedded in conservation practices such as, sacredness of plants or forest patches can be maintained even within in-situ and ex-situ conservation approaches (Dulloo *et al*, 2010). Ex-situ conservation is considered the most appropriate way of conserving plants as it relieves pressure exalted on the wild (Chen *et al*., 2016). For in-situ conservation, both the species and their habitat that are conserved, it is easy to protect larger species populations and less disruptive as species are not removed from their habitats. In supporting in-situ conservation approach, Tanzania has gazetted numerous areas with plant resources into national parks and nature reserves with legal frameworks to ensure total protection (URT, 2011).

5.7 Conclusions and Recommendations

The findings from this study indicated that the respondents were aware with anthropogenic activities such as arable farming, logging and overgrazing taking place in the Poroto forest reserve. The respondents were able to associate those threats with unsustainability of the medicinal plant species. More importantly, the respondents showed to be well informed with conservation approaches, this was revealed through the suggestions they made concerning conservation of medicinal plants in their area. Based on the findings the study urges the relevant institutions such as the conservationists, local people and policy makers to address conservation challenges that likely affected the growth of medicinal plant species used to manage HIV/AIDS opportunistic infections in the study area. In addressing all issues pertaining to conservation of medicinal plant species used to manage HIV/AIDS opportunistic infections, the study recommends all stake holders involved in medicinal plants implementing the proposed conservation framework jointly.

5.8 Policy implication

This study urges for inclusion of specific medicinal plants conservation frameworks into environmental policies.

5.9 Acknowledgments

The Carnegie Regional Initiative in Science Education- African Natural Products Network (CR-AFNNET) for financial support which facilitated the execution of this study. Supervisors for their tireless support and guidance, my employer Sokoine University of Agriculture, for granting me with study leave, the Head of Geography and Environmental Studies. Rungwe District Council Officers, District Medical Officers, Forest Officers, and Local Government leaders, community members especially the traditional practitioners and all other informants consulted, for their hospitality, advice, guidance and cooperation during this study.

References

Abdela, G. and Sultan, M. (2018). Indigenous Knowledge, Major Threats and Conservation Practices of Medicinal Plants by Local Community in Heban Arsi District, Oromia, South Eastern Ethiopia. *Advances in Life Science and Technology* 68 (2018). 2224-718.

Agisho, H., Osie, M. and Lambore, T. (2014). Traditional medicinal plants utilization, management and threats in Hadiya Zone, Ethiopia. *Journal of Medicinal Plants Studies* 2(2): 94–108.

Assefa, B., Glatzel, G. and Buchmann, C. (2010). Ethnomedicinal uses of *Hagenia abyssinica (Bruce) J . F . Gmel.* among rural communities of Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 6(1): 1–10.

Batugal, P. A., Jayashree, K., Lee, S. Y. and Jeffrey, T. O. (eds). (2004). Medicinal Plants Research in Asia, Volume1: The Framework and Project Workplans. International Plant Genetic Resources Institute. 221pp.

Chapeyama, O. (2009). Conservation and Sustainable Use of Traditional Medicinal Plants in Zimbabwe. Project Report. 69pp.

Chen, S. L., Yu, H., Luo, H. M., Wu, Q., Li, C. F. and Steinmetz, A. (2016). Conservation and sustainable use of medicinal plants: problems, progress and prospects. *Chinese Medicine* 11(37): 1–10.

Boyd, H. K., Westfall, R. and Stasch, S. F. (1981). Marketing research texts and cases. Richard D., Illinois. 675pp.

Drakenberg, O., Göran E. K. and Fernqvist, K. W. (2016). Environmental and Climate Change Policy Brief Tanzania. 30pp.

Dulloo, M. E., Hunter, D. and Borelli, T. (2010). *Not. Bot. Hort. Agrobot. Cluj* 38(2): 123-135.

East, R. and Williams, G. R. (1984). Island Biogeography and the conservation of New Zealand's indigenous forest-dwelling Avifauna. *New Zealand Journal of Ecology* 7: 27-35.

Francis, J., Edwin, K., Abiud, N. and Freddy, K. (2016). International Journal of Asian Social Science Analysis of Drivers and Agents of Deforestation and Forest Degradation in Masito Forests, Kigoma, Tanzania Contribution/Originality. *International Journal of Asian Social Science* 6(2): 93–107.

Gadgil, M., Berkes, F. and Folke, C. (1993). Indigenous Knowledge for Biodiversity Conservation. *Ambio* 22(2–3): 151–156.

Haile, K. T., Ayele, A. A., Mekuria, A. B., Demeke, C. A., Gebresillasie, B. M. and Erku, D. A. (2017). Traditional herbal medicine use among people living with HIV/AIDS in Gondar, Ethiopia: Do their health care providers know? *Complement Ther Med.* 35: 14-19.

The International Union for Conservation of Nature (2017). IUCN Species Strategic Plan 2017 - 2020. 26pp.

Kibonde, S. F., Augustino, S., Mabiki, F. K. and Mdegela, R. (2018). Ethnobotanical study of medicinal plants used to manage HIV/AIDS opportunistic infections in Rungwe, Mbeya Region, Tanzania. *Journal of Medicinal Plants Research* 12(2): 32-41.

Kisangau, D. P., Lyaruu, H. V. M., Hosea, K. M. and Joseph, C. C. (2007). Use of traditional medicines in the management of HIV/AIDS opportunistic infections in Tanzania: a case in the Bukoba rural district. *Ethnobiology and Ethnomedicine* 3(29): 1-8.

Langwick, S. A (2008). Traditional medicine in a Tanzanian hospital. *American Ethnologist* 35(3): 428–439.

Moshi, M. J. and Mhame, P. P. (2013). Medicinal Plant Research: Pharmacology and Chemistry. *Elsevier Inc.* 32 Jamestown Road, London NW, 7 BY. UK. 887pp.

Mwakisunga, B. and Majule, A. E. (2012). The influence of altitude and management on carbon stock quantities in Rungwe forest , southern highland of Tanzania. *Open Journal of Ecology* 2(4): 214–221.

Nakashima, D., Prott, L. and Bridgewater, P. (2000). Tapping into the world's wisdom. *UNESCO Sources* 125: 1-12.

National Institute for Medical Research (2011). Tanzania District Health Assessment 2008 – 2009 Summary Report. 85pp.

Ndyamkama, M. W., Mutabazi, K. and Silayo, D. A. (2013). Economic Implication of $REDD^{+}$ Initiative on Food Security of Farmers in Rungwe District, Tanzania. *In Proceedings of the International Conference on Reducing Climate Change Challenges Through Forestry and Other Land Use Practices* 1: 1-24.

Orisatoki, R. O. and Oguntibeju, O. O. (2010). The role of Herbal Medicine use in HIV/AIDS treatment. *IMedPub Journals* 1(3): 1–4.

Peltzer, K. (2009). Utilization and practice of Traditional/Complementary/Alternative Medicine (TM/CAM) in South Africa. *Afr. J. Trad. CAM* 6(2): 175-185.

Secretariat of the Convention on Biological Diversity (2009). The Convention on Biological Diversity Plant Conservation Report: A Review of Progress in Implementing the Global Strategy of Plant Conservation (GSPC). 48pp.

Smith-Hall, C., Larsen, H. O. and Pouliot, M. (2012). People, plants and health: a conceptual framework for assessing changes in medicinal plant consumption. *Journal of Ethnobiology and Ethnomedicine* 8(43): 1-11.

Tilumanywa, V. T. (2013). *Land use and livelihood changes in the Mount Rungwe ecosystem, Tanzania*. Thesis for Award of Doctor of Philosophy Degree at Stellenbosch University, Stellenbosch. 272pp.

United Republic of Tanzania, Ministry of Natural Resources and Tourism (2011). Management Plan for Mount Rungwe Nature Reserve 2011/12-2015/16. 150pp.

United Republic of Tanzania (2015). National Biodiversity Strategy and Action Plan (NBSAP) 2015-2020 Division of Environment, Vice President's Office. 154pp.

United Republic of Tanzania (2016). Ministry of Health, Community Development, Gender, Elderly and Children. HIV Service Delivery Models Mapping HIV Service Delivery Strategies in Tanzania. 88pp.

Wilson, E. O. and Willis, E. O. (1975). Applied biogeography. In: Cody, M. L. and Diamond, J. M. (eds) *Ecology and evolution of communities*. Harvard University Press, Cambridge. pp522–534.

World Health Organization, International Union for Conservation of Nature, World Wide Fund (1993). Guidelines on the Conservation of Medicinal Plants. 38pp.

World Health Organization (2003). WHO guidelines on Good Agricultural and Field Collection Practices (GACP) for medicinal plants. WHO, Geneva. 72pp.

World Bank (2004). Medicinal Plants: Conservation and Sustainable Use in Sri Lanka. No. 66. 4pp.

CHAPTER SIX

6.0 Summary, Conclusion, Recommendations and Findings Implication

6.1 Overall Summary of the Findings

This thesis addressed four major aspects in relation to conservation status of medicinal plants used to manage HIV/AIDS opportunistic infections in Rungwe District, Mbeya Region, Tanzania. Specifically, the study identified and documented medicinal plant species used to manage HIV/AIDS opportunistic infections in the study area and it explored indigenous knowledge on conservation of medicinal plant species in the study area. Furthermore, the study assessed the wild population status of the priority medicinal plant species in order to determine their spatial distribution, structure and density in the study area. Finally, the study proposed a conservation framework that could serve in conservation of medicinal plants.

6.2 Major Findings and Conclusions

This study revealed up to 31 medicinal plant species used to manage HIV/AIDS opportunistic infections in the study area. The mostly used families were Compositae and Rosaceae. Tuberculosis utilized largest share of the medicinal plant species. The findings also indicated that leaves were the most extracted plant parts in preparation of medicine. The knowledge on medicinal plant species was significantly influenced by respondents' ethnic backgrounds and education. Findings on indigenous knowledge on conservation indicated that people were knowledgeable to nine conservation practices of which selective harvesting of medicinal plants was highly acknowledged to contribute on conservation. Further, the findings indicated that adults had significantly higher indigenous knowledge on conservation than the youth. Similarly, with regard to gender, males had significantly higher conservation knowledge than females. The inventory

conducted to assess the wild population status of the priority medicinal plant species indicated species to prefer higher altitudes. The two species revealed *J*-shaped curves indicating lower population of young plants (seedlings). Moreover, the species displayed linear patterns by growing adjacent rivers. In terms of density, *Hagenia abyssinica* had higher stem density compared to *Myrica salicifolia.* Some of the conservation challenges as revealed by this study included arable farming, logging and overgrazing. Ex-situ conservation approach was credited by majority of the respondents.

Based on these findings it can be concluded that people in the study area have sound ethnobotanical knowledge meaning that people are aware with the available medicinal plant species used to manage HIV/AIDS opportunistic infections in their area. Likewise the respondents in Rungwe possess good indigenous knowledge on conservation of medicinal plants since they could mention up to nine indigenous conservation practices. Furthermore, the respondents in Rungwe attached more values to some species as they could prioritize seven out of many. The population status assessment carried out on two priority medicinal plant species indicated a general unsustainability among the species. More importantly, the communities in Rungwe showed understanding on conservation challenges dominant in the Poroto forest reserve and they were able to suggest some conservation approaches which could rescue the medicinal plants. Based on the study findings, variables to be included in the proposed conservation framework to help in conservation of medicinal plant species were obtained.

6.3 Recommendations

This study recommends for: more studies on identification and documentation of species which are potential for managing HIV/AIDS opportunistic infections in other areas. There is a need to carryout extensive assessment of the indigenous knowledge on

conservation in other areas of the country. Promoting and integrating indigenous knowledge in conservation is encouraged. Furthermore, there is a need of involving all the people in acquiring indigenous conservation knowledge. This would ensure knowledge sustainability. More strict measures should be formulated and implemented to safeguard medicinal plant species so as to improve population status. The relevant government local authorities, institutions such as Tanzania Forest Services Agency (TFS), Tanzania Forest Research Institute (TAFORI), environmental policy makers, academic institutions and other stake holders concerning medicinal plants should work jointly to conserve medicinal plant species. To attain medicinal plants conservation in the study area and elsewhere the mentioned stakeholders are encouraged to implement the proposed conservation framework.

6.4 Implication of the Study Findings

The findings from this study add valuable information on the existing data base of medicinal plants used to manage HIV/AIDS opportunistic infections. Specifically, the findings have the following implications: generated knowledge on medicinal plants for managing HIV/AIDS opportunistic infections will inform the community on their medicinal resource richness. Through this information, they would be in a position to participate in conserving the species voluntarily. Also, the findings may imply community valuing the plant species than before and by using their indigenous conservation knowledge the sustainability of medicinal plants is guaranteed. Through conserving medicinal plants, it is likely that the entire ecosystem would stabilize and be able to supply enough medicine for those who need them; and hence improving community's health status among people living with HIV/AIDS and the population in general. Furthermore, the country's health sector especially the institution dealing with traditional medicine (ITM) would be facilitated with new information on medicinal

species from where they can initiate their scientific drug innovations, while those responsible for management of plant resources are served with information on population status of the medicinal plants for them to take actions. For the conservation institutions, research institutions and academic institutions, the findings from this study provide the starting point in research activities concerning conservation status of the medicinal plant resources as a whole or by targeting specific threatened species. Moreover, the study findings inform decision makers about weaknesses and strengths of the existing policies towards medicinal plants. Additionally, the study findings would build confidence and raise the morale of traditional healers to get assured that their activities play a significant role in caring for people living with HIV/AIDS. The findings also provide local people with the real picture of their medicinal plant resources and hence putting them in a better position of engaging in conservation efforts.

6.5 Areas for Further Research

(i). There is a need for more and extensive identification of medicinal plants for managing HIV/AIDS opportunistic infections outside the study area.

(ii). In-depth studies are required to establish more ecological requirements of medicinal plants in the study area.

(iii). Phytochemical studies of the medicinal plant species documented in this study should be performed to verify claims on the importance, justify use and efficacy for curing the HIV/AIDS opportunistic infections.

APPENDICES

Appendix 1: Questionnaire

Interviewer's introduction

I am a PhD student from Sokoine University of Agriculture in Morogoro, Tanzania. I am at the stage of research and my research's title is; Conservation of medicinal plants used for managing HIV/AIDS opportunistic infections with focus on villages adjacent to Rungwe nature reserve and Poroto forest reserve, in Rungwe district in Mbeya, Tanzania. I would like to get your insights on the medicinal plants known to manage HIV/AIDS opportunistic infections, any indigenous knowledge associated with conservation of the species as well as your opinions on which strategies could safeguard medicinal plants. Be assured that your responses remain confidential and for academic uses only. Your responses will serve as cornerstone of decisions made for sustainable forest management in the district and the country in general.

Part A: Preliminary information

No	Item	Response
1.	Date of interview	
2.	Questionnaire no.	
3.	Name of interviewer	
4.	Name of respondent (optional)	
5.	Village	
6.	Ward	
7.	Division	
8.	District	
9.	Region	

Part B: Respondents' characteristics

Question Code	Question (A)	Codes and Responses (B)	Instructions to respondent (C)
R10	Respondent's sex	1. Female 2. Male	
R 11	Age		Write in years
R12	Occupation		Give your livelihood activities
R 13	Education level	1. Primary 2. Secondary 3. Tertiary 4. Others	Specify which others

Part C: Respondents' knowledge on HIV/AIDS OIs

R 14	Which of the following diseases do you know?	1. Tuberculosis (TB) 2. Herpes simplex (Genital herpes) 3. Oral candidiasis 4. Herpes zoster (Shingles) 5. Chronic cough 6. Chronic diarrhoea 7. Others	Symptoms and signs will be elaborated. Multiple responses allowed. Specify which others.
R 15	What do you call them in local language?	1. Tuberculosis (TB) 2. Herpes simplex (Genital herpes) 3. Oral candidiasis 4. Herpes zoster (Shingles) 5. Chronic cough 6. Chronic diarrhoea 7. Others	Multiple responses allowed. Specify which others.
R 16	Which of the diseases are more common in	1. Tuberculosis (TB) 2. Herpes simplex (Genital herpes) 3. Oral candidiasis	Rank them.

	your area?	4. Herpes zoster (Shingles) 5. Chronic cough 6. Chronic diarrhoea 7. Others	

Part D: Respondent's Knowledge on Medicinal Plants for HIV/AIDS OIs

R 18	Do you know any plant species used to treat any of the above diseases?		Multiple responses allowed
R 19	If yes how many species do you know and they treat what disease?		Multiple responses allowed
R 20	Where are they obtained?	…….	Multiple responses allowed
R 21	Apart from those managing the mentioned diseases what are other common medicinal plant species that you know and what diseases do they treat?	…… …… …… …… …….. ……..	
R 22	Where are these medicines found?		
R 23	Do you think that medicines	1. Yes 2. No	

	from plants work?	3. Not sure	
R 24	Are the plant species used to treat the fore mentioned diseases abundant?	1. Yes 2. No 3. Not sure	
R 25	Where do you get MPs?		Multiple responses allowed.
R 26	Are there specific medicinal plant species that are found in MRNR and Poroto forest only?	1. Yes 2. No 3. Not sure	
R 27	If Yes to no. 25, can mention the species?		Multiple responses allowed.
R 28	What can you say about the trend of medicinal plants during HIV era?	1. Decreasing 2. Increasing 3. Uncertain	
R 29	What could be reasons for your answer in no.28?		Multiple responses allowed.

Part E: Knowledge on conservation of medicinal plants			
R 30	What conservation practices can help in conserving medicinal plants?		Multiple responses allowed
R 31	Is there indigenous knowledge that is used to conserve MPs?		**Multiple responses allowed**
R 32	Are there specific species that a certain conservation practice works for?		**Multiple responses allowed**
R 33	What challenges conservation of medicinal plants?		**Multiple responses allowed**
R 34	Is there any need to conserve MPs?	1. Yes 2. No **3.** Not sure	**Multiple responses allowed**
R 35	If yes in 34, what could be done to conserve MPs?		**Multiple responses allowed**

Your comments……

"THANK YOU FOR YOUR COOPERATION''

Appendix 2: Questions for focus group discussions

1. Among the species mentioned to manage HIV/AIDS OIs, which are the most important?
2. At what stage is the plant harvested for medicine?
3. Are there threats that are facing the species?
4. Which species is more vulnerable to threats and why?
5. Which species need protection or conservation?
6. Is there any indigenous knowledge pertaining to conservation of species?
7. Which species is more targeted by the Ik? And why?
8. Does the IK works to safeguard species?
9. Are there any modern mechanisms aiming at conserving species?
10. Which species is more targeted and why?

Recommendation……..

Appendix 3: Guide observation for transect walk

1. Plant form (tick as appropriate. Filled in by interviewer from observation)
    i. Tree
    ii. Shrub
    iii. Herb
    iv. Grass
    v. Climber
    vi. Other (specify)……
2. Common (English) name(to be filled in by botanist
3. Scientific names (to be filled in by the botanist
4. Part(s) used or from which medicine is extracted (tick as appropriate)
    i. Leaves ……
    ii. Bark ……
    iii. Roots ……
    iv. Fruits ……
    v. Flowers ……
    vi. Other (specify) ……

Appendix 4: Interview guide for (THs) on the use of medicinal plants for managing HIV/AIDS OIs in Rungwe District, Mbeya Region, Tanzania.

District…….Ward…….Village……

Date……. Facilitator…….

During the interviews, the symptoms of various HIV/AIDS opportunistic infections will be described to (THs) so as to enable them give the appropriate plant species they usually use to manage the infections, how they use, which plant parts are used, where they get the medicine as well as their abundance. (Plant parts are: B-bark, F-fruit, L-leaves, R-roots, Se-seeds, St-stems, Sts-stem string, WP-whole plant).

List of OIs	Plant used (family-scientific name)	Local name (Nyakyusa)	Parts used	Preparation	Where they obtain	How abundant	Distance to access the medicine (km)
Tuberculosis (TB)							
Herpes simplex							
Oral candidiasis							
Herpes zoster (Shingles)							
Chronic cough							
Chronic diarrhoea							

THANK YOU FOR YOUR COOPERATION

Appendix 5: Interview guide for (MDs/ HIV/AIDS coordinator) on the use of medicinal plants for managing HIV/AIDS OIs in Rungwe District, Mbeya Region, Tanzania

1. What is the latest situation of HIV/AIDS prevalence?
   i. Region (Mbeya out of all regions in Tanzania)…… …..
   ii. District (out of all districts in Mbeya region)……..
2. What is the annual rate of spread?.....
3. What are the factors leading to your district holding the position it is?
   ……
   ……
4. How can you associate HIV/AIDS prevalence and OIs in your working area?.....
   .....
5. Basing on the above question what are common HIV/AIDS OIs in Rungwe District? (as per village)
   i. ……
   ii. ……
   iii. ……
   iv. ……
   v. ……
   vi. …….
6. What can you say about HIV/AIDS victims' attendance to health services?
   i. Good?
   ii. Poor?

   Give reasons to your response……
7. What could be the reasons for (PLHA) opting to use traditional medicine?.....
8. What efforts are in place to encounter the problem?…….....

Appendix 6: Checklist for medicinal plants used in managing HIV/AIDS OIs in Rungwe Nature Reserve and Poroto Forest Reserve

Region…… District……
Date…….. Time……

Transect	Plot No.	Latitude	Longitude	Altitude	Voucher No.	Local Name	Scientific Name	Habitat	DBH	Plant condition

Appendix 7: Data collection sheet for prioritized medicinal plants used in managing HIV/AIDS OIs in Poroto Forest Reserve

Region…… District……
Date…….. Time……

Village	Transect no.	Elevation	Sampling point no.	Sampling point coordinates	Species name	Species coordinates	DBH (cm)

Appendix 8: Consent form

My name is SUMA FAHAMU KIBONDE a PhD student at the Sokoine University of Agriculture (SUA). I'm doing a study with the above mentioned title to address an important conservation issues on medicinal plants species used to manage diseases and thus proposing as conservation framework that will ensure sustainability of the plant species to carter for many functions and services. In addition to that as a PhD student this study is mandatory for being awarded a degree at the end of study.

Aim of the study

My objective is to understand the uses of different medicinal plant species used by communities and their conservation measures around Forest Reserves in Rungwe District. I would like to speak with people, who use, and prescribe these medicinal plants so I can understand their knowledge on the issue.

Participation in this study:

I invite you to participate in my study, to ask and be asked questions. This interview will last for about 15 minutes. Feel free to expand on the topic or talk about related ideas and open for cases you would not like to disclose. If you have any question at any stage, please don't hesitate to ask. After the interview, I would like to request you to take me on a field trip depending on the distance to see the concerned plants.

Risks:

There is no risk anticipated in participating in this study apart from psychological ones.

Benefits:

By participating in this study, knowledge of traditional practitioners will be assessed. The prioritized Medicinal plant species will be listed in order for identification.

Confidentiality:

All the personal information will be kept confidential. We will keep the material in a secure place. Only we and research team will have access to the material. Results of our study will be informed back to participants of the study and presented on scientific conferences and published in an Open Access Journals.

Cost:

You will not be required to make any payments to participate in this study.

Contacts:

1. **The student researcher,**

Suma Fahamu Kibonde

Department of Geography and Environmental Studies

Solomon Mahlangu College of Science and Education

Sokoine University of Agriculture

P.O. Box 3038, Chuo Kikuu Morogoro, Tanzania.

2. **Administration**

Directorate of Research and Postgraduate Studies

P.O. Box 3151

Chuo Kikuu, Morogoro,Tanzania

Tel: 255564388

Fax: 255564388

Telex: 55308 UNIVMOG TZ

E-Mail: drpgs@suanet.ac.tz

3. Supervisors

Dr. Suzan Agustino

Department of Forest Engineering and Wood Sciences

College of Forestry, Wildlife and Tourism

Sokoine University of Agriculture

P.O. Box 3014 Chuo Kikuu, Morogoro, Tanzania

Dr. Faith MABIKI

Department of Chemistry and Physics

Solomon Mahlangu College of Science and Education

Sokoine University of Agriculture

P.O. Box 3014 Chuo Kikuu, Morogoro,

4. Participant's Agreement

I, _____have read/been told of the contents of this form and have understood its subject. I agree to participate in this study.

Signature of participant_____

Signature of researcher_____

Date_____

Appendix 9: Checklist used for survey of conservation of medicinal plants for managing HIV/AIDS OIs in Rungwe District, Mbeya Region, Tanzania.

1. When was the forest gazetted?..... Act No?.....Govt. Notice……
2. When was the upgrading to nature reserve done?.....Act No…….Govt. Notice……...
3. What has been the reasons for these shifts?.....
   ……
   ……
   What is the conservation status of the forest during these changes?.....
   ……
   ……
   What can you say about the presence of medicinal plants in the reserve?.....
   ……
   ……
   ……..
4. Any threats to medicinal plants?
   ……
   ……
   ……
5. What are your future plans?
   ……
   ……
   ……
   ……
   Any comments …….

Appendix 10: Ethical clearance certificate

THE UNITED REPUBLIC
OF TANZANIA

National Institute for Medical Research
3 Barack Obama Drive
P.O. Box 9653
11101 Dar es Salaam
Tel: 255 22 2121400
Fax: 255 22 2121360
E-mail: headquarters@nimr.or.tz

Ministry of Health, Community
Development Gender, Elderly & Children
6 Samora Machel Avenue
P.O. Box 9083
11478 Dar es Salaam
Tel: 255 22 2120262-7
Fax: 255 22 2110986

NIMR/HQ/R.8a/Vol. IX/2325

13th October 2016

Ms Suma F Kibonde
Sokoine University of Agriculture
Faculty of Science
P. O. Box 3038, MOROGORO.

CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: Conservation of Medicinal Plants for Managing HIV/AIDS Opportunistic Infections around Mount Rungwe Nature Reserve, Mbeya Region, Tanzania (Kibonde S F *et al)* has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine. NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Site: Villages around Mount Rungwe Nature Reserve: Ndaga, Ilundo, Syukula, Kyimo, Bunyakyolo and Nditu, Rungwe District, Mbeya Region

Approval is for one year: 13th October 2016 to 12th October 2017.

Name: Dr Mwelecele N Malecela

Signature
CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Prof. Muhammad Bakari Kambi

Signature
CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, COMMUNITY
DEVELOPMENT, GENDER, ELDERLY
&CHILDREN

CC: RMO Mbeya Region,
DED Rungwe District
DMO Rungwe District