

**Plant diversity and ethnobotany of medicinal plants with the antimicrobial  
investigation of selected plants in *Menz Gera* District, Amhara region,  
Ethiopia**

*Gbremicael Fisaha Gebremedhin*

Addis Ababa University

Addis Ababa, Ethiopia

October 2020



**Plant diversity and ethnobotany of medicinal plants with the antimicrobial investigation of selected plants in *Menz Gera* District, Amhara region, Ethiopia**

***Gebremicael Fisaha Gebremedhin***

A Dissertation Submitted to the Department of Plant Biology and Biodiversity Management, Presented in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy (Plant Biology and Biodiversity Management)

Addis Ababa University

Addis Ababa, Ethiopia

October 2020

# ADDIS ABABA UNIVERSITY

## GRADUATE PROGRAMMES

This is to certify that the Dissertation prepared by Gebremicael Fisaha Gebremedhin, entitled: **Plant diversity and ethnobotany of medicinal plants with the antimicrobial investigation of selected plants in *Menz Gera* District, Amhara region, Ethiopia;** and submitted in partial fulfillment of the Requirements for the Degree of Doctor of Philosophy (Plant Biology and Biodiversity Management) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

### Signed by Examining Board:

Name		Signature	Date
1. Mesfin Tadesse (Ph.D)	(Examiner)	_____	_____
2. Mirutse Giday (Prof.)	(Examiner)	_____	_____
3. Zemedet Asfaw (Prof.)	(Advisor)	_____	_____
4. Sebsebe Demissew (Prof.)	(Advisor)	_____	_____
5. Ermias Lulekal (Asso. Prof.)	(Advisor)	_____	_____

\_\_\_\_\_  
Chair of Department or Graduate Programme Coordinator

## ABSTRACT

### **Plant diversity and ethnobotany of medicinal plants with the antimicrobial investigation of selected plants in Menz Gera District, Amhara region, Ethiopia**

Gebremicael Fisaha, Ph.D Dissertation

Addis Ababa University, 2020

*This dissertation is the result of a study made on the plant diversity and ethnobotany of medicinal plants in Menz Gera District, North Shewa Zone, Amhara Region, Ethiopia. Data on vegetation and the ethnobotany of medicinal plants were collected during multiple field visits made at different seasons between 2016 and 2018. Vegetation data were collected in Yegana and Gajilo forest patches using a systematic random sampling design. Seventy-two quadrats, at 50m altitudinal drop from 14 transects (7 transects for each forest patch) set at 500 m interval, measuring 20mx20m for mature trees and 10mx10m, 5mx5m and 2mx2m sub quadrats for saplings, seedlings/shrubs and herbs respectively, were laid down. Ethnobotanical information on traditional medicinal plants was gathered through semi-structured interviews involving 390 informants representing different social groups, through group discussions, field observation, guided field walks and market survey in 13 Kebeles (sub-districts) of the District. Antimicrobial activity testing was conducted on eight medicinal plant species with high informant consensus values and no record of previous such tests. A total of 284 species in 213 genera and 89 families were recorded from both ecological and ethnobotanical studies. Asteraceae and Poaceae were the families with the highest number of species (14.44% each) followed by Fabaceae (6.69%). Twenty-five (8.8%) endemic species to Ethiopia were encountered. A total of 212 plant species representing 154 genera and 72 families were identified from the natural forest patches whereas 72 species belonging to 59 genera and 17 families were collected outside of the natural forest patches through ethnobotanical inventory. Three plant communities (*Juniperus procera* - *Olea europaea* subsp. *cuspidata*, *Hagenia abyssinica* - *Ekebergia capensis* and *Podocarpus falcatus* - *Galiniera saxifraga*) were identified. Structural and regeneration status analysis of tree species revealed different population structures indicating that there are species that require urgent conservation measures. A total of 156 plant species that belong to 136 genera and 67 families were identified to have values for treating 87 humans and 16 livestock ailments in traditional medicine. Asteraceae had the highest number of traditional medicinal plants (9.62%), followed by Lamiaceae (6.41%) and Solanaceae (5.77%). The most frequently used plant parts for the preparation of remedies were leaves and roots, which accounted for 32.05% and 30.77% respectively. The oral route of administration (46%) was commonly used for both human and livestock disease treatment. Out of the traditional medicine, 21(13.5%) were found to be traded at local markets and were sold and bought for different purposes. Gastrointestinal disease category scored highest ICF (0.78) and abdominal pain; Diarrhea and Gastritis were the most reported human health problems under this disease category. Parents were the major (85%) sources of indigenous knowledge on herbal medicine in the area. A broad-spectrum of antimicrobial activity of extracts was shown in the cases of *Inula confertiflora* (leaf), *Laggera tomentosa* (root) and *Satureja abyssinica* (leaf). Ever-increasing population, which demands more land for livelihood with the usual unsustainable collection of traditional medicinal plants from natural stands are the main threats to the plants of the study area. Plantation of indigenous trees to increase their abundance, providing alternative sources of livelihood to minimize deforestation, establishment of a research center for threatened medicinal plants and indigenous trees and further study on selected traditional medicinal plants for drug development are some of the actions required in the short time range.*

**Key words:** Antimicrobial test, ethnobotany, forest vegetation, forest patches, Indigenous knowledge, traditional medicine.

## DEDICATION

This dissertation is dedicated to my Father Late Kes Fisaha Gebremedihin and Mother Late Aregash Teferi who paid too much sacrifice for my today's life; and the *Menz Gera* District community for conserving and sharing their tremendous indigenous knowledge besides their hospitality.

--- *“If conservation of natural resources goes wrong, nothing else will go right.”* ...  
(M. S. Swaminathan, 2008)

*“Let's have a Green and Clean Common Living Room (Environment)”*

## ACKNOWLEDGMENTS

First and foremost, I thank the Almighty God for His unspeakable gift to this achievement.

I would like to pass a heartfelt thanks to my supervisors Professor Zemedu Asfaw, Professor Sebsebe Demissew and Dr. Ermias Lulekal, Department of Plant Biology and Biodiversity Management, Addis Ababa University (AAU), for their guidance, inputs and critical comments right from the development of the proposal up to the dissertation write-up.

I am very grateful to the following institutions: Addis Ababa University Research and Graduate Programmes Office for the research fund; Debre Berhan University (DBU) for sponsoring my Ph.D study. The Biology Department for allowing me the microbial laboratory to conduct the *in-vitro* antimicrobial test; Chemistry Department for their cooperation during medicinal plant extraction; Institute of Technology-Department of Chemical Engineering of DBU for the use of the laboratory facility for crushing the dried specimens for maceration are also acknowledged. My thanks also goes to the Institute of Biotechnology and the Center for Food Science and Nutrition of AAU for their support during medicinal plant extraction and EPHI for providing me the test pathogens for the anti-microbial tests. I am also grateful to Dr. Tigist Wondimu the PI for the third AAU Thematic Research Fund with three Sub-thematic titles for involving me to work in the project and evaluating my dissertation proposal and all members of the project. Professor Zemedu Asfaw the PI for the sub-thematic project entitled “*Utilization of Plant Resources by Local people in Some Ethiopian Mountains (Bale Mountains, Arsi Mountains, Gugie Highlands, Mt. Abune Yosef and Mt. Guassa: an Ethnobotanical Approach*” and all members of the sub-thematic project for the financial sponsorship and follow up are highly acknowledged. My special thanks go to Dr. Ermias Lulekal for his brotherly all-round advice, help and supply of a field vehicle from his project from MoIT during my data collection. I would like to extend my deepest gratitude to Rufford Small Grants for their financial support, which contributed a lot to my successful field and laboratory data collection. I would like to thank IDEA WILD for their research materials support.

I would like to extend my gratitude to Dr. Bikila Warkneh Chairperson of the Department of Plant Biology and Biodiversity Management for his kind cooperation both professional and administratively, members of the National Herbarium and the Plant Biology and Biodiversity Management Department experts; namely Ato Melaku Wondafrash, W/o Shewangiziw Lemma, Ato Wege Abebe, Ato Shambel Alemu, Ato Fisseha Getachew for their expert service and W/o Yirgalem Haileslase and W/o Nunu for their cooperation in administrative service. I

have also special thanks to Dr. Tamrat Bekele for his evaluation of my dissertation proposal and letter of recommendation as per my request, Dr. Ermias Aynekulu for his recommendation letter, Dr. Mesfin Tadesse for helping me during the identification and confirmation of specimens in the family Asteraceae, Dr. Gezahagn Degefe former Dean, of Natural and Computation Science at DBU for allowing me to use the Chemistry and Biology laboratories and other facilitations during my study, Solomon Mulaw, head of the Department of Chemistry at DBU for his facilitation and permission to access the Chemistry laboratory services, Dr. Kiflay Gebrehiwot for his all-round friendship cooperation.

I am indebted to the community of *Menz Gera* District, particularly the traditional medical practitioners who unreservedly shared with me their knowledge on medicinal plants, besides their wonderful hospitality throughout my stay in the study area for several times during my field studies. I would like to thank all administrative officials at *Menz Gera* District especially Ato Mulugeta Kebede manager of the district, Ato Dereje Mengistu manager of health office of the District, Ato Tale Lema manager of agriculture office of the District and all *Menz Gera* District *Kebele* managers, sector office leaders and experts for their full collaboration in providing me with relevant information and guidance concerning the District study sites.

I am also very thank full to W/ro Tizta Debebe and her family, Ato Tilahun Getachew from Natural Resources Management (NRM) experts at *Menz Gera* District for their hospitality and professional support, coordination of my field trips and office provision during my stay. Teacher Ayele Director for elementary school at *Weged Kebele* and teacher Getahun and his friends at *Siregedel Kebele* are highly acknowledged for their hospitality and charge-free room reservation during my data collection.

The following people are also truly acknowledged for their valuable contributions during my research work Kalayu Birhane from public health Department of DBU for his professional help in the translation of traditional local disease names to scientific medical terminology; Dr. Asmamaw Tesfaw, Dr. Minbale Guoshu, Mr. Belayhun Tesfaye and Moges Aklilu for their contribution during my laboratory work for their advices and technical assistance.

I am thankful for Dr. Gidey G/hiwot and his family, Dr. Mola Tsegaye, Mr. Abrham Gebremedhin, Mr. Tewele Aregayand his family, W/rt Birtukan Kebede, W/rt Yekite H/micael, W/rt Atsede Endaylalu, Mr. Abduselam Alemayehu and Mr. Dagmawi Ephrem for their meaningful contribution during my dissertation writing. My brothers and sisters

Mengisteab Fisaha, Nigisti Fisaha, Abrehet Fisaha, Aron Fisaha and Yibrah Fisaha are highly acknowledged for encouraging and supporting me always during my research period.

Finally, I am deeply indebted to my beloved wife, W/o Tsige Gebreegziabher, and my beloved children (Amanuel, Hemen and Yowhanan) for their moral, patience and strength throughout my study period. I also extend my thanks to several friends, classmates, colleagues whom I did not mention their names here, for their support and care during the course and research work.

## Table of Contents

ABSTRACT.....	iii
DEDICATION.....	iv
ACKNOWLEDGMENTS .....	v
Table of Contents.....	viii
List of Figures.....	xiii
List of Tables .....	xiv
List of Appendices .....	xvi
List of Acronyms and Abbreviations.....	xvii
CHAPTER ONE.....	1
1. INTRODUCTION.....	1
1.1. Background of the Study.....	1
1.2. Statement of the Problem .....	4
1.3. Research Questions, Hypotheses and Objectives.....	6
1.3.1. Research questions .....	6
1.3.2. Hypotheses .....	7
1.3.3. Objectives.....	7
1.3.3.1. General objective .....	7
1.3.3.2. Specific objectives .....	7
2. LITERATURE REVIEW.....	8
2.1. Vegetation Types in Ethiopia.....	8
2.1.1. Dry evergreen Afromontane and Afroalpine vegetation.....	9
2.2. Status of Forests in Ethiopia.....	10
2.3. Plant Community Classification and Indicator Species .....	12
2.4. Species Diversity, Evenness and Similarity .....	12
2.5. Plant Population Structure.....	14
2.6. Abundance, Frequency and Importance Value Index .....	14

2.7.	Regeneration Status of Natural Forests .....	15
2.8.	The Science of Ethnobotany.....	16
2.9.	Indigenous Knowledge, Traditional Medicinal Plants and Healthcare .....	17
2.9.1.	Indigenous knowledge.....	17
2.9.2.	Traditional medicinal plants and healthcare.....	18
2.10.	Traditional medicine, activity testing of medicinal plants, and drug development .....	19
2.11.	Threats and conservation of medicinal plants and associated knowledge .....	20
CHAPTER THREE .....		22
3.	MATERIALS AND METHODS .....	22
3.1.	Description of the Study Area .....	22
3.1.1.	Physical and biological setting of the study area .....	23
3.1.1.1.	Climate.....	23
3.1.1.2.	Soil.....	24
3.1.1.3.	Vegetation.....	25
3.1.1.4.	Fauna.....	25
3.1.2.	Human and livestock population, Health Status and socio-economic aspects..	26
3.1.2.1.	Human population and Health Status .....	26
3.1.2.2.	Livestock population and Health Status .....	28
3.1.2.3.	Socio-economic aspects of the community.....	28
3.2.	Equipment and chemicals.....	29
3.3.	Research Methods .....	30
3.3.1.	Reconnaissance survey.....	30
3.3.2.	Methods for vegetation study in <i>Yegana</i> and <i>Gajilo</i> forest patches.....	30
3.3.2.1.	Site selection and sampling design .....	30
3.3.2.2.	Vegetation data collection.....	31
3.3.2.3.	Vegetation data analysis of <i>Yegana</i> and <i>Gajilo</i> forest patches .....	32

3.3.2.4. Natural Regeneration Status analysis.....	35
3.3.3. Methods for Ethnobotanical study .....	35
3.3.3.1. Reconnaissance survey .....	35
3.3.3.2. Informant selection and sampling method.....	35
3.3.3.3. Ethnomedicinal plants data collection .....	37
3.3.3.4. Ethnomedicinal data analysis.....	39
3.3.4. Methods for antimicrobial study .....	41
3.3.4.1. Selection of medicinal plants .....	41
3.3.4.2. Preparation of plant extracts .....	41
3.3.4.3. Preparation of test micro-organisms .....	42
3.3.4.4. Antimicrobial assay .....	42
3.3.4.5. Data analysis of <i>in-vitro</i> antimicrobial test.....	44
3.4. Ethical Considerations.....	44
CHAPTER FOUR.....	46
4. RESULTS.....	46
4.1. Plant Diversity .....	46
4.1.1 Floristic Composition of the Remnant Natural Forest patches ( <i>Yegana &amp; Gajilo</i> ) .....	47
4.1.1.1 Plant community types of <i>Menz Gera</i> Forest patches .....	50
4.1.2 Species diversity, Richness and Evenness of <i>Menz Gera</i> Forest patches .....	55
4.1.3 Vegetation Structure.....	56
4.1.3.1 Density of trees and shrubs .....	56
4.1.3.2 Diameter at Breast Height (DBH) class distribution .....	57
4.1.3.3 Height class distribution .....	59
4.1.3.4 Vertical stratification .....	60
4.1.4 Basal area (BA) .....	60
4.1.5 Frequency of Woody species .....	61

4.1.6	Importance Value Index (IVI).....	61
4.2	Natural Regeneration Status of Trees Species of <i>Menz Gera</i> Forests.....	62
4.3	Ethnobotany of Medicinal Plants .....	65
4.3.1.	Medicinal plants for human and livestock ailments .....	65
4.3.1.1.	Informant background information.....	65
4.3.1.2.	Diversity of reported medicinal plants used for human and livestock remedy preparation .....	65
4.3.1.3.	Disease types treated and treatment methods .....	67
4.3.1.4.	Plant parts and condition used .....	68
4.3.1.5.	Modes of remedy preparation and application.....	69
4.3.1.6.	Routes of Administration.....	70
4.3.1.7.	Dosages and antidotes.....	72
4.3.1.8.	Marketability of medicinal plants .....	72
4.3.1.9.	Efficacy of medicinal plants .....	75
4.3.1.10.	Healing potential of medicinal plants against human ailments.....	76
4.3.1.11.	Use diversity of medicinal plants .....	77
4.3.1.12.	Preference ranking of medicinal plants .....	79
4.3.2.	Indigenous knowledge transfer on medicinal plants .....	80
4.4.	Antimicrobial Activity of Selected Traditional Medicinal Plants.....	81
CHAPTER FIVE .....		83
5.	DISCUSSION, CONCLUSION AND RECOMMENDATIONS .....	83
5.1.	Discussion .....	83
5.1.1	Plant Diversity .....	83
5.1.1.1	Floristic Composition of the Remnant natural forest patches (Yegana & <i>Gajilo</i> ).....	83
5.1.1.2	Plant community types of <i>Menz Gera</i> Natural Forests Patches.....	85
5.1.1.3	Species diversity, Richness and Evenness of <i>Menz Gera</i> Forests .....	88
5.1.2	Vegetation Structure.....	89

5.1.2.1	Density of trees and shrubs .....	89
5.1.2.2	Species population structure (DBH & Height) class distribution .....	90
5.1.2.3	Basal area (BA) .....	92
5.1.2.4	Frequency of Woody species .....	93
5.1.2.5	Importance Value Index (IVI) .....	93
5.1.3	Natural Regeneration Status of Tree Species of <i>Menz Gera</i> Forests .....	94
5.1.4	Ethnobotanical Study of Medicinal Plants .....	95
5.1.4.1	Medicinal plants for human and livestock ailments .....	95
5.1.4.2	Informant background information .....	95
5.1.4.3	Diversity of medicinal plants used to treat human and livestock ailments .....	97
5.1.4.4	Human and livestock disease types treated and treatment methods .....	99
5.1.4.5	Plant parts used .....	100
5.1.4.6	Modes of remedy preparation .....	101
5.1.4.7	Routes of administration .....	101
5.1.4.8	Dosages and antidotes .....	102
5.1.4.9	Marketability of medicinal plants .....	103
5.1.4.10	Healing potential of medicinal plants .....	103
5.1.4.11	Ranking of medicinal plants .....	105
5.1.5	Ways of Indigenous Knowledge Transfer in <i>Menz Gera</i> District .....	105
5.1.6	Antimicrobial Activity of Selected Traditional Medicinal Plants .....	106
5.2.	Conclusion .....	108
5.3.	Recommendations .....	111
REFERENCES .....		113
APPENDICES .....		133
DECLARATION .....		179

## List of Figures

Figure 1: Map of Ethiopia, showing Amhara Regional State and the study District.....	23
Figure 2: Climate diagram of <i>Menz Gera</i> District (Data source: National Meteorological Service Agency).....	24
Figure 3: Partial view of the natural forest patches: (a) <i>Yegana</i> Forest and (b) <i>Gajilo</i> Forest..	30
Figure 4: Quadrat layout and size for vegetation data collection .....	31
Figure 5: (a-f) In-vitro antimicrobial test of specimen collection to laboratory experiments .	44
Figure 6: Proportions of habit of plant species in <i>Yegana</i> and <i>Gajilo</i> remnant forest patches	47
Figure 7: Dendrogram showing plant community types of <i>Menz Gera</i> Forest patches .....	51
Figure 8: Density class distribution for woody plant species of <i>Menz Gera</i> forests .....	56
Figure 9: DBH class distributions of woody species in <i>Menz Gera</i> forest.....	57
Figure 10: Representative patterns of species population structures in <i>Menz Gera</i> forests ....	59
Figure 11: Height Class Distribution of woody plant species .....	59
Figure 12: Seedling, sapling and mature tree distributions of some selected species in <i>Menz Gera</i> forests.....	64
Figure 13: Informant background information of <i>Menz Gera</i> District .....	65
Figure 14: Routes of remedy administration for human ailments .....	71
Figure 15: Routes of remedy administration for livestock ailments.....	71
Figure 16: Some medicinal plants in the markets of <i>Menz Gera</i> District.....	74

## List of Tables

Table 1: Population of <i>Menz Gera</i> District.....	27
Table 2: Health Professionals at <i>Menz Gera</i> District.....	28
Table 3: Modified 1-9 Braun-Blanquet scale.....	32
Table 4: Number of general informants and key informants included in the study .....	37
Table 5: Informants distribution at different categories/Parameters.....	39
Table 6: Important families with many genera and species in <i>Menz Gera</i> District.....	46
Table 7: Endemic species recorded from <i>Menz Gera</i> District.....	49
Table 8: Floristic distribution in <i>Yegana</i> and <i>Gajilo</i> natural forests.....	50
Table 9: Synoptic Table of the three community types .....	52
Table 10: Species Richness, Diversity, Evenness values of plant communities identified from <i>Menz Gera</i> Forest patches .....	55
Table 11: Ratio of DBH Distribution in three size classes .....	58
Table 12: Density and number of woody species by storey in the study forest.....	60
Table 13: Basal area ( $m^2h^{-1}$ ) and percentage contribution of eight most dominant trees .....	60
Table 14: Important value index of tree species of <i>Menz Gera</i> forests .....	62
Table 15: Natural Regeneration status of trees in <i>Menz Gera</i> forests .....	63
Table 16: Eleven major use categories of plants in the study area .....	66
Table 17: Human and Livestock Disease categories of <i>Menz Gera</i> District.....	68
Table 18: Plant parts used for remedy preparation to treat human and livestock ailments in <i>Menz Gera</i> District .....	69
Table 19: Mode of Preparation and Application (MPA) (One species may have more than one mode of preparation) .....	70
Table 20: Medicinal plants collected from the markets of <i>Menz Gera</i> District for cash generation .....	73
Table 21: ICF values of traditional medicinal plants for treating human ailments and their disease categories in <i>Menz Gera</i> District .....	75
Table 22: ICF values of traditional medicinal plants for treating livestock ailments and their disease categories in <i>Menz Gera</i> District .....	76
Table 23: Fidelity level values of medicinal plants commonly reported against a given human diseases category .....	77
Table 24: Use Diversity matrix of some selected multi-purpose medicinal plants .....	78

Table 25: Direct Matrix Ranking (DMR) score of ten groups of key informants for ten medicinal plant species with additional uses beside medicinal role .....	79
Table 26: Preference ranking to medicinal plants used for treating eczema .....	79
Table 27: Preference ranking of medicinal plants reported for treating livestock diarrhea.....	80
Table 28: Sources of indigenous knowledge on the practice of traditional medicine .....	80
Table 29: MIC values of ethanol extracts of medicinal plant species with antimicrobial activities.....	82

## List of Appendices

Appendix 1: Semi-structured interview questions employed in the ethnobotanical data collection, <i>Menz Gera</i> District.....	133
Appendix 2: Checklist of semi-structured interview question for key informants.....	135
Appendix 3: Checklist of semi-structured interview questions for ethnobotanical data collection from market places .....	136
Appendix 4: List of equipments and chemicals during research data collection.....	137
Appendix 5: Plant species collected from <i>Menz Gera</i> District.....	139
Appendix 6: Plant species collected from <i>Yegana</i> and <i>Gajilo</i> natural forest patches .....	148
Appendix 7: Transect and quadrats geographical location and environmental data .....	153
Appendix 8: Frequency and density of woody species in <i>Menz Gera</i> District natural forest patches.....	155
Appendix 9: Basal area ( $\text{m}^2/\text{h}^{-1}$ ) of woody plants and their percentage contribution in the <i>Menz Gera</i> District natural forest patches .....	157
Appendix 10: Frequency of woody species with DBH > 2 cm in <i>Yegana</i> and <i>Gajilo</i> forests .....	159
Appendix 11: List of medicinal plants used for human ailments .....	161
Appendix 12: List of medicinal plants used for livestock ailments.....	176

## List of Acronyms and Abbreviations

AAU	Addis Ababa University
BA	Basal Area
CBD	Convention on Biological Diversity
CFU	Colony Forming Unit
DBH	Diameter at Breast Height
DBU	Debre Berhan University
DMR	Direct Matrix Ranking
DMSO	Dimethyl sulfoxide
DPBBM	Department of Plant Biology and Biodiversity Management
EFAP	Ethiopian Forestry Action Program
EPA	Environmental Protection Authority
EPHI	Ethiopian Public Health Institute
ETB	Ethiopian Birr
ETH	Ethiopian National Herbarium
EWNHS	Ethiopian Wildlife and Natural History Society
FAO	Food and Agricultural Organization of United Nations
FEE	Flora of Ethiopia and Eritrea
FL	Fidelity Level
GPS	Geographical Positioning System
ha	hectare
HHs	Households
IAR	Informant Agreement Ratio
IBC	Institute of Biodiversity Conservation
ICF	Informant Consensus Factor
IK	Indigenous Knowledge
IUCN	International Union for Conservation of Nature
IUFRO	International Union of Forest Research Organizations
IVI	Importance Value Index
m <sup>2</sup> /h <sup>-1</sup>	Meter square per hectare
m.a.s.l.	Meter above sea level
MEFCC	Ministry of Environment, Forest and Climate Change
MGD	<i>Menz Gera</i> District
MIC	Minimum Inhibitory Concentration
MoA	Ministry of Agriculture
MoIT	Ministry of Innovation and Technology
MPs	Medicinal Plants
MRPP	Multi-Response Permutation Procedures
Ss	Sorensen's similarity coefficient
TMPs	Traditional Medicinal Plants
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
WHO	World Health Organization

# CHAPTER ONE

## 1. INTRODUCTION

### 1.1. Background of the Study

Ethiopia is a country with varied macro and micro-climatic conditions that have contributed to the formation of diverse ecosystems inhabited with a great diversity of life forms of both animals and plants (FAO, 1996). Ethiopia situated in the Horn of Africa owned one of the richest assemblages of plants in the African continent and its wide Afromontane habitat. In addition to this, it is one of the mountainous areas and the low land has geologically active territory, which together creates a unique ecological identity (Ensermu Kelbessa and Sebsebe Demissew, 2014).

Ethiopia is a country of great geographic diversity with wide altitudinal and physiographic variations. Its altitude ranges from 110 m below sea level in the Danakil Depression in Afar National Regional State to the highest peak of 4,533 m.a.s.l. on Mount Ras Dashen in Amhara National Regional State with mean annual rainfall ranges from 100 to 2400 mm (Friis *et al.*, 2010). The Great Rift Valley divides the western and southeastern highlands, and the highlands on each side give way to vast, semi-arid lowland areas in the east and west, especially in the southern part of the country (EFAP, 1994). Besides, it is a country of high cultural and biological diversity, which harbors a significant portion of the Eastern Afromontane and Horn of Africa Biodiversity Hotspots and one of the few countries considered the cradle of humankind (EWNHS, 2010).

Ethiopia ranks among the six most plant biodiversity-rich countries in Africa (UNEP, 1995; Teshome Soromessa *et al.*, 2004), next to Congo, South Africa, Cameroon, Tanzania and Madagascar. The flora is very heterogeneous and has rich endemic elements owing to the diversity in climate, vegetation and terrains. According to Ensermu Kelbessa and Sebsebe Demissew (2014), the inventory of the flora of Ethiopia and Eritrea has recorded 6,027 vascular plant species (including subspecies), 1,882 are common to both countries while 3,875 have been recorded from Ethiopia only. Thus, there are 5,757 higher plant species (including subspecies) in Ethiopia with 633 species (10%) endemism. Ethiopia is also one of the African countries known for the endemism of wild plant and animal species (FAO, 1996).

The diverse ecosystems of Ethiopia have endowed the country with a various biological wealth of plants, animals and microbial species. However, the efforts towards conservation and sustainable use of these biological resources are inadequate. Some of the major contributing factors that accelerate the biological resources decline are the size and pattern of human and domestic animal population, low level of community awareness towards the conservation of natural resources and high level of resource consumption (IBC, 2009). Understanding diversity, distribution and use of plants with their associated indigenous knowledge in a country has been mentioned to be the basis for designing and implementing sound natural resource management and utilization system (Han *et al.*, 2011).

According to Friis (1986), it is difficult to establish the precise statistical cover of the past and present forest vegetation in Ethiopia. However, FAO (2010), indicated a continuous decline from the original 35% forest cover in 1950 to 11% in 2010 including the afforested areas. The latest report by MEFCC (2015) indicates that a recent national forest cover estimate is about 15.5 % based on the adopted forest definition by REDD+ Secretariat. On the other hand, only 2.4% of the natural forest has remained in Ethiopia (Sayer *et al.*, 1992) as reported 18 years ago prior to the update from FAO in 2010. Such percentage coverage variation may be due to the definition difference between FOA (2010) and MEFCC (2015). Here, according to MEFCC (2015) the forest is defined as land spanning at least 0.5 ha covered by trees and bamboos with a height of higher than at least 2 m and a canopy cover of at least 20% or trees with the potential to reach these thresholds in situ. However, the above forest definition differs from the definition used for international reporting to the Global Forest Resources Assessment and from the forest definition used in the National Forest Inventory both of which applied the FAO forest definition, which is defines as with the thresholds of 10% canopy cover, a 0.5 ha area and a 5 m height (FAO, 2010). Such a high rate of deforestation and ruthless exploitation of most forests exposed the fertile soil to high levels of erosion, estimated at 1.9 to 3.5 billion tons/year (EFAP, 1994). The current patchy vegetation observed in central and northern Ethiopia in the form of patchy natural high land forests, pockets of marginal land and mature trees dotted in sacred sites and farmlands are reminiscent of the vegetation continuum that was once present in the past in these areas (Friis, 1986; Tamrat Bekele, 1994). Ethiopia is one of the countries in the world with a good level of plant biodiversity (Zerihun Woldu, 2008) which serves a lot for the community socially, ecologically and economically.

Ethnobotany is the study of relations, which exist between humans and their ambient vegetation (Cotton, 1996). According to Martin (1995), ethnobotany is the study of local people's

interaction with the natural environment: how they name, classify, manage and use plants that are available around them. If plants did not exist, human life would not be possible. All members of the human family depend on plants for their survival in myriad ways; today we also depend on plants for many of our opportunities to improve the quality of human life. Plants are fundamental to the functioning of all human societies and the operation of all ecosystems. Along with the photosynthetic bacteria and algae, plants are responsible for the creation of almost all of the energy that we consume.

Ethnobotany is a multi-disciplinary science encompassing botany, anthropology, economics and linguistics among others, which studies how a society relates to its environment and particularly to the plant world. These relationships can be social, economic, symbolic, religious, commercial and artistic (Zemedu Asfaw, 1997). Ethnobotany provides preliminary information for screening and extraction of bioactive chemicals and leading towards compounds from plants (Cos *et al.*, 2006). The assumption here is that careful integration of ethnobotanical research on medicinal plants with other disciplines such as pharmacology would lead to successful development of pharmaceutical products (Tsekpo, 1997).

Among the potential uses of plants, traditional medicine is one of the most important once since they are essential to the survival of mankind (Toledo *et al.*, 2009). According to the World Health Organization (WHO, 2008), traditional medicine (TM) is defined as “the sum total of knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures that are used to maintain health, as well as to prevent, improve or treat physical and mental illnesses”.

About 85,000 medicinal plant species have been reported worldwide (Devi *et al.*, 2009, cited in Aqeel *et al.*, 2012). Historically, development of novel drugs was primarily through the extraction of biologically active compounds from plants. The compounds were identified through medicinal use or a variety of bioactivity screening Programmes (Aqeel *et al.*, 2012). Thus, study will contribute to the conservation and sustainable use of TMPs with their associated indigenous knowledge and a baseline for further multidisciplinary studies.

According to Ensermu Kelbessa *et al.* (1992), in Ethiopia, limitations to the opportunities for income generation caused by ecological and socio-economic constraints forced people to cultivate marginal lands and allow overgrazing and the felling of trees, thus catalyzing a spiral of environmental degradation and deforestation. The overall result of this environmental

degradation in Ethiopia, leads to desertification, which is the cause for the loss of biodiversity (Zerihun Woldu, 2008).

The same phenomenon occurs in *Menz Gera* District especially in Menz Guassa mountain area with a gradual erosion of vegetation. This is due to the growth of human population and demand on the environment with regard to fulfilling domestic requirements like thatching grass, fuelwood, agricultural materials and grazing (Zealelem Tefera *et al.*, 2012).

Menz Guassa mountain area of North Shewa, Amhara region is found on the western escarpment of the Rift Valley over 3,100 m.a.s.l. It is therefore a patch of Afroalpine ecosystem specifically, Afroalpine grassland and moorland with a suite of endemic fauna and flora. It harbors an important population of Ethiopian wolves (*Canis simensis*). It is also an important water catchment area for the Great Abay river (later forming the Blue Nile) and Awash river (Tewodros Atlabachew *et al.*, 2003).

*Menz Gera* District especially the Menz Guassa mountain area, *Yegana* and *Gajilo* natural forest patches are homes to many of the animal and plant species commonly associated with Afroalpine ecosystems. The area's flagship mammal species, the Ethiopian wolf (*Canis simensis*), also known as the Simien fox ('Critically Endangered' as categorized in the IUCN Red list) and Gelada baboon (*Theropithecus gelada*) ('Least Concern' as indicated in the IUCN Red list). According to Zealelem Tefera *et al.* (2012), 114 bird species were recorded in the area, of which six species are endemic to Ethiopia (*Serinus ankoberensis*, *Parophasma galinieri*, *Macronyx flavicollis*, *Serinus nigriceps*, *Vanellus melanocephalus*, and *Bostrychia carunculata*) (Tadesse Solomon and Demel Teketay, 2017). The name for the community conserved area "Guassa" is the common Amharic name for four species of the genus *Festuca* (*Festuca abyssinica*, *F. simensis*, *F. richardii* and *F. macrophyll*) which is highly valued by the local community for its uses, among other uses, for thatching and manufacturing of household items and farm implements. *Erica arborea*, *Thymus schimperi*, *Kniphofia foliosa*, *Helichrysum splendidum*, and *Lobelia rynchopetalum* are the most common plant species in the study area (Zealelem Tefera *et al.*, 2012; UNDP, 2012).

## **1.2. Statement of the Problem**

People of *Menz Gera* District are highly connected to use of plants from their environment especially from the fragmented remnant natural forest patches and Menz Guassa community conserved mountain for their day-to-day livelihood. Menz Guassa mountain area and the

remnant natural forest patches of the district are critical natural resources for the people of *Menz Gera* District, providing ecosystem services such as fodder for animals, fuel, building materials, farming, and household implements for subsistence purposes.

Menz Guassa mountain area is the site for the collection of Guassa grass and firewood and the largest area of communal grazing of livestock. Guassa is a key water catchment area both locally and internationally. A total of 26 rivers begin in the area and drain into either the Blue Nile or Awash Rivers (Zealelem Tefera *et al.*, 2012). The mountain block provides year-round water supplies for drought-prone settlements bordering regions, such as Afar region and Benshangul Gumuz region. It is also used as a potential source of ecotourism (UNDP, 2012). *Menz Gera* (*Yegana* and *Gajilo*) natural forest patches are good representatives of Abay and Awash rivers watershed respectively included in this study.

*Yegana* and *Gajilo* remnant natural forest patches are extended parts of the Menz Guassa community conserved mountain, which are detached and appear as fragmented remnant natural forest patches this time due to anthropogenic and natural factors. These remnant natural forest patches are under high pressure of anthropogenic interferences like agricultural expansion, house construction, firewood collection, timber extraction, unsustainable traditional medicinal plant collection and free grazing. In addition to this, frequent scarcity of rain and highly sloppy nature of the area lead to create many small fragmented natural forest patches from the large Menz Guassa community conserved area. So one component of this study focuses on scientific documentation of the ecology of the *Menz Gera* remnant natural forest patches because they contain a lot of plant and animal diversities that have social, ecological, economic and cultural importance to the local community and beyond.

Forest ecosystems play multiple roles at local, national and global levels. They provide a complex array of goods, medicine, services and economically valued products in terms of the ecological aspect they regulate local and global climate, ameliorate weather events, regulate the hydrological cycle, protect watersheds and their vegetation, water flows and soils, and provide a vast store of genetic information much of which has yet to be uncovered (UNEP, 2007). Human beings are an integral and inseparable part of the natural world. Our existence and health ultimately depend on the integrity and functioning of ecosystems. Human beings have deliberately managed and converted the landscape to utilize and exploit natural resources mainly to derive basic needs such as food, shelter, freshwater, and pharmaceutical products (Goldewijk and Ramankutty, 2004)

In the study area, one of the forest product use is in traditional medicine that plays a significant role in supporting primary healthcare. But so far only a limited attempt has been made to scientifically explore, document and promote the widely used medicinal plants and associated knowledge dynamics in the study area as also indicated by report of Ermias Lulekal *et al.* (2013). In developing countries like Ethiopia, indigenous knowledge about traditional medicinal plants is transferred orally from generation to generation. Thus, there is a gap in documenting and recording of medicinal plants with further anti-microbial test laboratories in *Menz Gera* District as well as in the country Ethiopia. Besides, indigenous knowledge on use of medicinal plants as remedies is getting lost due to migration of youngsters from rural to urban areas, industrialization and expansion of modern education; local healers do not deliver their knowledge to the next generation due to the culture of secrecy and for maintaining their social respect.

The age-old ethnomedicinal knowledge of the community in *Menz Gera* District and traditional medicinal plants used to treat various ailments for generations are subject to loss due to human population growth, frequent drought, rural development activities, uncontrolled traditional medicinal plants collection, agricultural expansion and uncontrolled grazing without being scientifically documented. Therefore, this study aims at providing a comprehensive documentation and analysis in the following three dimensions, which are plant diversity/floristic composition of the study area, medicinal plant ethnobotany and associated indigenous knowledge of the people and antimicrobial test of selected important medicinal plants. This research output is expected to contribute towards updating scientific data and analysis for sustainable conservation and utilization of plant resources.

### **1.3. Research Questions, Hypotheses and Objectives**

#### **1.3.1. Research questions**

1. What is the floristic composition, species diversity, community types and structure of *Menz Gera* remnant natural forest patches?
2. How is the natural regeneration status of tree species in *Menz Gera* remnant natural forest patches?
3. What are the traditional medicinal plants and associated indigenous knowledge used to treat human and/or livestock ailments in the study area?
4. How is the distribution of traditional medicinal plants (TMPs) within the remnant natural forest patches in the study area?

5. What is the top ranking TMPs for treating infectious diseases according to local perception and which of them have antimicrobial activity results?

### **1.3.2. Hypotheses**

1. Remnant natural forest patches in the District have diversified plant species compositions.
2. The natural regeneration status of trees at *Menz Gera* remnant natural forest patches is below natural expectation.
3. People in *Menz Gera* District are knowledgeable about traditional medicinal plants used to treat human and livestock ailments.
4. Remnant natural forest patches in the study area are the main reservoirs of traditional medicinal plants in the District.
5. Traditional medicinal plants that have high informant consensus on their local uses for treating infectious diseases have positive antimicrobial activities.

### **1.3.3. Objectives**

#### **1.3.3.1. General objective**

The general objective of the research is to document and analyze plant diversity and ethnobotany of traditional medicinal plants with the antimicrobial tests of selected traditional medicinal plant species.

#### **1.3.3.2. Specific objectives**

The specific objectives of this research are to:

1. Document plant species in *Menz Gera* District and produce a scientific name checklist.
2. Assess plant species diversity, structure, community types and analyze the natural regeneration status of tree species in the remnant natural forest patches.
3. Document traditional medicinal plants used in the treatment of human and livestock diseases and associated indigenous knowledge with a view to contribute to the efforts in building ethno-botanical database and assess their marketability in the district markets.
4. Identify availability and assess distribution of traditional medicinal plants within the remnant natural forest patches in the study area and
5. Assess antimicrobial activity of selected traditional medicinal plants of high informant consensus and fidelity level values for their use to treat infectious diseases.

## CHAPTER TWO

### 2. LITERATURE REVIEW

#### 2.1. Vegetation Types in Ethiopia

Ethiopia is endowed with a wide range of vegetation formations or types ranging from Afroalpine to desert vegetation. Vegetation is an assemblage of plants growing together in a particular location. It is the collective plant cover of an area (Zerihun Woldu, 1985; EFPA, 1994). Various authors, Pichi-Sermolli (1957), Hedberg (1951, 1978), White (1983), Zerihun Woldu *et al.* (1989), Friis and Mesfin Tadesse (1990), Ensermu Kelbessa *et al.* (1992), Tamrat Bekele (1993), EFPA (1994), Demel Teketay and Tamrat Bekele (1995), Zerihun Woldu (1999), Friis and Sebsebe Demissew (2001), Kumelachew Yeshitila and Tamrat Bekele (2002) and Tadesse Woldemariam (2003) have made considerable contributions toward understanding the vegetation of the country and proposed their conservation strategies. The oldest overall survey of the vegetation of Ethiopia made by Pichi-Sermolli (1957), recognized 24 vegetation types for the Horn of Africa, out of these 22 are found in Ethiopia.

Ethiopia is endowed with varied topographic features dominated by rugged mountains that are cut by river valleys and deep gorges, flat-topped plateaus, undulating hills and lowland plains. The country consists of two major high plateau regions separated by the Rift Valley and bounded on all sides by lowlands (Friis, 1992; Tamrat Bekele, 1993). The highlands, which are defined as land areas above 1500 m, with the associated valleys, constitute about 44% of the country (EFAP, 1993) in which the Dry Afromontane forests form the largest part (Demel Teketay, 1996). Mountain forests are the main constituents of the natural vegetation in the Ethiopian highlands. In general, most Afro-montane tree species have wide geographical distributions and wide ecological amplitudes. Many also exhibit a wide range of growth forms (White, 1983).

Updated study by Friis *et al.* (2010) Ethiopia classified into 12 potential vegetation types which include; Desert and Semi desert scrubland Forest; Acacia - Commiphora woodland and bush land; Wooded grassland of the Western Gambela region; Combretum - Terminalia woodland and wooded grassland; Dry Evergreen Afromontane forest and grassland complex; Moist Evergreen Afromontane forest and bush land; Transitional rain forest; Ericaceous belt; Afroalpine belt; Riverine vegetation; Fresh - water lakes; and Salt Lakes vegetation. The present study area was carried out in the Dry Evergreen Afromontane and Afroalpine forests.

Understanding the pattern of forest structure and composition has important implication on population dynamics. Fragmentation and habitat loss could influence the structure and regeneration of natural forests (Clark, 1991). Accordingly, regeneration of woody species in the forest is strongly influenced by anthropogenic disturbances and soil erosion which in turn determine the forest structure and floristic composition (Cotler and Ortega-Larrocea, 2006). Moreover, it often leads to altered environmental conditions, which influence the process that can both augment and erode species diversity in the tropical forest community (Kennard *et al.*, 2002; Sapkota *et al.*, 2010).

Studies by several authors (Gemedo Dalle and Masresha Fetene, 2004; Simon Shibru and Girma Balcha, 2004; Gemedo Dalle *et al.*, 2005; Abate Ayalew *et al.*, 2006; Kitessa Hundera *et al.*, 2007; Kitessa Hundera and Bishaw Deboch, 2008; Ermias Lulekal *et al.*, 2008b; Ensermu Kelbessa and Teshome Soromessa, 2008, Haile Yineger *et al.*, 2008a; Leul Kidane *et al.*, 2010, Gebremicael Fisaha *et al.*, 2013, Abyot Dibaba, *et al.*, 2016, Abiyot Berhanu *et al.*, 2017) provided general description of the vegetation types and their floristic composition in different parts of Ethiopia.

Since vegetation is part of biodiversity, which is very important for, securing different fundamental human needs since time immemorial, people have relied on plant resources to fulfill various needs. Hundreds of millions of people, mostly in developing countries, derive a major part of their subsistence and income from plant products. Indigenous knowledge systems associated with various plant uses have become recognized worldwide for their contribution to science and conservation (Yadav *et al.*, 2011).

### **2.1.1. Dry evergreen Afromontane and Afroalpine vegetation**

The Ethiopian highlands encompass over 50% of the African land area covered by Afromontane vegetation (Tamrat Bekele, 1993), of which Dry Afromontane forests comprise the largest part (Demel Teketay, 2005). This vegetation represents a complex system of successions involving extensive grasslands rich in legumes, shrubs and small to large trees to closed forests. The Dry evergreen Afromontane vegetation type is found in much of the highlands in the northern, northeastern, northwestern, central, southern and southeastern parts of the country between altitudes of 1800 and 3000 m.a.s.l. and having annual rainfall between 400 and 1500 mm (Zerihun Woldu, 1999; Friis *et al.*, 2010). The vegetation is largely characterized by *Juniperus procera*, *Olea europaea* ssp. *cuspidata*, *Prunus africana*, and *Ekebergia capensis*. Important grass genera are *Eragrostis*, *Pennisetum*, *Panicum*, *Sporobolus*

and *Hyparrhenia*, while herbaceous legumes are species of *Indigofera*, *Trifolium*, *Crotalaria* and *Tephrosia* (Friis *et al.*, 2010). Climbers include *Embelia schimperi*, *Rubia cordifolia*, *Urera hypselodendron* and *Jasminum abyssinicum* (IBC, 2009).

Afroalpine and sub-afroalpine vegetation types are widely distributed in Ethiopia, unlike in other African habitats. These vegetation types have been designated as national protected areas due to the presence of several endemic plant and animal species (IBC, 2009). The vegetation is highly restricted to the highlands with elevations ranging from 3200 to 4533 m.a.s.l. (the peak of Ras Dashen) (Mengesha Asefa *et al.*, 2020). Despite diurnal temperature fluctuations in which the days are summer-like and the nights are winter-like, seasonal temperature variation is not a characteristic of this vegetation type (Hedberg *et al.*, 2006). According to Mengesha Asefa *et al.* (2020) the past 10,000 years, the Ethiopian high lands were largely covered with Afroalpine vegetation type and grasslands. The current highland Afroalpine and sub-afroalpine vegetation represents remnants of these patches. Clearly, the remnants of these habitats in the complex highlands of Ethiopia demonstrate the effects of unprecedented and massive anthropogenic activity in the last 19<sup>th</sup> and 20<sup>th</sup> centuries (Nyssen *et al.*, 2014). Afroalpine and sub-afroalpine vegetation types in the Ethiopian highlands have not been widely studied even though they are inhabited by endemic plant and animal species. Small trees, shrubs and shrubby herbs characterize the lower zones of the Afroalpine belt in Ethiopia. Giant herbs, small herbs and grasses characterize the upper zones of this vegetation type. Afroalpine vegetation were characterized with young and flowering rosettes of *Lobelia rhynchopetalum* with an undergrowth of grasses, sedges, *Helichrysum citrispinum* (Friis *et al.*, 2010).

## **2.2. Status of Forests in Ethiopia**

In Ethiopia it is difficult to establish the precise coverage of the past as well as the present forest vegetation cover; it is believed that a substantial portion of the land area in highlands of Ethiopia was covered with forests having wide coverage than at present (Friis, 1986). The presence of a number of isolated forest trees, even on farmlands or patches of forests around churchyards and religious burial grounds in this country indicate the occurrence of vast expanse of forests earlier (Tamrat Bekele, 1993).

According to different authors, there are controversies about the extent of the former forest cover in Ethiopia. The natural forests are assumed to have covered 37% of the Afromontane region of Ethiopia in the past, which declined to only 4.4% by 1960 (von

Breitenbach, 1962; EFAP, 1994). Destruction of the remnant high forests continues at an estimated rate of 150,000 - 200,000 ha per year (EFAP, 1994). According to the estimate by Earth trends in 2000 cited in a report by Gatzweiler (2007), Ethiopia had 4,344 million ha of natural forest area, 4% of the country's landmass. Between 1990 - 2010, 2.91 million hectare of the area was deforested with an average loss of 140,900 ha, or 0.93% per year (EFAP, 1993 and FAO, 2010). However, according to Forest Sector Management in MEFCC (2015) the forest cover of Ethiopia was estimated to be 12.3 million ha (11%) with the new definition of forest to include dense woodlands found in Gambella and Benishangul Gumuz Regional States. Here, forest is defined as land spanning at least 0.5 ha covered by trees and bamboos with a height of higher than at least 2 m and a canopy cover of at least 20% or trees with the potential to reach these thresholds in situ (MFCC, 2015). However, the above forest definition differs from the definition used for international reporting to the Global Forest Resources Assessment and from the forest; definition used in the National Forest Inventory, which both applied the FAO forest definition with the thresholds of 10% canopy cover, a 0.5 ha, area and a 5 m height (FAO, 2010).

Currently, the remnants of the original natural forest species are largely restricted to churchyards and other sacred groves in a matrix of cropland and semiarid degraded savanna in the highlands of northern Ethiopia (Tamrat Bekele, 1993; Aerts *et al.*, 2006). This is because highlands of Ethiopia, in contrast to most mountain systems outside of Africa, are very suitable for human settlement. This population pressure on the highlands accompanied by sedentary agriculture, extensive cattle herding activities and political factors have resulted in heavy deforestation, forest fragmentation, loss of biodiversity and impoverishment of ecosystems in general (Eshetu Yirdaw, 2002) which in turn affects the forest structure. Accordingly, the forest degradation level due to firewood consumption is expected to increase in the same proportions as the Ethiopian population (2-3% per year until 2030) in a business as usual scenario (MOA and EPA, 2013).

Despite their economic and environmental values, the remaining forests in Ethiopia are under threat. The growing population requires more fuel wood and more agricultural production, in turn creating needs for new farmland and timber. These factors currently result in deforestation and forest degradation by affecting the structure of the existing forest in the country and remnant natural forest patches in the country including the *Menz Gera* District.

### **2.3. Plant Community Classification and Indicator Species**

Classification is to group together a set of vegetation samples (study plots of vegetation) based on their attributes, floristic or plant species composition (Kent, 2012). The end product of a classification analysis should be a set of groups derived from the individuals, where, ideally, every individual within each group is more similar to the other individuals in that group than to any individuals in any other group (Kent and Coker, 1992; McCune and Grace, 2002; Kent, 2012). Vegetation classification attempts to identify discrete, repeatable classes of relatively homogeneous communities or associations. Classification helps to group together a set of vegetation samples for similarity analysis (Kent, 2012). An important quantitative criterion in identifying different plant communities is the frequency and abundance of species in sampling units. Species occurrences are summarized as synoptic-cover abundance values. Synoptic values are the product of the species frequency and average cover abundance values (Van der Maarel *et al.*, 1987).

Plant community is a collection of plant species growing together in a particular location that show a definite association or affinity with each other (Kent and Cooker, 1992). Plant community can be understood as combination of plants that are dependent on their environment, influence one another, and modify their environment (Mueller-Dombois and Ellenberg, 1974). As stated in Mueller-Dombois and Ellenberg (1974), the floristic composition of vegetation includes all species occurring within a plant community. However, most plant communities consist of many different species, which are not particular to discover within a community.

According to Dufrêne and Legendre (1997), indicator species are species whose status provides information on the overall condition of the forest and gives information about other species in the forests. They reflect the quality and changes in the environmental condition as well as other aspects of the community composition. Moreover, their presence or absence or their relative wellbeing in a given environment is indicative of its ecosystem. There is no fixed size for a community. They can range from very small size to variable expanses of grassland or forest (Peters, 1996).

### **2.4. Species Diversity, Evenness and Similarity**

Biodiversity is defined as the total variability of all living organisms and the ecological complexes in which they occur. Species Diversity is measured by recording the number of

species richness (represents the number of different species in a given area or community) and their relative abundances (evenness or unevenness of species) within the sample or community (Kent, 2012). It is a function of the number of species present (species richness) and the evenness with which the individuals are distributed among these species (species evenness, species equitability, or abundance of each species) (Magurran, 2004). “Genetic diversity” refers to the variety of genes within a particular species variety or breed. “Plant diversity” refers to the totality and variability of all plants and their ecosystems (Van der Maarel, 2005).

The description of plant community involves the analyses of species diversity, evenness and similarity. Diversity and equitability of species in a given plant community is used to interpret the relative variations between and within the community and help to explain the underlying reasons for such a difference (Kent and Coker, 1992). Species diversity has been identified as one of the key indices of sustainable land use practices and considerable resources are expended to identify and implement strategies that will reverse the current decline in biodiversity at local, regional and international scales (Getaneh Belachew, 2006). Floristic description of vegetation community involves the analysis of species diversity, evenness and similarity. Species diversity is one of the most important indices used for evaluating the sustainability of forest communities. Species diversity is described based on two concepts (factors), the total number of species in the community (species richness) and the relative abundance of species (species evenness) within the sample or community. These two components of species diversity may be examined separately or combined into some forms of indices. A commonly applied index for measuring the species diversity is the Shannon diversity index (Kent and Coker, 1992; Van der Maarel, 2005).

As distinguished by Kent and Coker (1992) and Whittaker (1972), there are three different kinds of species diversity, *Alpha* ( $\alpha$ ), *Beta* ( $\beta$ ) and *Gamma* ( $\gamma$ ) diversity. *Alpha diversity* refers to the number of species within a sample habitat or community. *Beta diversity* describes the differences in species composition between two adjacent habitats or communities. It is a measure of the rate and extent of changes in species along a gradient from one habitat to another. Thus, *beta diversity* is habitat diversity that measures the turnover rates. Beta diversity is low when the overlap between the species composition of the two habitats is high and is highest when the habitats have no species in common at all. *Gamma diversity* describes regional differences in species composition (e.g., the difference in species composition between comparable habitats on two adjacent mountain ranges) and it depends on the alpha and beta diversity (Kent and Coker, 1992; Van der Maarel, 2005). Species diversity and species

evenness are often calculated using the *Shannon diversity index* ( $H'$ ), which naturally varies between 1.5 and 3.5 and rarely, exceeds 4.5 (Kent and Coker, 1992). Shannon diversity index is the most appropriate and the most widely used index for combining species richness and evenness (Van der Maarel, 2005).

## **2.5. Plant Population Structure**

Population structure is defined as the distribution of individuals of each species in arbitrarily diameter height size classes to provide the overall regeneration profile of the study species (Silvertown & Doust, 1993). Information on population structure of a tree species indicates the history of the past disturbance to that species and the environment and hence, used to forecast the future trend of the population of that particular species (Peters, 1996). Vegetation structure is one of the crucial components of vegetation ecology and it has a significant role in maintaining the reproductive cycle of plants through recruitment of seedlings. It depicts the horizontal, vertical and temporal arrangement of vegetation (Barkman, 1979). The vertical and horizontal distributions of tree sizes determine the distribution of micro-climatic conditions, the availability of resources and the formation of habitat niches. Thus, information about vegetation structure contributes to improved understanding of the history, functions and future development potential of a particular forest ecosystem (Van der Maarel, 2005).

## **2.6. Abundance, Frequency and Importance Value Index**

*Abundance* is the number of plant species per unit area. Measurement of plant abundance requires the counting of individual plants by species in each area. It can be used to show spatial distribution and ranges over time (Kent and Coker, 1992; Van der Maarel, 2005).

*Frequency* is the proportion of plots in which a species occurs. It is a measure of occurrence of a given species in a given area. It indicates how the species are dispersed and is an ecological meaningful parameter. In other words, it gives an approximate indication of the homogeneity of the stand under consideration (Kent and Coker, 1992).

*Importance Value Index* (IVI) permits a comparison of species in a given forest and reflects the dominance, occurrence and abundance of a given species in relation to other associated species in an area. Therefore, for setting priority, it is a good index for summarizing vegetation characteristics and ranking species for management and conservation practices. Whereas

species with lower IVI need high conservation efforts, those with higher IVI need monitoring management (Kent and Coker, 1992).

## **2.7. Regeneration Status of Natural Forests**

Forests, worldwide, have been fragmented into small patches. Forest structure and regeneration have been influenced due to this fragmentation and habitat loss. The fragmentation results in small stands of forests bordered by open, often agricultural lands (Haileab Zegeye *et al.*, 2011). Consequently, such landscapes are dominated by strong environmental gradients from the forest interior to forest edges and open fields (Alemayehu Wassie, 2007; Haileab Zegeye *et al.*, 2011). Under increasing pressure from human population, via e.g. tree harvesting and grazing activities, natural regeneration may be hampered and, as a result, the persistence of the remnant forest patches and their indigenous species in many areas are threatened. This is particularly the case in the rapidly developing tropical areas (Alemayehu Wassie, 2007; Getachew Tesfaye *et al.*, 2010).

Extensive deforestation has led to severe depletion of natural forests, loss of biodiversity and land degradation in Ethiopia (EFAP, 1994; IBC, 2009). In fact, deforestation has eroded the biological diversity to such an extent that some plants are facing local extinction. Regeneration is a key ecological process and a central component of forest ecosystem dynamics and restoration. Good understanding of natural regeneration in any forest ecosystem requires information on the presence and absence of persistent soil seeds or seedling banks, quantity and quality of seed rain, losses of seeds to predation and sources of regrowth after disturbances (Demel Teketay, 2005). Variation in patterns of regeneration both through differences in their constituent species and the environmental variables in which they grow was observed in tropical forests (Demel Teketay, 1997). According to Garwood (1989), tropical forest plants regenerate indifferent pathways, i.e. *seed rain*: seeds dispersed recently; *soil seed bank*: seeds that are in the soil; *seedling bank*: seedlings found in the understory and *coppice*: root or shoot sprouts of damaged individuals.

Analysis of population structures, using the size-class distribution of diameter at breast height (DBH), height of trees and density of naturally regenerated woody species sapling and seedling, can provide an insight into their regeneration status (Silvertown, 1982). Plant population structure shows whether or not the population has a stable distribution that allows continuous regeneration to take place. Plant population structure may change due to changes in recruitment of individuals at low diameter size classes or exploitation of individuals at high size classes or

throughout the class size structure. The population structural change is the function of regeneration pattern of individuals within the community. If regeneration was taking place continuously, then, the distribution of species would show reverse J-shape structure, which is an indicator of healthy/good regeneration (Demel Teketay, 1997), which is common in natural forests where external disturbances are minimum (Feyera Senbeta, 2006; Getachew Tesfaye *et al.*, 2010). Any population structural pattern different from inverted J-shape (e.g. U-shape, J-shape and bell shape) have been attributed to disturbed forests (Poorter *et al.*, 1996).

Successfully regenerating plant species are characterized by the presence of a sufficient number of individuals at both lower (seedling and sapling) and higher size classes including the reproductive individual trees that are capable of contributing a significant number of viable seeds (Mligo & Rocky, 2012). Lack of individuals at low size classes and mature reproductive individuals may be related to their regeneration failure in combination with over-exploitation for poles, firewood, charcoal burning and timber extraction. Selective cutting of matured trees leaving out the few stunted and genetically poor individuals causes population decline (Lyaruu *et al.*, 2000).

## **2.8. The Science of Ethnobotany**

People-plant relationship is the domain of ethnobotany, which is an important dimension for assessment of the status of plant biodiversity. Cotton (1996) underlined that ethnobotany encompasses all studies that concern the mutual relationships between plants and traditional people. Indigenous medical knowledge is among the outcomes of the relationships of humans with plants. Thus, people depend on plants not only for food but also for preparation of remedies. The focus of ethnobotany is on how plants have been or are used, managed and perceived in human societies and includes plants used for food, medicinal, rituals, social life and others. The relationship between plants and human cultures is not limited to the use of plants for food, clothing and shelter but also includes their use for religious ceremonies, ornamentation and healthcare (Khan *et al.*, 2007). Ethnobotanical research documents the knowledge on cultural interaction of people with plants, figures out how local people have traditionally used plants for various purposes and how they incorporate plants into their cultural tradition and religion (Balick and Cox, 1996).

Traditional rural people around the world possess unique knowledge of plant resources on which they depend for food, medicine and general utility including tremendous botanical expertise (Sofowora, 1982; Martin, 1995). Ethnobotanical work seems to have started with Christopher

Columbus in 1492, at a time when he brought tobacco, maize, spices and other useful plants to Europe from Cuba (Cotton, 1996) and when other immigrants from the new world documented food, medicine and other useful plants of the Aztec, Maya and Inca peoples (Martin, 1995). The term ethnobotany was for the first time mentioned orally by John Hershberger in 1895 during a public lecture (Balick, 1996; Cotton, 1996; Hamilton, 2003).

Currently, ethnobotany has become a more diversified and multidisciplinary subject that require experts in various fields of academic study such as botany, anthropology, agriculture, linguistics, archeology and economics (Martin, 1995; Alexiades, 1996; Balick, 1996). Ethnobotany is also a rapidly growing science, attracting people with widely varying academic backgrounds and interests (MacDonald, 2009) and nowadays ethnobotany has tended to become more analytical, quantitative, cross disciplinary, and multi institutional (Hamilton, 2003). Ethnobotanical studies are now growing and progressing fast throughout the world. One of the main motivating forces behind this expansion is the increasing awareness of the considerable practical and social value of traditional knowledge. Medicinal plants play a key role in the development and advancement of modern studies by serving as a starting point for the development of novelties in drug (Wright, 2005).

## **2.9. Indigenous Knowledge, Traditional Medicinal Plants and Healthcare**

### **2.9.1. Indigenous knowledge**

Indigenous knowledge (IK) is, broadly speaking, the knowledge used by local people to make a living in a particular environment (Warren, 1991). Terms used in the field of sustainable development to designate this concept include indigenous technical knowledge, traditional environmental knowledge, rural knowledge, local knowledge and farmers or pastoralists' knowledge. Indigenous knowledge can be defined as "a body of knowledge built up by a group of people through generations of living in close contact with nature" (Johnson, 1992).

Indigenous knowledge is now considered cultural knowledge in its broadest sense, including all the social, political, economic and spiritual aspects of a local way of life (Ayensu, 1983). Sustainable development researchers, however, have found the following categories of indigenous knowledge to be of particular interest: resource management knowledge and the tools, techniques, practices and rules related to pastoralism, agriculture, agroforestry, water management and the gathering of wild food; classification systems for plants, animals, soils, water and weather; empirical knowledge about flora, fauna and inanimate resources and their

practical uses; and the worldview or way the local group perceives its relationship to the natural world (Emery, 1996).

Indigenous knowledge is important for an essential first step for development projects, allows better innovation and adaptation of technologies, adds to scientific knowledge, increases understanding between researchers and local people, increases the local capacity to experiment and innovate and empowers local people (Warburton and Martin, 1999). It also has relevance to conservation and sustainable development because of locally appropriate, diversified production systems, respect for nature, flexible and social responsibility (Dewalt, 1994).

### **2.9.2. Traditional medicinal plants and healthcare**

According to the World Health Organization (2008) more than 3.5 billion people in the developing world rely on medicinal plants as components of their healthcare. On the other hand, about 60-85% of the population in every country of the developing world has to rely on traditional medicine (Balick and Cox, 1996). The practice of traditional medicine is widespread in China, India, Japan, Pakistan, Sri Lanka and Thailand. In Africa, traditional medicine is a part of the people's culture even though this form of medicine is not as well organized unlike, for example, that of India and China. Practitioners include herbalists, bonesetters, village midwives or traditional birth attendants, traditional psychiatrists, herb sellers, and other specialists (Sofowora, 1996).

Studies conducted in Ethiopia have found out that some cultural beliefs and traditional practices that are vital in contributing to the conservation of medicinal plants and biodiversity as a whole. For example, Zewdie Kassa *et al.* (2016) documents the ethnobotanical study of medicinal plants used by the local people in Tulu Korma and its surrounding areas of Ejere District (Western Shewa Zone); Abraha Teklay (2015) assessed medicinal plants used in ethnoveterinary medicine in Kilde Awulaelo District (Tigray Region); Ermias Lulekal *et al.* (2013) documented ethnobotany of human traditional medicinal plants in Ankober District (North Shewa Zone). Fisseha Mesfin *et al.* (2009) also documented cultural and spiritual beliefs used for the conservation of medicinal plants in Wonago Wereda (SNNPR). Alemayehu Wassie (2007) also noted the role of Ethiopian Orthodox Church (EOC), in northern part of Ethiopia, for the conservation of biodiversity. Thus, if ethnobotany is strengthened and if ethnobotanists work together with stakeholders, including the local communities, governments, educators, NGOs, etc., it can address future environmental degradations that are accelerating loss of cultural knowledge and language (Hamilton, 2003).

Traditional veterinary medicine is an ancient practice that emerged with the domestication of animals (Zemedede Asfaw and Tigist Wondimu, 2007). The academic circle addresses traditional veterinary medicine with a term ethnoveterinary medicine, coined for the first time by Constance McCorkle in 1986. McCorkle (1986) defined ethnoveterinary medicine as local or indigenous knowledge and methods of caring for, healing and managing livestock.

In Ethiopia as well as in most developing countries, animal disease remains one of the principal causes of poor livestock performance, leading to an ever-increasing gap between the supplies of, and the demand for, livestock products (Teshale Sori *et al.*, 2004). Ethnoveterinary medicine and related study is one of the most important means of controlling livestock diseases. Ethnoveterinary medicine refers to traditional animal healthcare knowledge and practices comprising of traditional surgical and manipulative techniques, traditional immunization, magic-religious practices and beliefs, management practices and the use of herbal remedies to prevent and treat arrange of disease problems encountered by livestock holders (Tafesse Mesfine and Mekonnen Lemma, 2001).

Ethnoveterinary studies conducted in Ethiopia have been to contributed to the conservation of livestock medicinal plants and associated indigenous knowledge. Such as that of Teshale Sori *et al.* (2004) in Borena Pastoralists, Southern Ethiopia, Debela Hunde, *et al.* (2006) in Boosat, Welenchiti area, Haile Yineger *et al.* (2007) in Bale Mountains National Park, Gidey Yirga *et al.* (2012) in Seharti-Samre District, Northern Ethiopia, Abiy Shilema, *et al.* (2013) in Amaro District, Southern Ethiopia, Ermias Lulekal, *et al.* (2014) in Ankober District, North Shewa Zone, Yared Yigezu *et al.* (2014) in four districts of Jima zone, South western Ethiopia.

## **2.10. Traditional medicine, activity testing of medicinal plants, and drug development**

Historically, the developments of novel drugs were primarily through the extraction of biologically active compounds from plants, which were identified through medicinal use or a variety of bioactivity screening programmes. Many researchers have examined long-established uses of medicinal plants, but only a few studies have led to these ethnobotanical findings with laboratory activities to confirm the antimicrobial property of plants (Mahmood *et al.*, 2012).

There is an increased interest to explore the scientific basis of traditional herbal remedies based on information collected from local residents and traditional practitioners in different parts of

the world. Chemical and biological investigations of folk medicinal plants with the reputation of being curative have provided the world with many of the clinical drugs of today (Izzo and Ernst, 2009). It has been reported that at least 119 compounds derived from 91 plant species served as source of important drugs currently in use and that 77% of them were derived from traditional medicines. The search for new antibacterial agents, in particular, has increased in the last decade mainly because of the increase in bacterial infections especially in countries with low income populations and more so because of bacterial resistance to current antibiotics (Khan *et al.*, 2014).

Medicinal plants used in the traditional medicines offer a great reservoir for the discovery of new plants having antimicrobial properties comparable to antibiotics used in modern medicines (Khan *et al.*, 2014; Mahmood *et al.*, 2012). According to Ermias Lulekal *et al.* (2013), traditionally used medicinal plants against some microbial diseases in Ankober District, Ethiopia shows potential therapeutic role. This report confirms that about 74% of the ethanol extracts obtained from medicinal plant species have already proven to show antimicrobial activity against microbial strains.

### **2.11. Threats and conservation of medicinal plants and associated knowledge**

Today between 60,000 and 100,000 plant species (including about 4,000 to 10,000 medicinal plants) are threatened worldwide, of which 34,000 are classified as globally threatened with extinction (Schippmann *et al.*, 2002). The conversion and destruction of habitats, over-exploitation and destructive harvesting techniques have been considered the main causes for the depletion and loss of medicinal plants which are largely obtained from the wild (IUCN, 1993).

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

According to Jansen (1981), in Ethiopia, even though the traditional medicinal partitions are the best source of information about the knowledge of medicinal plants, it was found very difficult to obtain their traditional medicinal information as they considered their indigenous knowledge as a professional secret, only to be passed orally to their elder sons at oldest age. According to Amare Getahun (1976), practitioners do not want to tell the use of medicinal plants because they believe that the plants loose their healing power and healing virtues; therefore it should be kept secret (that is, the name of the plant and its reputed use should not be disclosed). In addition knowledge on traditional medicine is commonly passed from generation to generation orally, valuable information can be lost whenever a medicinal plant is lost or when a traditional medical practitioner dies without passing over his/her indigenous knowledge to others (Cunningham, 1993).

In Ethiopia, traditional medicine as elsewhere in other developing countries is faced with a problem of sustainability and continuity mainly due to loss of taxa of medicinal plants and, loss of habitats (Zemedu Asfaw, 2001). Conserving the diverse cultures with indigenous medicinal and other knowledge that exists within the traditional communities may contributed greatly in giving value to the biodiversity and maintaining the resource for generations (Medhin Zewdu, 2002). Thus for conservation of plant biodiversity, both *in-situ* (conservation in their natural habitats like natural reserves and parks e.g. home-gardens) and *ex-situ* (conserving them in field gene bank, seed bank and botanical garden) conservation methods needs to be applied (Frankel *et al.*, 1995).

## CHAPTER THREE

### 3. MATERIALS AND METHODS

#### 3.1. Description of the Study Area

This study was conducted in *Menz Gera* District, in the north-central highlands of Ethiopia. *Menz Gera* District is located in North Shewa Zone, Amhara National Regional State, Ethiopia. It is 282 km northeast of the Ethiopian capital, Addis Ababa; 149 km North of Debre Birhan, the administrative town of North Shewa. *Mehal Meda* is the administrative town of *Menz Gera* District.

The elevation of *Menz Gera* District ranges from 2300 m a.s.l. at northern *Siregedel Kebele* to 3700 m a.s.l. at the pick of *Menz Guassa* community conserved mountain. *Menz Gera* District is bordered in the South by *Menz Lalo* District, Southwest by *Menz Keya Gebreal*, West by *Kechene River* from South Welo zone, North by *Geshe Rabel* District, Northeast by *Antsokiya Gemza* District and East by *Efratana Gidim* District of Amhara Regional State. The district is known by *Menz Guassa* community conserved mountain, which is known for its plant and animal diversity and longtime services to the local community especially by tourism. *Menz Guassa* mountain area is 17 km from *Mehal Meda* to the main road to *Debre Birhan*. It lies at latitude  $10^{\circ} 8' - 10^{\circ} 40'N$  and longitude  $39^{\circ} 24' - 39^{\circ} 48'E$ . Its total area is 100 km<sup>2</sup>, and its elevation ranges from 3200 m to 3700 m.a.s.l. The annual rainfall for the area averages between 1,200 and 1,600 mm. (Tewodros Atlabachew *et al.*, 2003; Getachew Simeneh, 2010, Zelealem Tefera *et al.*, 2012; Habtamu Wodaj *et al.*, 2016; Solomon Ayele and Demel Teketay, 2017).

The district also contains important remnant natural forest patches fragmented from *Menz Guassa* Community Conserved Mountain with a total of 1300 hectares. The fragmented natural forest patches are *Yegana* from the Blue Nile (Abay) river watershed and *Gajilo* from Awash river watershed. *Yegana* natural forest patch is bounded by three *Kebeles* (sub-districts), in the south by *Dargegn* (016), in the north by *Wejed* (017) and *Anaz* (019) and in the east by *Guassa* community conserved area and the forest accounts for more than 750 ha which has a hilly topography and difficult to access for data collection. *Gajilo* natural forest patch is found in *Kebele* 020 (*Siregedel*) covering around 550 ha. Both patches are found near *Guassa* *Menz* community conserved area, fragmented due to anthropogenic and natural factors and are located at very hilly and sloppy inaccessible areas. They are homes to many floral and faunal diversities with important social, economic and cultural roles to the local community.

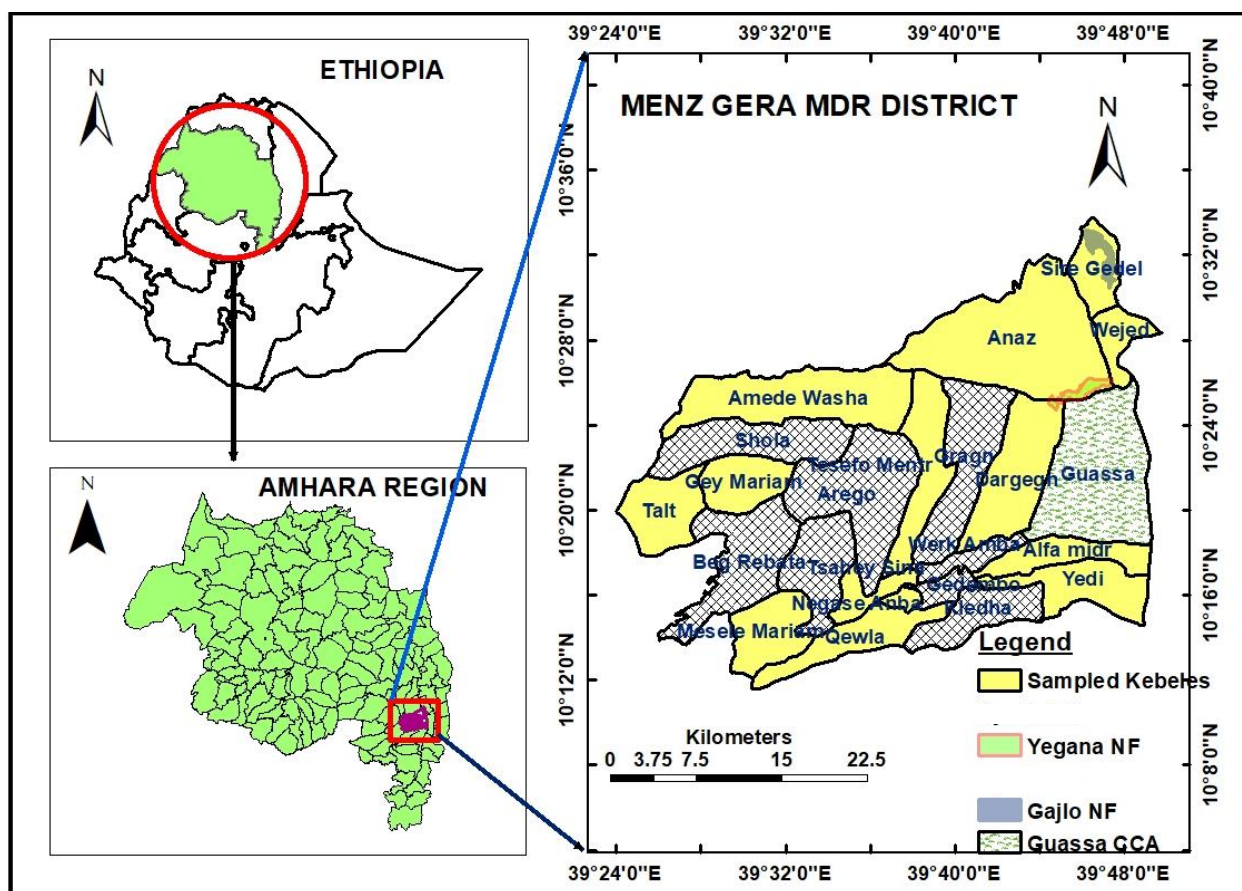


Figure 1: Map of Ethiopia, showing Amhara Regional State and the study District

### 3.1.1. Physical and biological setting of the study area

#### 3.1.1.1. Climate

The central highlands of Ethiopia are characterized by temperate rain climate type, with distinct dry and wet months. However, considerable variation occurs as a result of differences in elevation and size of mountain blocks (Getachew Simeneh, 2010).

The climate of *Menz Gera* District is affected by northerly winds, which blow throughout the year. There is high rainfall, frequent storms and occasional snow at higher altitudes during the wet season (July to September) and frequent frosts during the dry season. Therefore, the climate of the study area is unfavourable for most crops. However, the surrounding farming communities grow barley and some pulses (Zealelem Tefera *et al.*, 2000).

In the driest months (December to February), the day time temperature can be as high as 21<sup>0</sup>C while at night it can fall to -7<sup>0</sup>C, a diurnal fluctuation of 28<sup>0</sup>C. The diurnal temperature variation is low during the wet season with a daytime mean annual temperature of 12.8<sup>0</sup>C and

temperature of 3<sup>0</sup>C at night. This fluctuation is expected to cause high temperature stress on the flora and fauna of the area. In the early dry season, frost is very common and fog can be seen any time of the year (Getachew Simeneh, 2010).

The rainfall data were recorded from the metrological station at *Mehal Meda*; the of the district’s city. The Equatorial Westerly’s and the Indian Ocean air streams are the sources of rain for the area at different times of the year. Even though showers of light rain can occur in any month of the year, there are two main rainy seasons “*Kiremt*” between June to September and minor rainy season “*Belg*” in February, March and April. The mean annual rainfall at *Menz Gera* District is 868 mm (Zelalem Tefera, 2001; Hailu Beyene, 2010; Solomon Ayele and Demel Teketay, 2017). The area is characterized by high humidity in the wet season and low humidity in the dry season. The annual humidity ranges from 55.18% to 80.90% (Hailu Beyene, 2010)

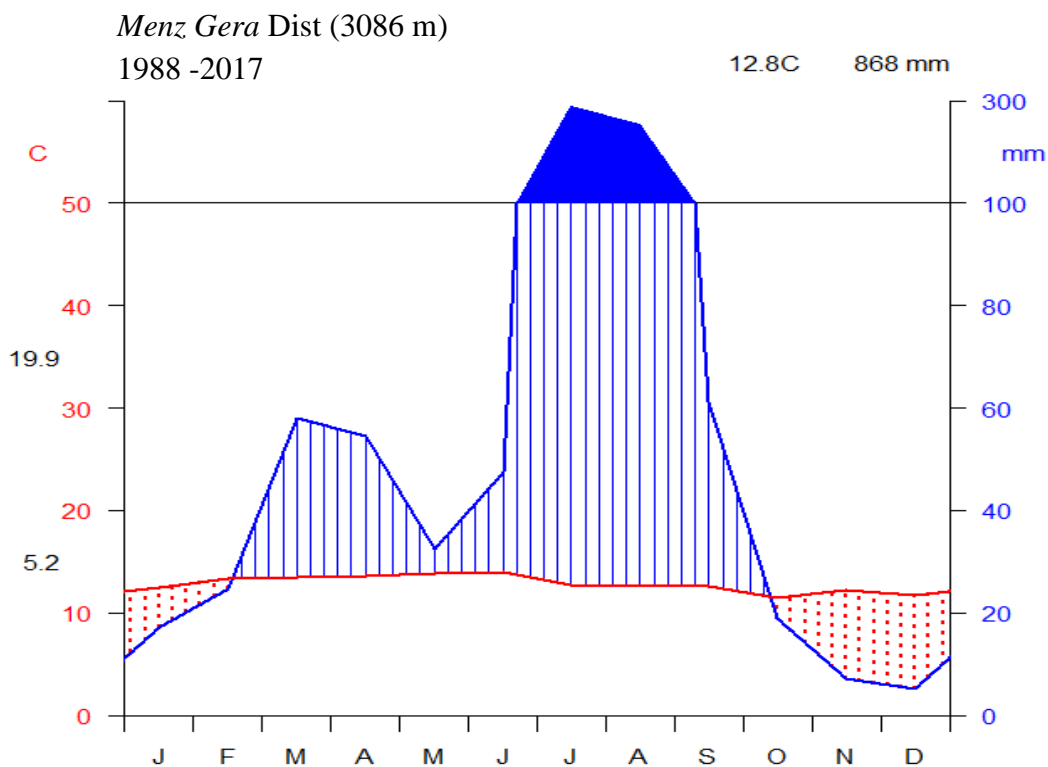


Figure 2: Climate diagram of *Menz Gera* District (Data source: National Meteorological Service Agency)

### 3.1.1.2. Soil

The central highland soil is characterized by two principal types, originating from the disintegration of volcanic substrates intermingled with sand and limestone. These comprise

black clay soil (vertisols) and reddish-brown heavy loam (redsoil). The former type appears on flat plateau along the bottom of valleys. The latter appears on valley slopes and well-drained areas. Generally, the soil of Menz Guassa area is deep. However, on higher ground, the soil is shallow and highly mineralized (Getachew Simeneh, 2010).

### **3.1.1.3. Vegetation**

The main vegetation type of *Menz Gera* District are Dry Evergreen Afroalpine and Afroalpine forests. The study area is largely characterized by *Juniperus procera*, *Olea europaea* ssp. *cuspidata*, *Prunus africana* and *Ekebergia capensis*. Important grass genera are *Eragrostis*, *Pennisetum*, *Panicum*, and *Hyparrhenia*, while herbaceous legumes are species of *Indigofera*, *Trifolium* and *Crotalaria*, which are the common characteristic species of Dry Evergreen Afroalpine forests of Ethiopia (Friis *et al.*, 2010). *Embelia schimperi*, *Rubia cordifolia*, *Urera hypselodendron* and *Jasminum abyssinicum* are also characteristic species of the study area some are climbers.

The Afroalpine vegetation of *Menz Gera* District mostly represented by Menz Guassa community conserved area is characterized by *Euryops-Alchemilla* shrub land, *Festuca* grassland, *Euryops-Festuca* grassland or Mima mound, and *Erica* dominated land (Habtamu Wodaj *et al.*, 2016). The area derives its name from the so-called ‘Guassa grass’, which comprises four species of *Festuca* (*F. abyssinica*, *F. simensis*, *F. richardii*, *F. macrophyll*) which are highly valued by the local community, among other uses, for thatching and manufacturing of household and farm implements. *Erica arborea*, *Thymus schimperi*, *Kniphofia foliosa*, *Helichrysum splendidum*, *Podocarpus falcatus*, *Galiniera saxifraga*, *Juniperus procera*, *Olea europaea* subsp. *cuspidata*, *Osyris quadripartita*, *Hagenia abyssinica*, *Ekebergia capensis* and *Lobelia rhynchopetalum* are the most common plant species in the study area. The area is rich in biodiversity and contains several endemic and threatened species of flora and fauna (Zealealem Tefera *et al.*, 2012; UNDP, 2012).

### **3.1.1.4. Fauna**

The *Menz Gera* District harbors 23% of the endemic mammals of Ethiopia, among others including the Ethiopian Wolf (*Canis simensis*), gelada (*Theropithecus gelada*) and the Abyssinian hare (*Lepus starcki*). The Ethiopian wolf is legally protected, and with a total population of 500 individuals, it is the most endangered canid in the world. It is threatened predominantly by habitat loss and disease transmission from domestic dogs. The other large

endemic mammal of note is the gelada baboon. This is the only living member of the once widespread genus *Theropithecus* found in the highlands of northern Ethiopia only (Biniyam Admassu and Zelalem Terefe, 2011).

*Menz Gera* District is a home for small mammals, two shrew and six rodent species. *Crocidura thalia* and *Crocidura baileyi* are the most widespread of the endemic shrews in the area. The rodent species found in *Menz Guassa* include, porcupine (*Hystrix cristata*), common mole rat (*Tachyoryctes splendens*), the unstriped grass rat (*Arvicanthis abyssinicus*), the Harsh-furred rat (*Lophuromys flavopunctatus*), the Abyssinian meadow rat (*Stenocephalemus grisecauda*) and the Groove-toothed rat (*Otomys typus*). Two of the rodent species, *Arvicanthis abyssinicus* and *Stenocephalemus grisecauda* are endemic to Ethiopia. Ankober serin (*Serinus ankoberensis*) is also one of the endemic large fauna of *Guassa*. The other large mammal species inhabiting the area are: grey duiker (*Sylvicapra grimmia*), klipspringer (*Oreotragus oreotragus*), common jackal (*Canis aureus*), spotted hyaena (*Crocuta crocuta*), civet (*Civeta civettictis*), rattle (*Melivora capensis*), Egyptian mongoose (*Herpestes ichneumon*) and serval cat (*Felis serval*) (Getachew Simeneh, 2010).

### **3.1.2. Human and livestock population, Health Status and socio-economic aspects**

#### **3.1.2.1. Human population and Health Status**

The people living in *Menz Gera* District are from the Amhara ethnic group. According to the Ethiopian Census of 2007, *Menz Gera* district has a total population of 116,634 (49.66 % males and 50.34% females) of whom only 20.53 % are urban inhabitants. Age class, less than 14 years is the most dominant which covers 38.21 % (Table: 1). The number of householders at *Menz Gera* District is 25,930 which indicates approximately five individuals per household. According to the statistics of the district, the great majority (99.5%) of the inhabitants practiced Ethiopian Orthodox Tewahdo Christian faith.

Table 1: Population of *Menz Gera* District

Age class	Age range	Number of Individuals								
		Rural			Urban			Rural + Urban		
		Male	Female	Sub Total	Male	Female	Sub Total	Male	Female	Total
Child	0 - 14	19397	18525	37922	3952	2691	6643	23349	21216	44565
Adolescent	15 - 24	9859	8240	18099	3197	4620	7817	13056	12860	25916
Adult	25 - 59	13621	16137	29758	3414	4944	8358	17035	21081	38116
Senior Adult	>= 60	3773	3138	6911	712	414	1126	4485	3552	8037
Total		46650	46040	92690	11275	12669	23944	57925	58709	<b>116,634</b>

Source: *Menz Gera* District administrative office, Ethiopian Census year of 2007

According to the *Menz Gera* district's health office there is one hospital at *Mehal Meda* town, which is the administrative seat of the district. This hospital serves nearby districts, Four health centers are found at *Mehal Meda* town and *Wejed*, *Tsehay Sina* and *Ashen Kebeles* and two private clinics are found at *Mehal Meda*. All *Kebeles* of the district have health posts (toll centers), giving service to a total of 25,930 households and 116,634 people. There are 160 health professionals directly or indirectly associated with health services. The professionals are composed of medical doctors (at the hospital only), health officers, pharmacists, laboratory technicians, nurses, midwives, health information and health extension workers (Table 2) health extension workers are available at each *Kebele* for prevention of diseases, family planning and sexually transmitted diseases protection but very poorly supplied with drugs, medical equipment and office rooms. The top ten human ailments in the area in year 2017/18 G.C include pneumonia, diarrhea (non-bloody), acute febrile illness (AFI), diarrhea with blood (Dysentery), helminthiasis, acute upper respiratory infections, Diarrhea with dehydration, Infection of skin and subcutaneous tissue, moderate acute malnutrition and neoplasms (*Menz Gera* District Health office, 2018).

Table 2: Health Professionals at *Menz Gera* District

Health Professionals	Hospitals	Others	Total
Medical Doctor	6	0	6
Health Officer	1	7	8
Nurse	5	53	58
Midwife	5	10	15
Laboratory Technicians	3	6	9
Pharmacist	3	10	13
Dental Doctor	1	0	1
Environmental Health expert	0	2	2
Health information expert	0	2	2
Health Extensions expert	0	46	46
		Total	160

Source: *Menz Gera* district health office

### 3.1.2.2. Livestock population and Health Status

According to *Menz Gera* district agriculture office livestock population in the district was estimated at 56,927 heads of cattle, 20,406 equines (donkeys, horses, and mules), 16,105 goats, 169,915 sheep, 82,197 hens and 5,314 hives of bees in the year 2017/18. There are only 13 rural veterinary clinics at 13 *Kebeles* out of the 21 *Kebeles* in the district, located at *Wejed* (17), *Tsehay Sina* (08), *Talt* (21), *Shola* (12), *Ashen* (11), *Anaz* (19), *Yedi* (20), *Kuledha* (04), *Alfamidir* (05), *Dargegn* (16), *Giragn* (15), *Kewla* (02) and *Tesfumentir* (14). There are eleven veterinarians (2 Veterinary Doctors and 9 with BSc) working in the District since 2018, a number found to be insufficient to provide proper health services for more than 345,550 heads of livestock present in the District. From the central district administration, veterinarian experts work by circulating in the community. Diarrhea, abscess, eczema, sudden abdominal cramp, lashing and various parasitic diseases are reported as the most common disease types affecting the livestock.

### 3.1.2.3. Socio-economic aspects of the community

Subsistence agriculture and livestock production are the major livelihoods in *Menz Gera* district with almost no specialization for crop production. The most widely cultivated crops are *Hordeum vulgare* (*Gebes*), *Triticum* species (*Sinde*), *Vicia faba* (*Bakela*), *Pisum sativum* (*Ater*), and *Eragrostis tef* (*Tef*). Declining landholding sizes because of population growth and deteriorating soil fertility are among the biggest challenges facing the local communities. Local community elders reported that, shrinking of natural forest patches due to settlement, timber

and agricultural materials extraction, unwise manipulation of traditional medicinal plants, extensive free grazing and agricultural expansion led to drought and loss of crop productivity.

The other source of socio-economy is use of plant species from their cultivated area and/or the wild for cultural, social and economic purposes. Plants such as *Rhamnus prinoides*, which is locally known as “*Gesho*”, is grown in the wild and as a plantation crop in home gardens both for sale (income-generation) and for domestic use. It is used as a flavoring agent in locally produced beverages (“*Tella, Tej and Areki*”). *Thymus schimperi* “*Tosign*” is collected from the wild by the local people and sold as an alternative income-generating option especially from Guassa community conserved mountain and other mountains of the district. The well-dried leaves of *Thymus schimperi* are boiled and used as a spice for tea preparation and other food materials. The cultivation of *Hordeum vulgare* has now expanded onto the steepest slopes around to edge of different natural forest patches of the district. People in *Menz Gera* District also grow fruit trees such as apple fruit (*Malus domestica*) in the highlands “*Dega*” of the district and papaya (*Carica papaya*), orange (*Citrus sinensis*) and banana (*Musa x paradisiaca*) in medium altitude lands “*Weina Dega and Dega*” zones.

There are a large number of beehives in the margin of the remnant natural forest patches, especially on cliff sides near the *Erica* dominated areas with high density *Thymus schimperi*. The forest provides bee forage, nesting habitat for bees and materials for beehives making in addition to the modern beehives provided by the agricultural office. The species preferred for bee fodder in the forest are *Erica arborea*, *Ilex mitis*, *Allophylus abyssinicus*, *Hagenia abyssinica* and *Thymus schimperi*. Farmers favor these species due to the attractive odor, abundance and long flowering periods and the good nature of the honey that is produced from their flowers.

Forest products are used by local people for house construction, as grazing land, agricultural utensils, beehives, fuelwood, charcoal, fencing, medicinal plants, and as forage. Forests are also a source of spring water and of timber trees (particularly *Juniperus procera*, *Podocarpus falcatus* and *Olea europaea* subsp. *cuspidata*) that are illegally harvested.

### **3.2. Equipment and chemicals**

For the successful research data collection, getting appropriate materials at the right time is very important. All the materials and chemicals used during this research are listed with their respective functions (Appendix 4).

### 3.3. Research Methods

#### 3.3.1. Reconnaissance survey

A reconnaissance survey was done from May 2, 2016 up to May 10, 2016 G.C to get a general impression of the physiognomy of *Menz Gera* District including the remnant natural forest patches (at *Yegana* and *Gajilo*) which helped in the selection of sampling sites (Figure 3). Ethnomedicinal and ecological data were collected from the study area during the field visits made at different seasons, which were conducted from November 2017 – June 2018 and September to November 2018. The last trip was for sample collection of selected traditional medicinal plants for *in-vitro* antimicrobial testing and remaining ecological and ethnobotanical data and specimen collection.



Figure 3: Partial view of the natural forest patches: (a) *Yegana* Forest and (b) *Gajilo* Forest

#### 3.3.2. Methods for vegetation study in *Yegana* and *Gajilo* forest patches

##### 3.3.2.1. Site selection and sampling design

The vegetation data collection in *Menz Gera* natural forest patches was made using a systematic sampling technique (Kent and Coker, 1992). A total of 14 transects from *Yegana* and *Gajilo* forests, 7 in each forest transects set at 500 meters apart from each other were established from the ridge top of the mountain (highest elevation) to the bottom (lowest elevation). Transects were laid from different points of the mountain where the forest is stretched and hence have different lengths. A total of 72 quadrats from both forests were taken. Out of these 34 quadrats were from *Yegana* natural forest patch and 38 quadrats were from *Gajilo* natural forest patch. Quadrats measuring 20 m x 20 m and 10 m x 10 m for mature tree and sapling, respectively were laid down by arranging the small ones within the large quadrats. The other sub quadrats

were 5 m x 5 m for seedling and shrub and 2 m x 2 m for herbaceous layers established within the large 400 m<sup>2</sup> quadrat, four at the corner and one at the center of the main quadrat then the average of the five sub quadrats were taken following Kent and Coker (1992) (Figure 4). The quadrats on the transect lines were located systematically at 50 m altitudinal drop from each other using GPS but the initial quadrat was selected randomly at least 30 m from the edge of the forest. For this study, the plants were categorized as seedling (height  $\leq$ 1m), sapling (height between 1m and 3m) and tree (height  $\geq$  3m and DBH  $\geq$  2cm) (Feyera Senbeta and Demel Teketay, 2001; Shankar, 2001).

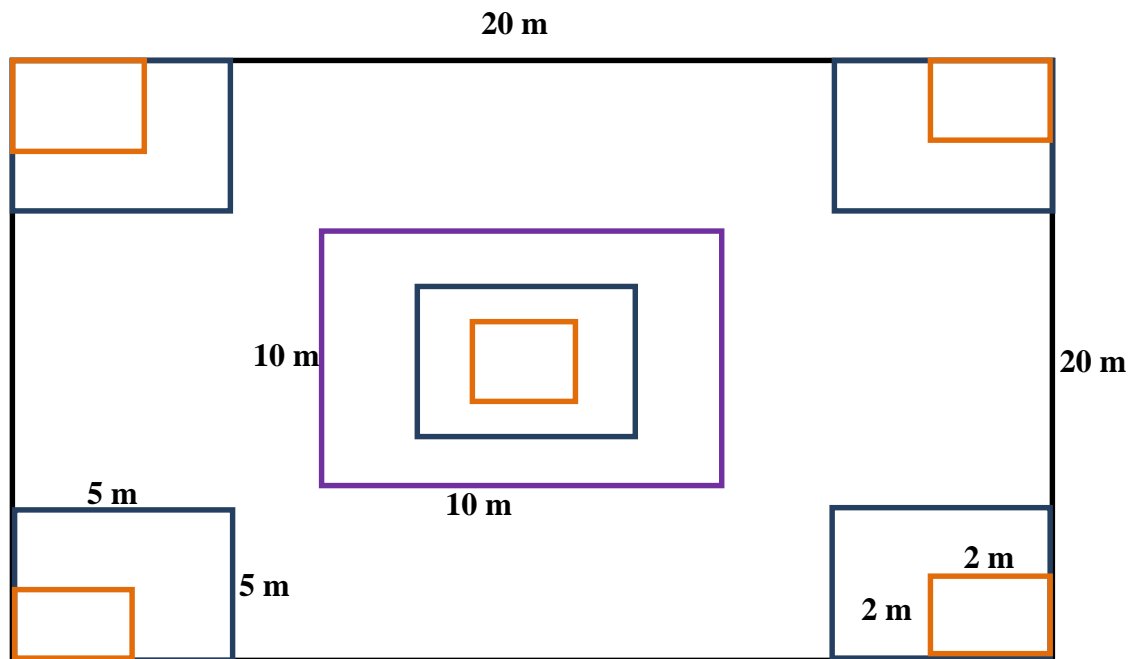


Figure 4: Quadrat layout and size for vegetation data collection

### 3.3.2.2. Vegetation data collection

In each quadrat, trees and shrubs with a diameter at breast height (DBH)  $>$  2 cm and height  $\geq$  3 m were counted, measured and cover-abundance were estimated following the modified 1-9 Braun-Blanquet scale as modified by Van der Maarel (2005) (Table 3). Growth forms and growth stages of plants were listed. Location (altitude, longitude and latitude) of the study site and each quadrat were measured using GPS.

Table 3: Modified 1-9 Braun-Blanquet scale

---

1	Rare, generally one individual
2	Occasional or sporadic with less than 5% cover of the total area
3	Abundant, with less than 5% cover of total area
4	Very abundant, with less than 5% cover of the total area
5	5-12% cover of the total area
6	12-25% cover of the total area
7	25-50% cover of the total area
8	50-75% cover of the total area and
9	75-100% cover of the total area

---

Voucher specimens of each plant were collected in duplicate for later taxonomical identification with their respective field note information for both floristic and medicinal plants studies. Field note information included vernacular names, specimen code, parts used, habitat, flower color, place and time of collection etc. Elevation and location where plants are collected were recorded using a GPS. After having the above information voucher specimens were taxonomically identified in the National Herbarium of Ethiopia (ETH) using the published volumes of Flora of Ethiopia and Eritrea (Hedberg and Edwards, 1989; Edwards *et al.*, 1995; Hedberg and Edwards, 1995; Edwards *et al.*, 1997; Edwards *et al.*, 2000; Hedberg *et al.*, 2003; Hedberg *et al.*, 2004; Hedberg *et al.*, 2006) and by comparing these with herbarium specimens. To avoid misidentification, identifications were confirmed by plant taxonomists.

### **3.3.2.3. Vegetation data analysis of Yegana and Gajilo forest patches**

Vegetation data were analyzed via hierarchical cluster analysis using R statistical software version 3.6.0 (R Development Core Team, 2009). Quadrats were grouped into clusters based on floristic similarity and species abundance to define distinct plant community types. Identified communities were further refined in a synoptic table where species occurrences were summarized as synoptic cover-abundance values (Van der Maarel *et al.*, 1987). Synoptic values were calculated as the product of average cover abundance values of species and their frequency in a specific community type following Van der Maarel *et al.* (1987). Community types were named after one or more dominant and/or characteristic species per community.

For community classification the output of Multi-response Permutation Procedures (MRPP) conducted in R software, resulting in T statistics having more negative value with significant P-value ( $T = -40.56$ ,  $P < 0.001$ ) and an agreement statistic A (0.10) confirming the distinctness of clusters. The test statistic T describes the separation between the groups. The more negative T value, the stronger the separation. The P-value is useful for evaluating how likely an observed difference is due to chance (McCune and Grace, 2002). The agreement statistic A describes within group homogeneity, compared to the random expectation, and falls between 0 and 1. When all items within-groups are identical  $A = 1$  and 0 if the groups are heterogeneous. In community ecology, A values are commonly below 0.1, and an A value greater 0.3 is high (McCune and Grace, 2002).

Structural analysis of both natural forest patches was performed based on frequency, density, diameter at breast height (DBH), height and basal area (BA) per hectare, following Tamrat Bekele (1993). Frequencies of species were computed as the proportion of samples within which a species is found. Density was then computed by converting the count from all quadrats into a hectare basis as indicated in Kent & Coker (1992). DBH values were classified into six classes (Tamrat Bekele, 1993) and density distribution of each tree and shrub species were computed per DBH class (Kent and Coker, 1992). The ratio of density of individuals with DBH of 2 cm to 10 cm, 11 cm to 20 cm and  $DBH > 20$  cm were computed to measure the size class distribution of species in the forest, following Grubb *et al.* (1963). Relative density of species in different DBH classes was used to get representative patterns of species population structures, following Popma *et al.* (1988).

To analyze the population structure of woody species, all individuals of each species encountered in the quadrats were grouped into diameter classes and height classes; graphs were developed using the diameter classes and height classes versus the number of individuals categorized in each of the classes using Microsoft Excel 2013 Computer Software. Six density classes (density per hectare): A=  $>50.01$ ; B= 35.01-50; C= 20.01-35; D= 10.01-20; E= 1.01-10; F=  $\leq 1$ , Six DBH classes (cm) with  $DBH \geq 2$  cm (1= 2 – 10; 2= 10.1–30; 3= 30.1–50; 4= 50.1–70; 5= 70.1–90 and 6  $\geq 90.1$ ) were formed. Ten height classes, height  $\geq 3$  m (1= 3 – 6; 2= 6.1 – 9; 3= 9.1 – 12; 4= 12.1 – 15; 5= 15.1 – 18; 6= 18.1 – 21; 7= 21.1 – 24; 8= 24.1 – 27; 9= 27.1 – 30; 10  $\geq 30$ ) were also formed.

**Shannon-Wiener diversity index ( $H'$ )** was calculated to measure species diversity of identified plant communities (Kent and Coker, 1992) in the study area, using:

$$H' = - \sum_{i=1}^S p_i \ln p_i,$$

Whereby,

$H'$  = Shannon diversity index,  $S$  = number of species,

$p_i$  = proportion of individuals or abundance of the  $i^{\text{th}}$  species expressed as a proportion of total cover in the sample; and  $\ln$  = the natural logarithm.

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

$$J = \frac{H'}{H'_{\max}} = \frac{\sum_{i=1}^S P_i \ln P_i}{\ln S}$$

Where,  $H'$  = Shannon–Wiener Diversity Index; and

$H'_{\max} = \ln S$  where  $S$  is the number of species in the sample (Kent and Coker, 1992).

The following structural parameters were computed for all woody species with height  $\geq 3\text{m}$  and DBH  $\geq 2\text{cm}$  using the formula indicated below (Mueller- Dombois and Ellenberg, 1974 and Martin, 1995).

Percent frequency of species

$$= \frac{\text{the number of plots in which that species occur}}{\text{total number of plots}} \times 100\%$$

$$\text{Relative frequency} = \frac{\text{frequency of species A}}{\text{total frequency of all species}} \times 100\%$$

According to their total frequency expressed as percentage, species were grouped in to the following five frequency classes following (Simon Shibru and Girma Balcha, 2004): A= 81 – 100, B= 61– 80, C= 41 – 60, D= 21 – 40, E= 0 – 20%.

$$\text{Density of a species} = \frac{\text{the number of individuals of the same species}}{\text{area sampled}} \times 100\%$$

$$\text{Relative density} = \frac{\text{density of species A}}{\text{total density of all species}} \times 100\%$$

$$\text{Basal area (m}^2\text{)} = (\text{DBH}/200)^2 \pi (3.14)$$

$$\text{Dominance} = \frac{\text{total of basal area}}{\text{area sampled}}$$

$$\text{Relative dominance} = \frac{\text{Dominance of species A}}{\text{total dominance of all species}} \times 100$$

$$\text{IVI} = \text{Relative density} + \text{Relative frequency} + \text{Relative dominance}$$

#### **3.3.2.4. Natural Regeneration Status analysis**

The numbers of individuals of each mature tree, sapling and seedling species per hectare were calculated from the sampled area. According to Chauhan *et al.* (2008) the regeneration status of each forest was evaluated based on the following categories:

- a. 'Good', if presence of seedling > sapling > mature strata;
- b. 'Fair', if presence of seedling > sapling < mature strata;
- c. 'Poor', if a species survives only in the sapling stage, but not as seedlings (even though saplings may be less than, more than, or equal to mature);
- d. 'None', if a species is absent both in sapling and seedling stages, but present as mature; and
- e. 'New', if a species has no mature strata, but only sapling and/or seedling stages.

#### **3.3.3. Methods for Ethnobotanical study**

##### **3.3.3.1. Reconnaissance survey**

A reconnaissance survey was conducted from May 2, 2016 up to May 10, 2016 G.C to get a general impression of *Menz Gera* District including the potential *Kebeles* (smallest administrative units in Ethiopia) for ethnomedicinal plants and associated indigenous knowledge to select sampling sites. Fieldwork materials and related equipment were made ready for the fieldwork.

##### **3.3.3.2. Informant selection and sampling method**

Before data collection, the necessary ethical clearance and legal support was obtained from the *Menz Gera* District Administrative Office through an official request for support from the Department of Plant Biology and Biodiversity Management (DPBBM), AAU. Then, the district administrative official wrote a letter to each *Kebele* leader and contacted them over their mobile phones. The study objectives were introduced to the local *Kebele* leaders and selected local community members to have common consensus. This was followed by formal data collection procedure.

*Menz Gera* District has 20 *Kebeles* and one administrative town. Out of these *Kebeles* 13 *Kebeles* were purposefully selected based on agro-ecological representation of the study district (locally named as "Woinadega" (cool sub-humid, altitude 1800-2400 masl), "Dega" (cool and humid, altitude 2400-3200 masl) and "Wirch" (cool and moist altitude above 3200 masl). Representative general informants and knowledgeable traditional medicine practitioners (Key

informants) of the district were selected using purposive (peer recommendation) sampling approach (Martin, 1995).

The sample size for collecting quantitative data for this research were determined using a formula developed by Cochran's (1977) as indicated by Bartlett *et al.* (2001) as follows:

$$n = \frac{N}{1+N(e)^2}$$

n = sample size for the research;

N= total number of households in the 13 *Kebeles*

e = maximum variability or margin of error 5% (0.05); 1= the probability of the event occurring.

Therefore, sample size was determined based on the total number households (i.e. 15,604) from the sampled *Kebeles* through the total householder of the district were 25,930.

$$n = \frac{15604}{1 + 15604(0.05)^2} = \frac{15604}{40.01} = 390$$

The required sample size was identified as 390 householders (230 males and 160 Females; aged 22 to 80) from the 13 *Kebeles*. Sample sizes for each *Kebele* were calculated using the proportion number of households in each *Kebele* to the total number of households of the 13 *Kebeles* (Table 4). From the 390 informants 338 are general informants (195 males and 143 females) selected randomly and 52 (35 males and 17 females) key informants were selected purposefully based on peer-recommendations from community members. Elderly people and knowledgeable inhabitants were used to nominate traditional herbalists who participated as key respondents (Davis and Wagner, 2003; Ermias Lulekal *et al.*, 2013), whereas general informants were sampled randomly during the field visits made to households in the selected study *Kebeles*. Informed consent was obtained from each informant who may participate in the study after explaining the purpose of the study and assuring him/her of the most responsible judicial use of information before the start of interviews.

Table 4: Number of general informants and key informants included in the study

Sampled <i>Kebeles</i>	Agro ecology Locally	Average elevation	№ of HHs			№ of sampled HH			№ of Key Informants		
			M	F	T	M	F	T	M	F	T
<i>Kewla</i> (02)	Dega	3010	933	421	<b>1354</b>	19	11	<b>30</b>	3	1	<b>4</b>
<i>Alfa Midir</i> (05)	Dega & Wirch	3306	1001	21	<b>1022</b>	12	9	<b>21</b>	3	0	<b>3</b>
<i>Negasi Amba</i> (07)	Woinadega & Dega	3072	881	198	<b>1079</b>	14	9	<b>23</b>	3	1	<b>4</b>
<i>Mesele Mariam</i> (09)	Woinadega & Dega	2840	980	25	<b>1005</b>	13	8	<b>21</b>	3	1	<b>4</b>
<i>Gey Mariam/ Slase</i> (10)	Dega	2916	844	289	<b>1133</b>	15	9	<b>24</b>	2	1	<b>3</b>
<i>Hanamariam/ Ashen</i> (11)	Woinadega & Dega	2951	1601	372	<b>1973</b>	26	19	<b>45</b>	1	2	<b>3</b>
<i>Amed Washa</i> (13)	Woinadega & Dega	2859	1026	328	<b>1354</b>	18	12	<b>30</b>	4	1	<b>5</b>
<i>Dargegn</i> (16)	Dega & Wirch	3356	911	236	<b>1147</b>	15	10	<b>25</b>	3	2	<b>5</b>
<i>Wejed</i> (17)	Woinadega & Dega	3022	1007	102	<b>1109</b>	15	9	<b>24</b>	3	2	<b>5</b>
<i>Siregedel</i> (18)	Woinadega & Dega	2768	621	300	<b>921</b>	6	13	<b>19</b>	3	2	<b>5</b>
<i>Anaz</i> (19)	Dega & Wirch	3214	1559	265	<b>1824</b>	22	20	<b>42</b>	2	1	<b>3</b>
<i>Yedi</i> (20)	Dega & Wirch	3203	946	58	<b>1004</b>	11	10	<b>21</b>	2	1	<b>3</b>
<i>Talt</i> (21)	Woinadega & Dega	2870	566	113	<b>679</b>	9	4	<b>13</b>	3	2	<b>5</b>
Total			12876	2728	<b>15604</b>	195	143	<b>338</b>	35	17	<b>52</b>

Key: HH: Household, numbers in bracket are alternative *Kebele* names

### 3.3.3.3. Ethnomedicinal plants data collection

Ethnomedicinal data were collected from 13 *Kebeles* of *Menz Gera* District, from November 2017 to June 2018 and from September to November 2018 during multiple field trips made considering the different seasons needed to obtain different plant specimen collection and during respective flowering seasons.

Semi-structured interviews, focus group discussions, participant observation and guided field walk and observation were used (Martin, 1995 and Cotton, 1996) to collect ethnobotanical study of medicinal plant uses (Appendix 1). Informants were interviewed individually in the local language, Amharic. Semi-structured interviews addressed questions regarding name, age, gender, level of education, occupation, religion and ethnic background of each informant. The

individual semi-structured interviews focused on enquiries pertinent to the local names of medicinal plants, ailments treated, habitat of the species, seasonality and marketability of species, parts used, condition of plant part used (fresh/dried), methods of remedy preparation, dosage prescriptions and routes of remedy administration (Martin, 1995; Cotton, 1996).

In addition, the semi-structured interviews were designed to investigate on the degree of management (wild/cultivated); abundance, existing threats and traditional conservation practices if any, distance from the house to medicinal plants' gathering sites, uses of other ingredients or additives if any, noticeable adverse effects of remedies, use of antidotes for adverse effects, taboos/beliefs related to collection and use of plants, source of knowledge about medicinal plants and method of indigenous knowledge transfer (Appendix 1). Moreover, informants were also asked about other (non-medicinal) uses of medicinal plant species that they reported, to identify overall use values and use diversities of species (Martin, 1995; Alexiades, 1996; Cotton, 1996). Questions pertinent to the number of years of practice as a healer and the amount of income earned per person/animal treated for an ailment were also asked following the methods used by Alexiades (1996) and Balick (1996).

Each semi-structured interview was followed by independent walks-in-the-woods, which allowed for more discussion with individual informants and the practical identification and collection of traditionally used medicinal plants in their natural environment. This method was combined with participant observation through which reliability of the information collected on medicinal plant collection methods and preparation of specific remedial parts were ascertained as described by Cotton (1996) and Alexiades (1996). Besides, focus group discussions with key informants (a total of 13 focus group; one focus group per *Kebele* with an average number of four participants) were undertaken to gain further information on medicinal plant knowledge at the community level and to triangulate information collected through semi-structured interviews (Martin, 1995) (Appendix 2).

Surveys of traditional medicinal plants were also made in official markets (*Mehal Meda* town, *Wejed Market* (17 *Kebele*), *Gey Mariam* (10 *Kebele*) and homes of traditional healers in the study area (Appendix 3).

### 3.3.3.4. Ethnomedicinal data analysis

#### i. Descriptive statistics and test of significance

Data on informants' background and medicinal plants used by people in the study area were entered into an Excel spreadsheet (Microsoft Corporation, version 2013) and organized for statistical analysis. Traditional knowledge dynamics on use of medicinal plants by men and women, young to middle-aged (23-39 years) and elderly (40 and above years); literate (completed at least primary education) and illiterate; and knowledgeable (key) and local (general) informants were compared using t-test and one way ANOVA at 95% confidence level between means using R software version 3.6.0 (R Development Core Team, 2009) (Table 5). Descriptive statistics were also applied to identify the number and percentage of species, genera and families of medicinal plants used, their growth forms, proportions of parts harvested, modes of remedy preparation and routes of administration (Alexiades, 1996).

Table 5: Informants distribution at different categories/Parameters

<b>Parameters</b>	<b>Informant groups</b>	<b>Individuals</b>	<b>Percentage</b>
<b>Gender</b>	Male	261	66.92
	Female	129	33.08
<b>Age</b>	Young member	120	30.77
	Senior Member	270	69.23
<b>Literacy Level</b>	Illiterate	111	28.46
	Literate	279	71.54
<b>Distance from health centres</b>	Near to health centre	169	43.33
	Far away from health centre	221	56.67
<b>Experience (Informant category)</b>	Key informants	52	13.33
	General informant	338	86.67

#### ii. Direct matrix ranking and preference ranking

*Use diversity* of six multipurpose medicinal plants were evaluated by a direct matrix ranking (DMR) exercises as described in Cotton (1996), that involved ten groups (averagely 5 members) key informants from the study districts, to assess their relative importance by discussing them with considering the range of their contribution.

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

**Preference ranking** (*many plants against single purpose/ effectiveness to criteria*) is the ordinal scale each key informant scored to each species were summed and ranked to estimate the relative order of preference of each species and generate a preference ranking matrix. This is a matrix of relative position of plants in the judgment of key informants for the cultural domain in question (Hussien Adal, 2014).

**Direct matrix ranking** (*single plant against many purposes*) involves asking informants to order medicinal plants according to several criteria such as for curing specific diseases. Direct matrix ranking exercise to evaluate their relative importance to the local community. Such a method allows identifying plants with multiple values for the community.

### iii. **Informant consensus factor (ICF)**

ICF was computed to determine the most important human and livestock ailment categories in the study area and identify potentially effective medicinal plant species in the respective disease categories. For this analysis, reported traditional remedies and corresponding diseases were grouped into 15 disease categories for humans, and 8 disease categories for livestock. ICF was obtained by computing number of use citations in each disease category ( $n_{ur}$ ) minus the number of taxa or species that are used for that plant use category for all informants ( $n_t$ ), divided by the number of use citations in each category minus one (Heinrich *et al.*, 1998).

$$ICF = \frac{n_{ur} - n_t}{n_{ur} - 1}$$

Informant Consensus Factory values range between 0 and 1. A high value (close to 1) indicates that relatively few taxa (usually species) are used by a large proportion of healers. Such high value indicates the plants which are culturally important and may be with high relevance for detailed pharmacological studies.

### iv. **Fidelity level (FL)**

The relative healing potential of each reported medicinal plant used against human and livestock ailments was evaluated using an index of fidelity level (Alexiades, 1996). The relative healing potential of a species for a specific ailment is estimated by using FL values (Heinrich *et al.*, 1998). Prior to FL calculation, all human and livestock ailments mentioned during

interviews were grouped into 15 and 8 major disease categories respectively, by using a similar approach employed by Heinrich *et al.* (1998). As a result, computing FL helps to identify the most likely species with a healing potential to a specific disease that most likely merits further in-depth study. FL is defined as:

$$FL = \frac{I_p}{I_u} * 100\%$$

Where  $I_p$  = is the number of informants who independently cited the importance of a species for treating a particular disease; and

$I_u$  = the total number of informants who reported the plant for any given disease.

### **3.3.4. Methods for antimicrobial study**

#### **3.3.4.1. Selection of medicinal plants**

Eight traditional medicinal plant species with relatively high informant consensus value for treating infectious diseases in the study area were selected for further antimicrobial activity study (Mahmood *et al.*, 2012, Ermias Lulekal *et al.*, 2013, Khan *et al.*, 2014). Local use reports of candidate medicinal plants from the study area were compared with related ethnomedicinal use reports from other parts of Ethiopia and/or out of Ethiopia.

#### **3.3.4.2. Preparation of plant extracts**

The fresh plant parts (leaf and root) (Figure 5-a) were chopped and shade-dried at room temperature (Figure 5-b & c), grounded manually using metallic mortar and pestle then electrically by Metal Universal Miller at Debre Berhan University, Chemical Engineering Department laboratory on October 21-22, 2018 to a fine powder for ease of extraction of active compounds. The ground samples were packed in paper bags and then transported for extraction process (Cheruiyot *et al.*, 2009). Plant parts were kept out of direct sunlight to prevent the degradation of active ingredients.

Powdered dried plant materials were extracted by macerating with 80% ethanol. *Inula confertiflora* (leaf), *Urtica simensis* (leaf), *Osyris quadripartita* (leaf), *Satureja abyssinica* (leaf), *Laggera tomentosa* (leaf & root), *Solanum incanum* (root), *Kalanchoe marmorata* (root) and *Minuartia filifolia* (root) were selected for extraction. From each part of the plants identified 20 grams of dry powder were macerated with 200 ml of 80% ethanol (Javid *et al.*, 2015). Maceration was carried out for 72 hours at room temperature from November 26, 2018

to November 28, 2018 at Debre Berhan University, laboratory of Chemistry Department with manual shaking at every 8 hours time interval. After 72 hours the macerated solution was filtered using Whatman paper number 1 with the help of a pressure vacuum pump. Filtrated solution was then transferred into flask and extraction was done using Vacuum Rotary Evaporator at 40 °C, then further dried in vacuum oven at 40 °C for 48 hours to get a concentrated extract. All extract residues were stored in a sterile glass bottle and refrigerated at -4 °C (Figure 5-e) until further use (Cheruiyot *et al.*, 2009; Ermias Lulekal *et al.*, 2013; Khan *et al.*, 2014; Berhan Mengiste *et al.*, 2014, Javid *et al.*, 2015).

#### **3.3.4.3. Preparation of test micro-organisms**

Antimicrobial activities were evaluated against four bacterial strains which are *Listeria monocytogenes* (ATCC19115) (Gram-positive), *Staphylococcus aureus* (ATCC25923) (Gram-positive), *Escherichia coli* (ATCC25922) (Gram-negative), *Salmonella typhimurium* (ATCC13311) (Gram-negative) and a fungal strain which is *Candida albicans* (extracted from patient) obtained from the Ethiopian Public Health Institution (EPHI). Bacterial strains were selected as representative of both classes of Gram-positive and Gram-negative bacteria. Based on the traditional medicinal plant knowledge obtained from the local informants and causative potential pathogens of the cited diseases, traditional medicinal plants were selected for antimicrobial laboratory test. Those plants of the area with high informant consensus factor values and not attempted by other researchers were selected.

#### **3.3.4.4. Antimicrobial assay**

Antibacterial activity of selected traditional medicinal plant extracts was examined following an agar disc diffusion susceptibility method (Khan *et al.*, 2014) (Figure 5-d). Agar plates and standardized bacterial cultures were prepared in Debre Berhan University, Biology Department, biomedical laboratory.

The prepared Mueller-Hinton agar medium was poured into the pre-labeled sterilized petri dish plates. After solidification, freshly prepared culture in the nutrient broth was swabbed with the help of sterilized cotton swab, carefully on the respective plates. Sterile Whatman filter paper discs (6 mm diameter) were impregnated with 100 mg/ml to 6.25 mg/ml serial dilution for each of the extract was placed on the bacterial and fungal agar disc plates until the Minimum Inhibition Concentration (MIC) occurs. The highest dilution with no bacterial colony growth was taken as the minimum inhibition concentration. The bacterial suspension was prepared and

added inoculum average size  $1.9 \times 10^9$  CFU/ml for bacteria and  $4 \times 10^8$  cell/ml for fungi to the sterilized medium before solidification (Singariya, *et al.*, 2012). Ampicillin (10  $\mu$ g/ml) and Chloramphenicol (30  $\mu$ g/ml) discs as a positive control and universal solvent (5% DMSO) as negative controls were used. Plates were incubated at 37 °C for 24 hours. All plates were used in triplicates and the average diameter of zone of inhibition on each plate was recorded.

Dilution was made from the stock of 100 mg/ml extract, which was also considered as the first dilution for test and serial dilutions were made to 50 mg/ml, 25 mg/ml, 12.5 mg/ml and 6.25 mg/ml following Cos *et al.* (2006). Each well was inoculated at 37°C for 24 hours and then plates were checked for Minimum Inhibitory Concentrations (MICs) by measuring the inhibition zone (diameter of the zone of inhibition) (Figure 5-f). MICs were based on the density of the growth control and expressed as the lowest extract concentrations that resulted in  $\geq 80\%$  reduction in bacterial growth compared to that of the extract-free growth control (Cos *et al.*, 2006, Singariya, *et al.*, 2012).



Figure 5: (a-f) In-vitro antimicrobial test of specimen collection to laboratory experiments

### 3.3.4.5. Data analysis of *in-vitro* antimicrobial test

Activities of antibacterial test results were analyzed using mean values of the triplicate inhibition zones.

## 3.4. Ethical Considerations

Initially, compliance was checked with Proclamation No. 482/2006, articles 11:4 and 22:2 providing access to genetic resources, community knowledge, and community right (GoE, 2006). The contents of this proclamation are aligned with those of the Convention on Biological Diversity (CBD) as they relate and apply to Ethiopia. Thus, ethical clearance letter was obtained from the Culture and Tourism office of North Shewa Zone written to *Menz Gera* district and lastly to all *Kebeles* of *Menz Gera* district stepwise by showing different official

letters written from the Plant Biology and Biodiversity Management Department, Addis Ababa University and presenting the purpose of the study.

To develop a positive mind-set between informants and the researcher as well as to create a positive interaction, the objective of the study was explained in a simple way because ethnobotanical indigenous knowledge is only obtained from traditional specialists within the community. After everything was made clear, the informants were told about the purpose, benefit of the study so that they understood the value of the research and gave individual informed oral consent. The interview was administered in their native language “Amharic”. All data collections were conducted with special care on the basis of the cultural view of the local communities in the study area.

## CHAPTER FOUR

### 4. RESULTS

#### 4.1. Plant Diversity

A total of 284 plant species distributed in 213 genera and 89 families were recorded from *Menz Gera* District (Appendix 5). Asteraceae was represented with the highest number of species (14.44%; 41 species representing 23 (10.8%) genera). Poaceae was the second highest family which accounts for 20 (7%) species representing 12 (5.63%) genera followed by Fabaceae with 19 (6.69%) species representing 17 (7.98%) genera and Lamiaceae was the fourth 15 (5.28%) species represented by 10 (4.69%) genera. Moreover, Solanaceae, Apiaceae and Euphorbiaceae contributed 11 (3.87%), 8 (32.82%), and 7 (2.46%) species, respectively to the total species composition (Table 5). About 47 (52.81%) families were represented with only one species. From the plant diversity study, 25 species (8.8%) are endemic to Ethiopia.

Table 6: Important families with many genera and species in *Menz Gera* District

R.№	Family	№ of Genus	% Genus	№ of Species	% Species
1	Asteraceae	23	10.80	41	14.44
2	Poaceae	12	5.63	20	7.04
3	Fabaceae	17	7.98	19	6.69
4	Lamiaceae	10	4.69	15	5.28
5	Solanaceae	8	3.76	11	3.87
6	Apiaceae	8	3.76	8	2.82
7	Euphorbiaceae	4	1.88	7	2.46
8	Crassulaceae	3	1.41	6	2.11
9	Rosaceae	5	2.35	6	2.11
10	Boraginaceae	3	1.41	5	1.76
11	Rubiaceae	5	2.35	5	1.76
12	Brassicaceae	3	1.41	5	1.76
13	Asclepiadaceae	5	2.35	5	1.76
14	Cucurbitaceae	5	2.35	5	1.76
15	Anacardiaceae	2	0.94	5	1.76
16	Celastraceae	2	0.94	4	1.41
17	Rutaceae	4	1.88	4	1.41
18	Ranunculaceae	3	1.41	4	1.41
19	Cyperaceae	2	0.94	4	1.41
20	Oleaceae	2	0.94	4	1.41
21	Polygonaceae	2	0.94	4	1.41

#### 4.1.1 Floristic Composition of the Remnant Natural Forest patches (*Yegana* & *Gajilo*)

Out of the total plant species recorded in the District, 212 species representing 154 genera and 72 families were identified from the remnant natural forest patches. Seventy-one of the species were recorded from both *Yegana* and *Gajilo* remnant natural forests, 44 species were recorded only from *Yegana* and 97 species were collected from *Gajilo* only. Out of the total 212 species recorded from the remnant natural forest patches, 204 (96.23%) are angiosperm species, 2 (0.94%) are a gymnosperm species, 4 (1.89%) are pteridophytes and 2 (0.94%) are mosses (Appendix 6). In terms of habit, 85 (40.09%) species are woody [46 (21.70%) are Shrubs, 26 (12.26%) are trees, 13 (6.13%) are liana] and 127 (59.91%) are herbaceous plants (Figure 6).

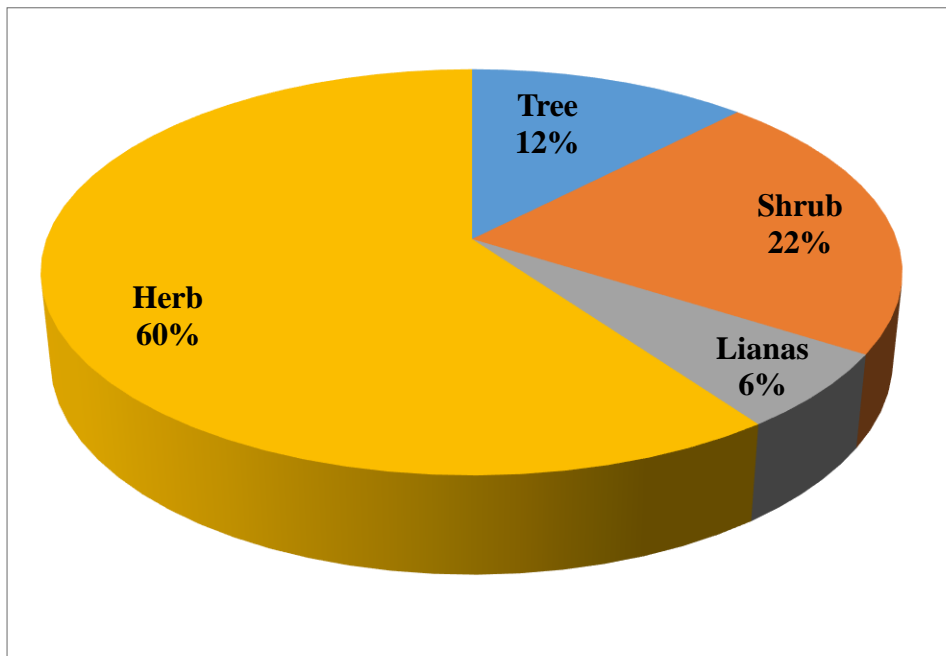


Figure 6: Proportions of habit of plant species in *Yegana* and *Gajilo* remnant forest patches

The highest numbers of species were recorded in families: Asteraceae 38 (17.92%) species belonging to 22 (14.29%) genera, Poaceae 16 (7.55%) species belonging to 9 (5.84%) genera, Fabaceae 13 (6.13%) species belonging to 13 (8.44%) genera and Lamiaceae 13 (6.13%) species belonging to 9 (5.84%) genera. Euphorbiaceae, Rosaceae and Solanaceae were represented with six species each. Anacardiaceae, Apiaceae, Crassulaceae, Cyperaceae, Oleaceae, Polygonaceae and Rubiaceae were represented by four species each while Asclepiadaceae, Aspleniaceae, Boraginaceae, Caryophyllaceae, Celastraceae, Geraniaceae, Ranunculaceae, Scrophulariaceae and Urticaceae were represented by three species each. Moreover Adiantaceae, Aloaceae, Asphodelaceae, Brassicaceae, Flacourtiaceae, Loganiaceae,

Malvaceae, Myrsinaceae, Polygalaceae and Sapindaceae were represented by two species each whereas the other 39 (54.17%) of the reported families were represented by single species each.

From the reported species, 84 (35 from *Gajilo* forest, 12 from *Yegana* forest and 37 from both forests) were reported for one or more of the traditional medicinal uses in the District. The medicinal flora of the forests was composed of 36 (42.86%) herbaceous species, 29 (34.52%) shrub species, 12 (14.29%) tree species and 7 (8.33%) lianas.

According to the published volumes of Flora of Ethiopia and Eritrea (FEE), 25 (11.8%) endemic species belonging to 21 genera and 11 families were recorded in *Yegana* and *Gajilo* remnant forest patches. Almost half of the endemic species were recorded in the family of Asteraceae (12 species belonging to 10 genera) followed by Aloaceae with two species belonging to one genus and the other nine families were represented by single species. Of the endemic plants *Yegana* natural forest patch accounts for 10 (41.67%) species followed by *Gajilo* natural forest patch with nine (33.33%) species and the rest six (25.00%) species were recorded from both forest patches (Table 6).

Table 7: Endemic species recorded from *Menz Gera* District.

R.No	Scientific Name	Family	Habit	Found in
1	<i>Aloe debrana</i> Christian	Aloaceae	H	B
2	<i>Aloe pulcherrima</i> Gilbert & Sebsebe	Aloaceae	H	B
3	<i>Anchusa affinis</i> R.Br. ex DC.	Boraginaceae	H	Y
4	<i>Argyrolobium schimperianum</i> Hochst. ex A. Rich.	Fabaceae	S	G
5	<i>Bidens macroptera</i> (Sch. Bip. ex Chiov.) Mesfin	Asteraceae	H	B
6	<i>Ceropegia sobolifera</i> N.E. Br.	Asclepiadaceae	H	Y
7	<i>Cirsium dender</i> Friis	Asteraceae	H	Y
8	<i>Cirsium schimperi</i> (Vatke) C. Jeffrey ex Cufod.	Asteraceae	H	G
9	<i>Clematis hirsuta</i> Perr. & Guill.	Ranunculaceae	Li	Y
10	<i>Conyza abyssinica</i> Sch. Bip. ex A. Rich.	Asteraceae	H	G
11	<i>Echinops kebericho</i> Mesfin	Asteraceae	H	Y
12	<i>Erythrina brucei</i> Schweinf.	Fabaceae	T	G
13	<i>Euryops antinorii</i> (Avetta) S. Moore	Asteraceae	H	Y
14	<i>Euryops pinifolius</i> A. Rich.	Asteraceae	S	Y
15	<i>Inula confertiflora</i> A. Rich.	Asteraceae	S	B
16	<i>Jasminum stans</i> Pax	Oleaceae	S	G
17	<i>Kniphofia foliosa</i> Hochst.	Asphodelaceae	H	Y
18	<i>Kniphofia isoetifolia</i> Steud.ex Hochst	Asphodelaceae	H	G
19	<i>Phagnalon quartinianum</i> A. Rich.	Asteraceae	S	Y
20	<i>Plectocephalus varians</i> (A. Rich.) C. Jeffrey ex Cufod.	Asteraceae	H	B
21	<i>Poa simensis</i> Hochst. ex A. Rich.	Poaceae	H	B
22	<i>Polygala rupicola</i> A.Rich.	Polygalaceae	H	G
23	<i>Rhus glutinosa</i> A.Rich. Subsp <i>neoglutinosa</i> (M. Gilbert) M.Gilbert	Anacardiaceae	T	G
24	<i>Solanecio gigas</i> (Vatke) C. Jeffrey	Asteraceae	H	Y
25	<i>Vernonia leopoldi</i> (Sch. Bip. ex Walp.) Vatke	Asteraceae	H	G

**Key:** B: Species found at both forests; G: Species found at *Gajilo*; Y: Species found at *Yegana*  
H: Herb; S: Shrub; Li: Liana; T: Tree

Out of the 26 tree species, 15 were recorded from *Gajilo* natural forest patch and 11 species were found at both natural forest patches but there were no tree species recorded from *Yegana* natural forest patch only (Table 7).

Table 8: Floristic distribution in *Yegana* and *Gajilo* natural forests

Habit	Forest species		<i>Yegana</i> Only		<i>Gajilo</i> Only		Spp. in Both forests	
	Number	Percentage	Nº of Spp.	%	Nº of Spp.	%	Nº of Spp.	%
Tree	26	12.26	0	0.00	15	7.08	11	5.19
Shrub	46	21.70	4	1.89	26	12.26	16	7.55
Lianas	13	6.13	2	0.94	7	3.30	4	1.89
Herb	127	59.91	38	17.92	49	23.11	40	18.87
	212	100.00	44	20.75	97	45.75	71	33.49

#### 4.1.1.1 Plant community types of *Menz Gera* Forest patches

Based on the floristic composition, hierarchical cluster analysis and synoptic table values of the entire data set of *Menz Gera* forest patches, the following was obtained. Three community types were identified from the hierarchical cluster analysis in combination with Multi-response Permutation Procedures (MRPP) of the whole data set (Figure 7). The analysis was based on the cover abundance data of 212 plant species in 72 quadrats. The decision on the number of communities (clusters) was based on objective methods of obtaining an optimal number of clusters in R program. From the output of MRPP, the test statistic T value for the three communities was -40.56 ( $P < 0.001$ ) and the agreement statistics A which describes within-group homogeneity compared to the random expectation was 0.10. The more negative T value, the stronger the separation.

These clusters were designated as local plant community types and given names after two dominating plant species, usually a woody species with higher synoptic value (Table 8). The communities identified were *Juniperus procera* - *Olea europaea* subsp. *cuspidata* Community one (C-1), *Hagenia abyssinica* - *Ekebergia capensis* Community two (C-2) and *Podocarpus falcatus* - *Galineria saxifraga* Community three (C-3). The identified plant communities of this study varied in size ranging from 18 to 35 quadrats (Figure 7). A synoptic cover-abundance value for species reaching a value  $\geq 0.5$  in at least one community type was presented in Table 8.

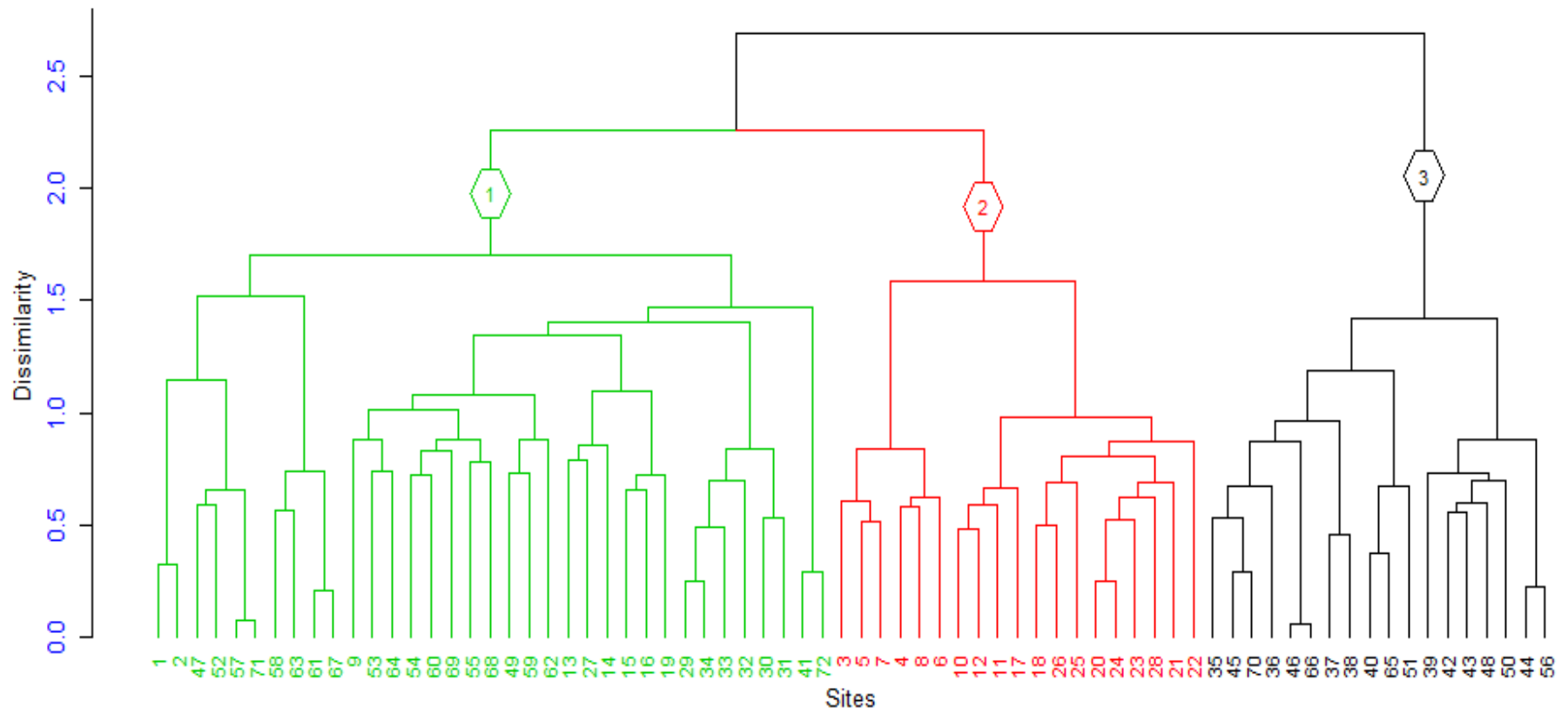


Figure 7: Dendrogram showing plant community types of *Menz Gera* Forest patches

Table 9: Synoptic Table of the three community types

R.No	Species	Habit	Communities		
			1	2	3
	Number of Quadrats		35	19	18
1	<i>Juniperus procera</i>	T	<b>4.69</b>	2.21	0.28
2	<i>Olea europaea</i> subsp. <i>cuspidata</i>	T	<b>2.91</b>	1.53	0.89
3	<i>Osyris quadripartita</i>	S	1.69	0.79	0.39
4	<i>Thymus schimperi</i> subsp. <i>schimperi</i>	H	1.17	0	0.22
5	<i>Dodonea angustifolia</i>	S	0.91	0.05	0.61
6	<i>Myrica salicifolia</i>	T	0.89	0	0
7	<i>Maytenus arbutifolia</i>	S	0.71	0.37	0.44
8	<i>Rosa abyssinica</i>	S	0.69	0.11	0.22
9	<i>Bidens macroptera</i>	H	0.66	0	0
10	<i>Phagnalon quartinianum</i>	S	0.63	0	0
11	<i>Aloe debrana</i>	H	0.63	0.26	0
12	<i>Andropogon abyssinicus</i>	H	0.51	0.16	0
13	<i>Prunus africana</i>	T	0.51	0.26	0
14	<i>Hagenia abyssinica</i>	T	0.31	<b>7.21</b>	0
15	<i>Ekebergia capensis</i>	T	1.06	<b>4.16</b>	0
16	<i>Hypericum revolutum</i>	T	0	2.74	0
17	<i>Erica arborea</i>	S	1.97	2.42	0
18	<i>Myrsine africana</i>	S	0.34	2.05	0
19	<i>Asparagus africanus</i>	Li	0.4	1.79	0.67
20	<i>Clematis hirsuta</i>	Li	0	0.89	0
21	<i>Solanum benderianum</i>	Li	0.09	0.84	0.06
22	<i>Poa simensis</i>	H	0.34	0.79	0.83
23	<i>Anchusa affinis</i>	H	0.06	0.58	0
24	<i>Helichrysum splendidum</i>	S	0.14	0.58	0
25	<i>Pennisetum villosum</i>	H	0	0.53	0
26	<i>Olinia rochetiana</i>	T	1.89	0.32	3.17
27	<i>Oplismenus hirtellus</i>	H	0.66	0	0.61
28	<i>Pittosporum viridiflorum</i>	T	0.34	0	0.61
29	<i>Croton macrostachyus</i>	T	0.91	0	0.94

30	<i>Allophylus abyssinicus</i>	T	0.31	0	0.94
31	<i>Ficus sur</i>	T	0.43	0	0.72
32	<i>Podocarpus falcatus</i>	T	0.77	0	<b>6.78</b>
33	<i>Galiniera saxifraga</i>	T	0.77	0.32	<b>3.83</b>
34	<i>Nuxia congesta</i>	T	0.49	0	3.17
35	<i>Olea capensis</i> subsp. <i>macrocarpa</i>	T	0	0	2.56
36	<i>Bersama abyssinica</i>	T	0.63	0	2.44
37	<i>Maytenus gracilipes</i> subsp. <i>arguta</i>	S	0.14	0	2.33
38	<i>Maytenus obscura</i>	S	0.14	0	2.22
39	<i>Polyscias fulva</i>	T	0.14	0	1.39
40	<i>Dombeya torrida</i>	S	0.03	0	1.39
41	<i>Debregeasia saeneb</i>	S	0.4	0	1.22
42	<i>Impatiens rothii</i>	H	0.09	0.47	0.83
43	<i>Discopodium penninervium</i>	S	0.43	0.79	0.78
44	<i>Pteris cretica</i>	H	0	0.21	0.72
45	<i>Rhus natalensis</i>	T	0	0	0.67
46	<i>Pennisetum villosum</i>	H	0.06	0	0.61
47	<i>Hypoestes forskaolii</i>	H	0.17	0	0.5
48	<i>Zehneria scabra</i>	H	0	0.89	0
49	<i>Buddleja polystachya</i>	T	0	0.58	0

Note: Synoptic cover abundance values of species reaching a value of  $\geq 0.5$  in at least one community type were included in the table.

Key: Values in bold refer to species used to name the community types

The description of the three plant community types identified using hierarchical cluster analysis were explained mainly by their altitudinal ranges, dominant plant habits and plant species, species richness and evenness between community types (C-1 to C-3) as follows:

### 1. *Juniperus procera* - *Olea europaea* subsp. *cuspidata* Community (C-1)

This community type consists of 35 of the total quadrats sampled, of which 15 quadrats from *Yegana* forest patch and 20 quadrats from *Gajilo* forest patch and 157 species were recorded out of the 212 total recorded forest species. The altitudinal range of this community is from 2403 to

3260 m above sea level (m.a.s.l) with mean altitude of 2871 m.a.s.l. The community was distributed on a low to high sloppy area with a range slope of 13% to 74% and with an average slope of 42.6%. The quadrats were facing towards all aspects except southeast direction with a low rate of disturbance (low trampling or 2 stumps in the quadrats) (Appendix 7).

The characteristic tree and shrub species more important to this community include *Juniperus procera*, *Olea europaea* subsp. *cuspidata*, *Osyris quadripartita*, *Dodonea angustifolia*, *Myrica salicifolia*, *Maytenus arbutifolia* and *Rosa abyssinica*. The herbaceous species representing this community includes *Thymus schimperi* subsp. *schimperi*, *Bidens macroptera* and *Andropogon abyssinicus*. In this community, there were no dominant liana species, which is easily recognized as part of this community type.

### **2. *Hagenia abyssinica* - *Ekebergia capensis* Community (C-2)**

This community type was found between 2340 and 2701 m.a.s.l with mean altitude of 2563 m.a.s.l. The community was found in a highly sloppy area with a range of 40% to 67% and with an average slope of 52%. The community was facing towards the north (42%), west (16%), northeast (26%) and northwest (16%) directions and most of the quadrats were medium (medium trampling or 3-4 stumps in the quadrat) disturbed. The community consists of 19 of the total quadrats sampled, which are totally from *Yegana* forest patch and 93 species were recorded out of the total recorded forest species (Appendix 9).

The common tree and shrub species of this community include *Hagenia abyssinica*, *Ekebergia capensis*, *Hypericum revolutum*, *Erica arborea*, *Myrsine africana*, *Helichrysum splendidum*, *Olinia rochetiana*, *Pittosporum viridiflorum*, *Croton macrostachyus*, *Allophylus abyssinicus* and *Ficus sur*. *Asparagus africanus*, *Clematis hirsuta* and *Solanum benderianum* were found to be the dominant liana species in this community. The dominant herb layer of this community was composed of *Poa simensis*, *Anchusa affinis*, *Pennisetum villosum* and *Oplismenus hirtellus*.

### **3. *Podocarpus falcatus* - *Galiniera saxifraga* Community (C-3)**

This community consists of 18 of the total quadrats sampled, which are totally recorded from *Gajilo* forest patch and 95 species were recorded out of the total recorded forest species. The altitudinal range of this community is from 2635 to 3256 m a.s.l with a mean altitude of 3056 m a.s.l, which is found in the highest altitude relative to the study area. The community was distributed from low to high sloppy areas with a range of 13% to 80% and with an average slope of 39.5%, which has highly cliffy area relative to the other community types. The quadrats were

facing towards the north (17%), south (39%), west (39%) and southwest (5%) directions and most of the quadrats were with a low rate of disturbance (low trampling or 2 stumps in the quadrats) (Appendix 7).

The common trees and shrub species of this community include *Podocarpus falcatus*, *Galiniera saxifraga*, *Nuxia congesta*, *Olea capensis* subsp. *macrocarpa*, *Bersama abyssinica*, *Maytenus gracilipes* subsp. *arguta*, *Maytenus obscura*, *Polyscias fulva*, *Dombeya torrida*, *Debregeasia saeneb*, *Discopodium penninervium*, *Pennisetum villosum*, *Rhus natalensis* and *Buddleja polystachya*. *Impatiens rothii*, *Pteris cretica*, *Hypoestes forskoolii* and *Zehneria scabra* are the dominant herbaceous layer of this community types.

#### 4.1.2 Species diversity, Richness and Evenness of Menz Gera Forest patches

The overall Shannon - Wiener diversity and Shannon evenness values of *Menz Gera* forests were 3.92 and 0.85, respectively which were generated from the mean value of the three community values. The three plant community types showed variation in their species richness, diversity, and evenness. Community-1 (*Juniperus procera* - *Olea europaea* subsp. *cuspidata*) consisting of quadrats from *Yegana* and *Gajilo* natural forest patches had the highest species richness (157 species), diversity (4.10), and evenness (0.87) recorded from 35 quadrats. Whereas, community-3 (*Podocarpus falcatus* - *Galiniera saxifraga*) exclusively recorded from *Yegana* natural forest patch was the second in species richness (95 species), diversity (3.86), and evenness (0.85) recorded from 18 quadrats which is the least community in quadrat number. Community-2 (*Hagenia abyssinica* - *Ekebergia capensis*) exclusively from *Gajilo* natural forest patch was the least in species richness (93 species) diversity (3.80), and evenness (0.84) recorded from 19 quadrats, which is the second community in quadrat number (Table 9).

Table 10: Species Richness, Diversity, Evenness values of plant communities identified from *Menz Gera* Forest patches

Community	No of Quadrats	Species Richness (S)	Shannon diversity index (H')	Shannon Evenness (J)	Altitude Range	Mean Altitude	Slop Range	Mean Slope
1	35	157	4.10	0.87	2403 - 3260	2871	13.0 - 74.3	42.6
2	19	93	3.80	0.84	2340 - 2701	2563	40.1 – 67.0	52.0
3	18	95	3.86	0.85	2635 - 3256	3058	13.0– 80.0	39.5
Mean			3.92	0.85				

### 4.1.3 Vegetation Structure

#### 4.1.3.1 Density of trees and shrubs

The density of woody species (trees and shrubs) in the study area was 1,113 individuals per hectare (Appendix 8). The 72 woody species recorded from the study area were classified into six density classes, A-F as follows: A  $>50.01$ ; B = 35.01 – 50; C =20.1 – 35; D = 10.1 – 20; E = 1.01-10 and F =  $\leq 1$ . A great proportion of woody individuals were found in density class E (32 species) followed by D (11 species). The least proportion of woody individuals was recorded in density class F (3 species). Density class A, B and C scores almost the same number of woody individuals (Figure 8).

More than half of the total densities of the forests were dominated by five species, which are *Erica arborea* with 453 (20%) individuals  $\text{ha}^{-1}$ , *Myrsine africana* with 429 (19%) individuals  $\text{ha}^{-1}$ , *Hypericum revolutum* with 134 (6%) individuals  $\text{ha}^{-1}$ , *Osyris quadripartita* with 80 (4%) individuals  $\text{ha}^{-1}$  and *Dodonea angustifolia* with 78 (3%) individuals  $\text{ha}^{-1}$  which sum-up to 52% of the total density. *Celtis africana*, *Rhus glutinosa* Subsp *neoglutinosa* and *Euphorbia ampliphylla* with 0.7 (0.03%) each have the least density in the forest next to *Heteromorpha arborescens*, *Rhus natalensis*, *Rhus quartiniana* and *Vernonia urticifolia* having 1.11 (0.05%) individuals  $\text{ha}^{-1}$  each. These seven species were the least scored species, which accounted for 0.29% of the total density.

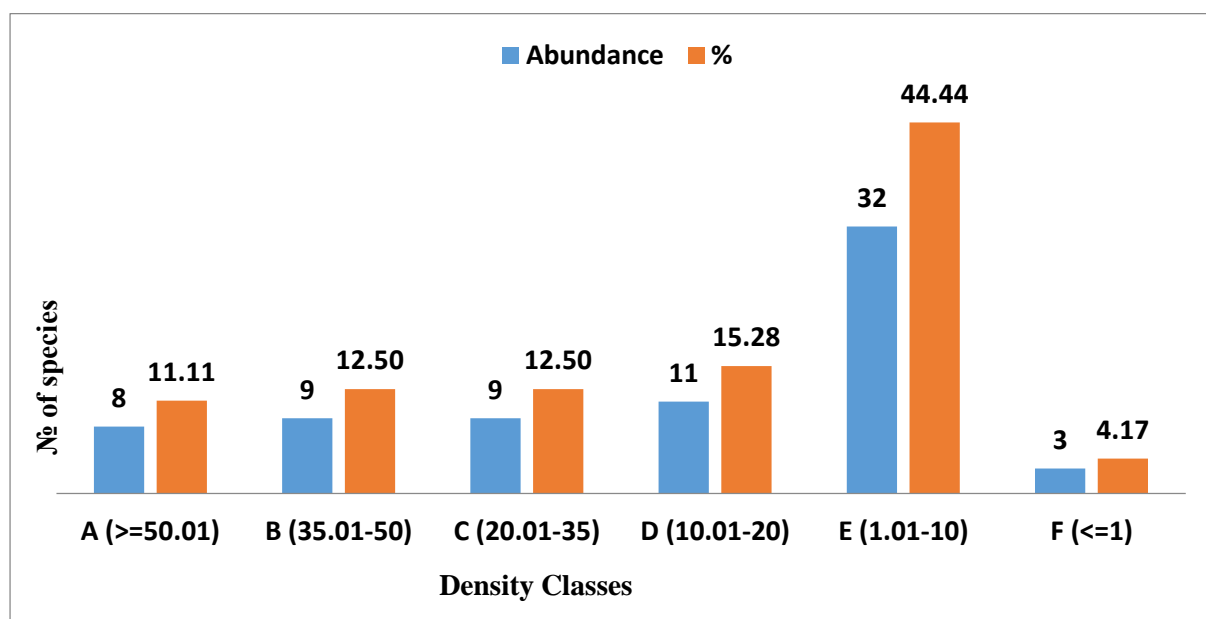


Figure 8: Density class distribution for woody plant species of *Menz Gera* forests

#### 4.1.3.2 Diameter at Breast Height (DBH) class distribution

The size class distribution of trees and shrubs in *Menz Gera* forest across six DBH classes indicated a relatively large number of individuals in the first DBH class with 513 (46.09%) individuals ha<sup>-1</sup>, second DBH class with 262 ha<sup>-1</sup> (23.54%) and third DBH class with 201 (18.06%). As the DBH class size increases, the number of individuals gradually decreases towards the successive higher DBH classes (DBH class 6 with 17 (1.53%) individuals ha<sup>-1</sup>) (Figure 9).

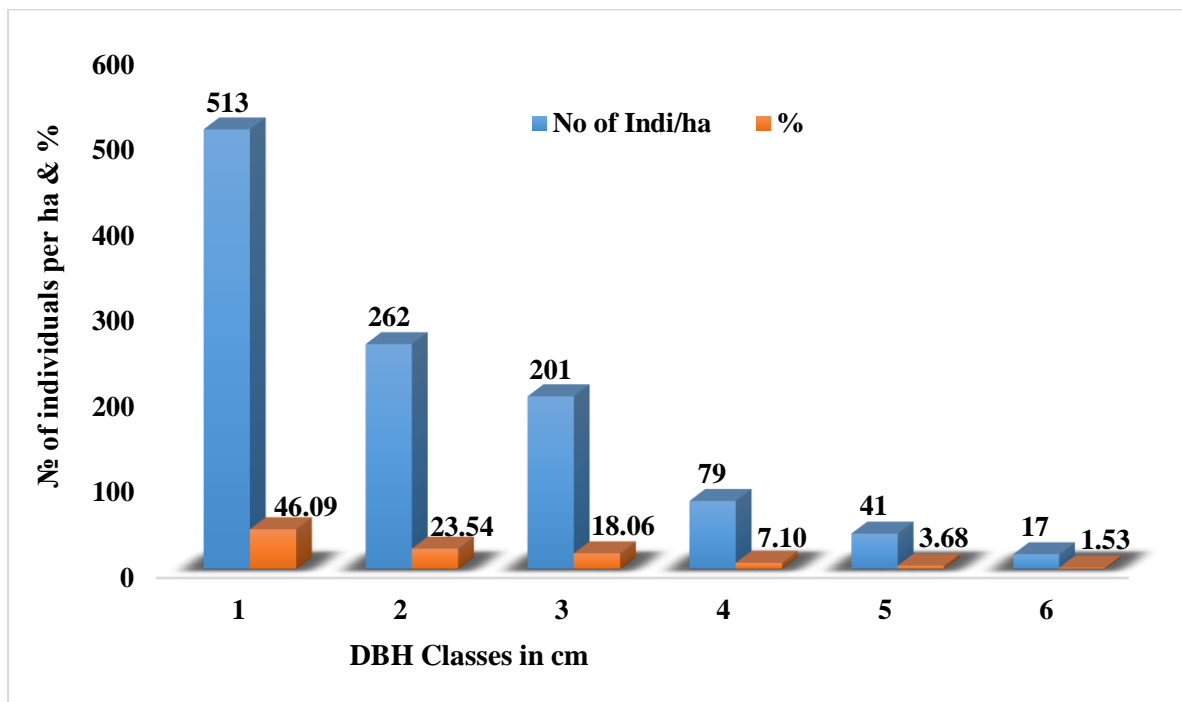


Figure 9: DBH class distributions of woody species in *Menz Gera* forest

DBH classes: 1= 2 – 10; 2= 10.1–30; 3= 30.1–50; 4= 50.1–70; 5= 70.1–90 and 6 ≥ 90.1

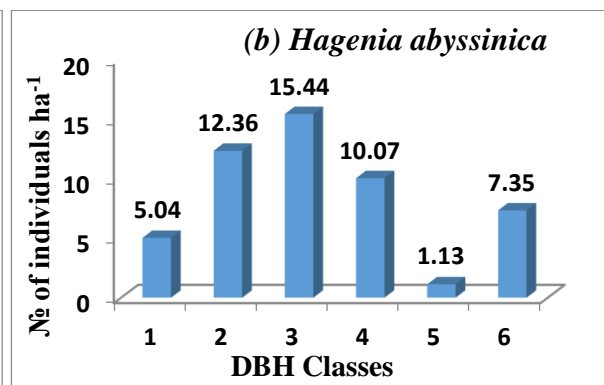
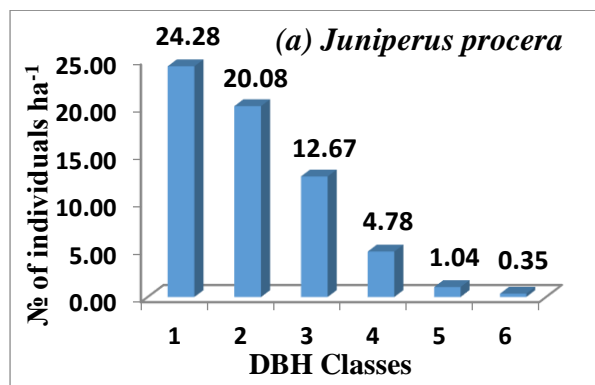
The density of trees and shrubs with DBH 2-10 cm was 513 (46.09%) individuals ha<sup>-1</sup>. The density of species with DBH 10.01-20 cm was 252 (22.64%) individuals ha<sup>-1</sup> whereas that of species with DBH > 20.01 cm was 348 (31.27%) individuals ha<sup>-1</sup>. Thus, the ratio of the density of woody species with DBH greater than 2 cm to 10 cm, 10 cm to 20 cm and greater than 20 cm in the forests was 2.4: 1: 1.6 (Table 10).

Table 11: Ratio of DBH Distribution in three size classes

DBH size (cm)	N <sup>o</sup> of individuals/ quadrats	N <sup>o</sup> individuals/ha	% Distribution
2.00-10.00	845	513	46.09
10.01-20.00	466	252	22.64
>20.00	634	348	31.27
<b>Total</b>		<b>1113</b>	<b>100.00</b>

Analysis of the population structure of the 26 tree species revealed four general patterns in the study area (Figure 10 a-d).

The first pattern was an inverted J-shaped distribution formed by species with the high-frequency distribution of individuals in the lower DBH classes followed by a gradual decrease towards the higher DBH classes represented by *Juniperus procera* (Figure 10\_a). The second pattern was irregular distribution over DBH classes, where some DBH classes had a small number of individuals while other DBH classes had a large number of individuals, which was represented by *Hagenia abyssinica* (Figure 10\_b). The third pattern was formed by species having a bell-shaped distribution formed by species where the frequency distribution of individuals in the lower and higher DBH classes was lower than the middle classes represented by *Myrica salicifolia* (Figure 10\_c). The fourth pattern was a J-shaped distribution formed by species with low-frequency distribution of individuals in the lower DBH classes followed by a gradual increase towards the higher DBH classes represented by *Olea europaea* subsp. *cuspidata* (Figure 10\_d).



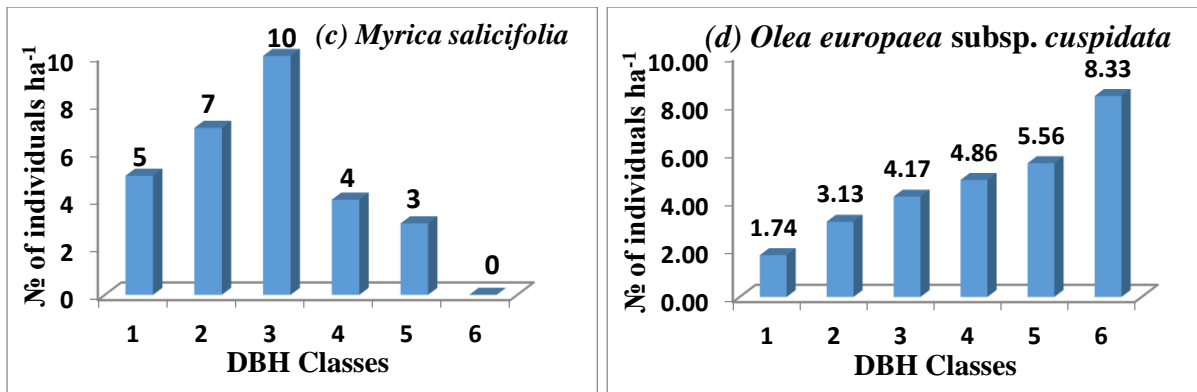


Figure 10: Representative patterns of species population structures in *Menz Gera* forests

DBH classes: 1= 2 – 10; 2= 10.1–30; 3= 30.1–50; 4= 50.1–70; 5= 70.1–90 and 6 ≥ 90.1

#### 4.1.3.3 Height class distribution

The cumulative height class distribution of *Menz Gera* natural forest patches was grouped in to ten classes. The high proportion of individuals were found in the first height class (213 individuals ha<sup>-1</sup> (19.14%)) followed by a rapid decline up to the ninth class (39 individuals ha<sup>-1</sup> (3.5%)) and with minor increment in the tenth class (43 individuals ha<sup>-1</sup> (3.86%)) (Figure 11). Half of the number of individuals were aggregated in the first three height classes which is about 50.04% of the woody species were less than 12 m tall (Height classes 1, 2 and 3).

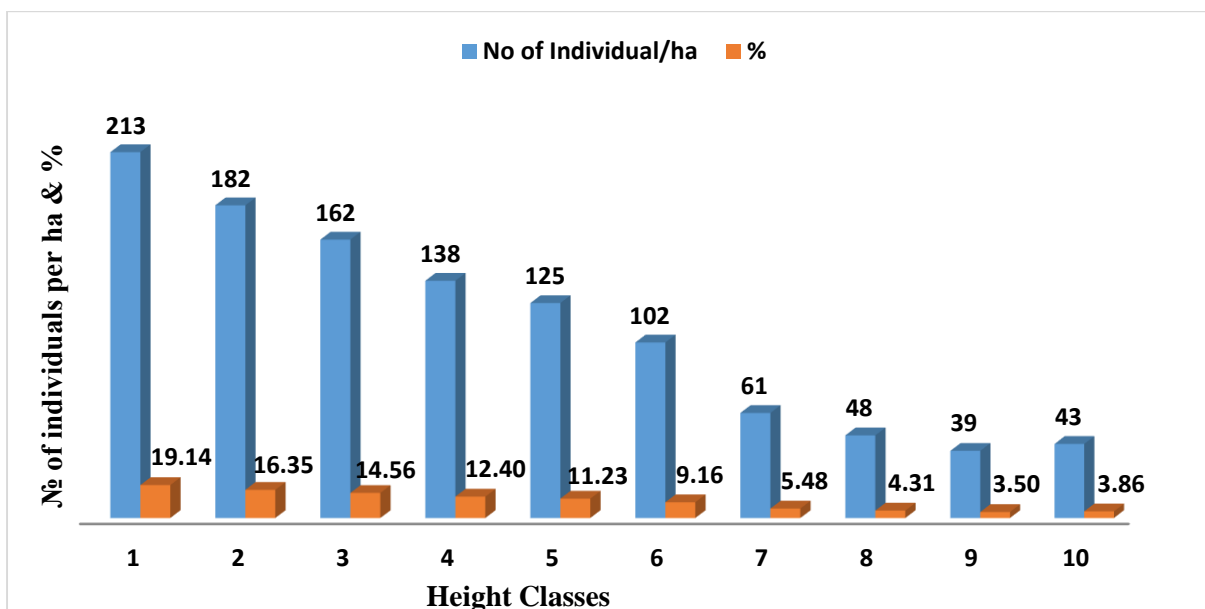


Figure 11: Height Class Distribution of woody plant species

Height classes (m): 1= 3 – 6; 2= 6.1 – 9; 3= 9.1 – 12; 4= 12.1 – 15; 5= 15.1 – 18; 6= 18.1 – 21; 7= 21.1 – 24; 8= 24.1 – 27; 9= 27.1 – 30; 10= ≥ 30

#### 4.1.3.4 Vertical stratification

Three simplified vertical structures were distinguished in the study forest. These were the upper, middle and lower storey. The upper storey includes tree height that exceeds 2/3 of the top height while the middle storey includes species having height between 1/3 and 2/3 of the top height and the lower storey is less than 1/3 of the top height. The tallest height in *Menz Gera* forest was recorded for *Juniperus procera*, *Allophylus abyssinicus*, *Hagenia abyssinica*, *Ekebergia capensis* and *Podocarpus falcatus* with a height greater than 45 m. Therefore, the upper storey was represented by a height > 30 m, the middle storey by a height ranges between 15 and 30 m and the lower storey by height < 15 m (Table 11).

Table 12: Density and number of woody species by storey in the study forest

Storey	Height (m)	Stem Abundance		Species	
		No of individuals/ha	%	Number	%
Lower	3.00-15.00	662.20	59.50	60	83.33
Middle	15.01-30.00	381.09	34.24	32	44.44
Upper	>30.00	69.71	6.26	14	19.44

#### 4.1.4 Basal area (BA)

The total basal area of *Menz Gera* forest patches was 57.56 m<sup>2</sup>ha<sup>-1</sup> (Appendix 9). About 65.53% of the total basal area is derived from eight large-sized trees. Three indigenous trees, namely *Hagenia abyssinica*, *Juniperus procera* and *Podocarpus falcatus* dominating more than 41% of the total basal area of the study forests (Table 12).

Table 13: Basal area (m<sup>2</sup>h<sup>-1</sup>) and percentage contribution of eight most dominant trees

Scientific Name	BA (m <sup>2</sup> ha <sup>-1</sup> )	Percentage
<i>Hagenia abyssinica</i>	11.8	20.50
<i>Juniperus procera</i>	7.56	13.13
<i>Podocarpus falcatus</i>	4.50	7.82
<i>Galiniera saxifraga</i>	4.00	6.95
<i>Olea europaea</i> subsp. <i>cuspidata</i>	3.95	6.86
<i>Ekebergia capensis</i>	2.50	4.34
<i>Nuxia congesta</i>	1.80	3.13
<i>Olinia rochetiana</i>	1.61	2.80
<b>Total</b>	<b>37.72</b>	<b>65.53</b>

#### **4.1.5 Frequency of Woody species**

*Erica arborea* and *Myrsine africana* were found as the most frequent species in the forests occurring in 55.56% of the sampled quadrats. Species such as *Ekebergia capensis* (50%), *Juniperus procera* (45.83%), *Olea europaea* subsp. *cuspidata* (40.28%), *Osyris quadripartita* (37.50%), *Podocarpus falcatus* (34.72%), *Hagenia abyssinica* (31.94%) and *Olinia rochetiana* (31.94%) were also common across different quadrats in the study area (Appendix 10).

#### **4.1.6 Importance Value Index (IVI)**

Plant species with the greatest importance value implies they are highly frequent, dense and dominant in the forest. Accordingly, analysis of the importance value index (IVI) of tree species revealed that the forests are dominated by a very few species. Woody species with the highest IVI values in decreasing order were *Juniperus procera* (74.42), *Hagenia abyssinica* (72.97), *Ekebergia capensis* (61.23) and *Podocarpus falcatus* (50.52) whereas *Rhus natalensis* (1.35), *Celtis africana* (1.26), *Rhus quartiniana* (1.23), *Rhus glutinosa* Subsp *neoglutinosa* (1.02) and *Euphorbia ampliphylla* (0.85) were the list dominant tree species in the study area (Table 13).

Table 14: Important value index of tree species of *Menz Gera* forests

Scientific Name	Family	Relative Dominance	Relative Frequency	Relative Density	IVI	% IVI
<i>Juniperus procera</i>	Cuperssaceae	13.13	5.04	56.25	74.42	14.03
<i>Hagenia abyssinica</i>	Rosaceae	20.50	3.51	48.96	72.97	13.76
<i>Ekebergia capensis</i>	Meliaceae	4.34	5.50	51.39	61.23	11.55
<i>Podocarpus falcatus</i>	Podocarpaceae	7.82	3.82	38.89	50.52	9.53
<i>Olinia rochetiana</i>	Oliniaceae	2.80	3.51	34.03	40.34	7.61
<i>Olea europaea</i> subsp. <i>cuspidata</i>	Oleaceae	6.86	4.43	25.00	36.29	6.84
<i>Bersama abyssinica</i>	Meliantaceae	1.82	2.14	23.26	27.23	5.13
<i>Galiniera saxifraga</i>	Rubiaceae	6.95	2.75	16.32	26.02	4.91
<i>Allophylus abyssinicus</i>	Sapindaceae	2.61	1.98	13.19	17.79	3.35
<i>Prunus africana</i>	Rosaceae	2.61	2.75	12.15	17.51	3.30
<i>Nuxia congesta</i>	Loganiaceae	3.13	1.98	12.15	17.26	3.26
<i>Myrica salicifolia</i>	Myricaceae	2.74	1.22	10.07	14.04	2.65
<i>Croton macrostachyus</i>	Euphorbiaceae	0.96	1.22	11.11	13.29	2.51
<i>Canthium lactescens</i>	Rubiaceae	1.39	1.68	10.07	13.14	2.48
<i>Olea capensis</i> subsp. <i>macrocarpa</i>	Oleaceae	2.61	1.22	6.25	10.08	1.90
<i>Ficus sur</i>	Moraceae	2.61	0.76	5.90	9.27	1.75
<i>Buddleja polystachya</i>	Loganiaceae	0.10	0.92	5.90	6.92	1.31
<i>Polyscias fulva</i>	Araliaceae	0.87	1.07	4.17	6.10	1.15
<i>Pittosporum viridiflorum</i>	Pittosporaceae	0.52	0.61	3.47	4.60	0.87
<i>Euphorbia abyssinica</i>	Euphorbiaceae	0.00	0.31	2.78	3.08	0.58
<i>Erythrina brucei</i>	Fabaceae	0.00	0.46	2.08	2.54	0.48
<i>Rhus natalensis</i>	Anacardiaceae	0.00	0.31	1.04	1.35	0.25
<i>Celtis africana</i>	Ulmaceae	0.26	0.31	0.69	1.26	0.24
<i>Rhus quartiniana</i>	Anacardiaceae	0.03	0.15	1.04	1.23	0.23
<i>Rhus glutinosa</i> subsp. <i>neoglutinosa</i>	Anacardiaceae	0.02	0.31	0.69	1.02	0.19
<i>Euphorbia ampliphylla</i>	Euphorbiaceae	0.00	0.15	0.69	0.85	0.16

#### 4.2 Natural Regeneration Status of Trees Species of *Menz Gera* Forests

In this study, the total density of seedling, sapling and adult trees were 2,722 ha<sup>-1</sup>, 390h a<sup>-1</sup> and 458 ha<sup>-1</sup> respectively, all recorded from 26 tree species. Out of the 26 tree species, 13 species were not represented in the seedling growth stage and 11 species were not represented in the sapling growth stage. Five species contributed 79.85% and 80.91% of the total seedling and sapling counts respectively. Those were *Erythrina brucei*, *Galiniera saxifraga*, *Myrica salicifolia*, *Ficus sur* and *Croton macrostachyus* (Table 14).

Table 15: Natural Regeneration status of trees in *Menz Gera* forests

Scientific Name	Mature Tree ha-		Sapling ha-		Seedling ha-		Regeneration Category
	Abun.	%	Abun.	%	Abun.	%	
<i>Erythrina brucei</i>	2.08	0.45	105.56	27.07	673.61	24.74	Good
<i>Galiniera saxifraga</i>	26.74	5.83	93.33	23.93	631.94	23.21	Fair
<i>Myrica salicifolia</i>	10.07	2.20	60.00	15.38	381.94	14.03	Good
<i>Ficus sur</i>	5.90	1.29	32.22	8.26	305.56	11.22	Good
<i>Croton macrostachyus</i>	11.11	2.42	24.44	6.27	180.56	6.63	Good
<i>Rhus quartiniana</i>	1.04	0.23	20.00	5.13	173.61	6.38	Good
<i>Rhus natalensis</i>	1.04	0.23	11.11	2.85	83.33	3.06	Good
<i>Buddleja polystachya</i>	5.90	1.29	10.00	2.56	27.78	1.02	Fair
<i>Juniperus procera</i>	63.19	13.79	8.89	2.28	69.44	2.55	Fair
<i>Pittosporum viridiflorum</i>	3.47	0.76	7.74	1.98	62.50	2.30	Good
<i>Ekebergia capensi</i>	64.93	14.17	5.56	1.42	62.5	2.30	Fair
<i>Podocarpus falcatus</i>	42.36	9.24	3.33	0.85	55.56	2.04	Fair
<i>Allophylus abyssinicus</i>	13.19	2.88	3.33	0.85	0.00	0.00	Poor
<i>Euphorbia abyssinica</i>	2.78	0.61	2.22	0.57	13.89	0.51	Fair
<i>Olea capensis</i> subsp. <i>macrocarpa</i>	9.72	2.12	1.11	0.28	0.00	0.00	Poor
<i>Olea europaea</i> subsp. <i>cuspidata</i>	27.43	5.98	1.15	0.30	0.00	0.00	Poor
<i>Hagenia abyssinica</i>	52.43	11.44	1.15	0.30	0.00	0.00	Poor
<i>Olinia rochetiana</i>	35.42	7.73	0.00	0.00	0.00	0.00	None
<i>Bersama abyssinica</i>	23.26	5.08	0.00	0.00	0.00	0.00	Noon
<i>Prunus africana</i>	20.83	4.55	0.00	0.00	0.00	0.00	Noon
<i>Nuxia congesta</i>	17.01	3.71	0.00	0.00	0.00	0.00	Noon
<i>Canthium lactescens</i>	10.07	2.20	0.00	0.00	0.00	0.00	Noon
<i>Polyscias fulva</i>	6.25	1.36	0.00	0.00	0.00	0.00	Noon
<i>Celtis africana</i>	0.69	0.15	0.00	0.00	0.00	0.00	Noon
<i>Euphorbia ampliphylla</i>	0.69	0.15	0.00	0.00	0.00	0.00	Noon
<i>Rhus glutinosa</i> Subsp <i>neoglutinosa</i>	0.69	0.15	0.00	0.00	0.00	0.00	Noon
	<b>458.33</b>	<b>100.00</b>	<b>390.00</b>	<b>100.00</b>	<b>2722.22</b>	<b>100.00</b>	

The regeneration status of the study forests was evaluated based on the following regeneration categories of seedling, sapling and mature tree abundance:

- a. 'Good', if presence of seedling > sapling > mature strata (Figure 12-a): This pattern was exhibited by *Erythrina brucei*, *Myrica salicifolia*, *Ficus sur*, *Croton macrostachyus*, *Rhus quartiniana*, *Rhus natalensis* and *Pittosporum viridiflorum*.
- b. 'Fair', if presence of seedling > sapling < mature strata (Figure 12-b): This pattern was exhibited by *Galiniera saxifraga*, *Buddleja polystachya*, *Juniperus procera*, *Ekebergia capensi*, *Podocarpus falcatus* and *Euphorbia abyssinica*.

- c. 'Poor', if a species survives only in the sapling stage, but not as seedlings (even though saplings may be less than, more than, or equal to mature) (Figure 12-c): this category was represented by *Hagenia abyssinica*, *Allophylus abyssinicus* and *Olea capensis* subsp. *macrocarpa*.
- d. 'None', if a species is absent both in sapling and seedling stages, but present as mature (Figure 12-d): this is category was represented by *Prunus africana*, *Olinia rochetiana*, *Olea europaea* subsp. *cuspidata*, *Bersama abyssinica*, *Nuxia congesta*, *Canthium lactescens*, *Polyscias fulva*, *Celtis africana*, *Euphorbia ampliphylla* and *Rhus glutinosa* Subsp *neoglutinosa*.
- e. 'New', if a species has no mature strata, but only sapling and/or seedling stages: this category was not represented in this study forests.

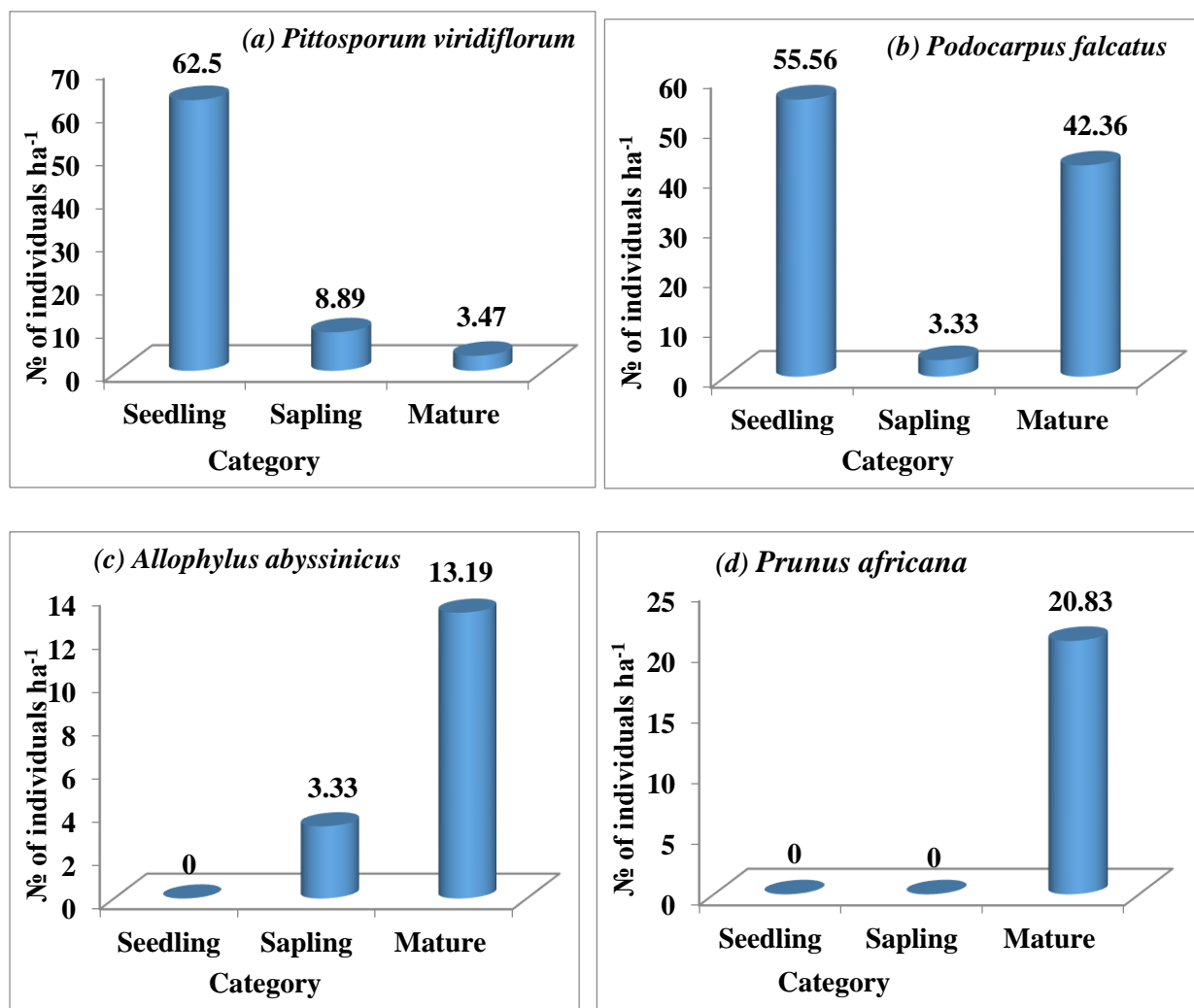


Figure 12: Seedling, sapling and mature tree distributions of some selected species in *Menz Gera* forests

### 4.3 Ethnobotany of Medicinal Plants

#### 4.3.1. Medicinal plants for human and livestock ailments

##### 4.3.1.1. Informant background information

A total of 390 informants were involved in this study to investigate the knowledge associated with traditional medicinal plants to manage human and livestock ailments. The background information of informants was categorized by gender (male, 66.92% and female, 33.08%); age class (Young (18-34 years) 30.77% and adult/Senior (>34 years) 69.23%); educational status (illiterate (cannot read and write) 71.54% and literate (read and write) 28.46%). In addition to this, distance from health centers (near less than 2 km from health centers) 43.33% and far (greater than 2 km from health centers) 56.67%; and informant type (key 13.3% and general 86.67%) were considered (Figure 13).

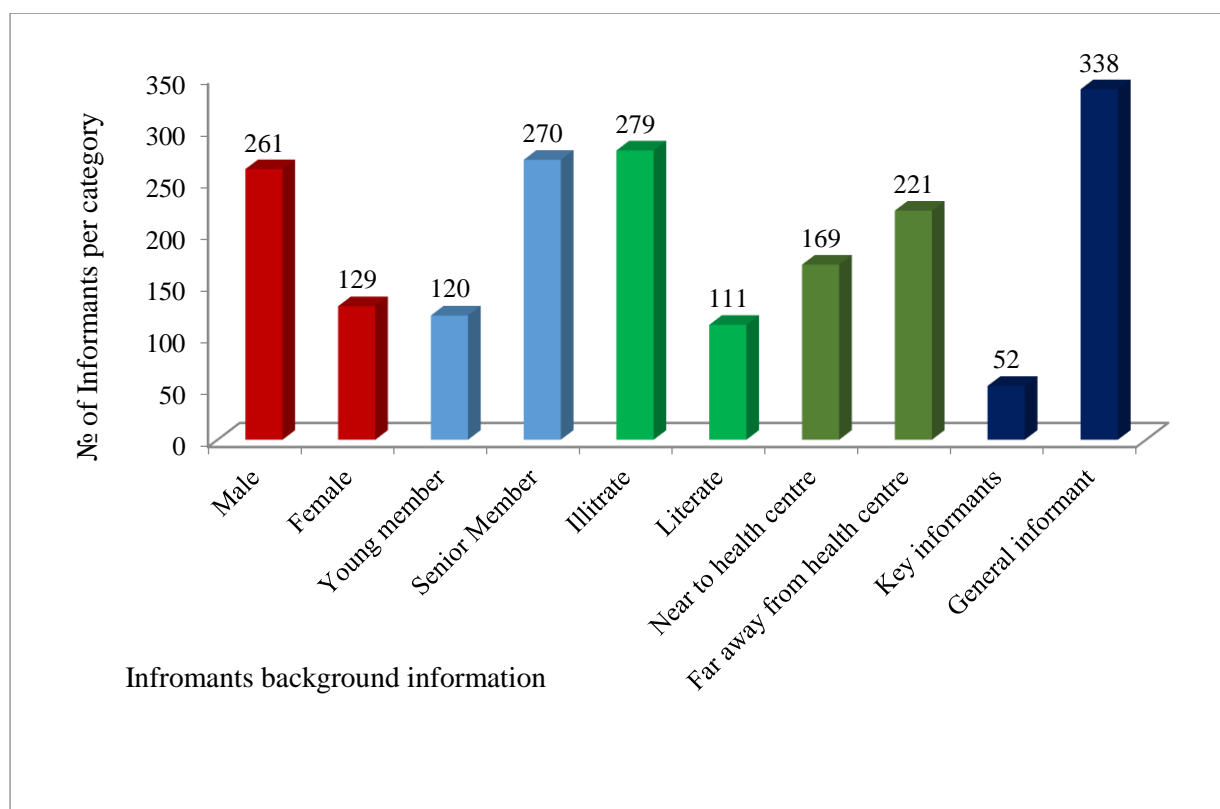


Figure 13: Informant background information of *Menz Gera* District

##### 4.3.1.2. Diversity of reported medicinal plants used for human and livestock remedy preparation

A total of 156 plant species that belong to 136 genera and 67 families were recorded from *Menz Gera* district and reported for treating humans (Appendix 11) and livestock (Appendix 12)

ailments. From the reported medicinal plants 122 (78.2%) were used for human ailments only, those medicinal plants used to treat both human and livestock ailments were 32 (20.51%), whereas, two (1.28%) species were used to treat livestock ailments only. Of the total 156 species, 86 (55.13%) were herbs, 43 (27.56%) were shrubs, 19 (12.18%) were trees and eight (5.13%) were lianas.

Asteraceae had the highest number of medicinal plants with 15 (9.62%) species, followed by Lamiaceae, with 10 (6.41%) species and Solanaceae, with nine (5.77%) species. Fabaceae was represented by seven (4.49%) species, whereas Apiaceae, Poaceae and Euphorbiaceae had six (3.86%) medicinal plant species each followed by Crassulaceae, Cucurbitaceae, Polygalaceae and Rosaceae which were represented with five (3.21%) medicinal plants species each. In addition, Asclepiadaceae, Boraginaceae and Rutaceae were represented with four (2.56%) species each, followed by Brassicaceae, Ranunculaceae, Verbenaceae and Vitaceae which had three (1.92%) species each while, Aloaceae, Celastraceae, Myrsinaceae, Oleaceae and Sapindaceae had two (1.28%) species representation for each, the remaining 44 (65.67%) of the families were represented with single species (Appendix 11 and 12).

Based on informant's data, the medicinal plants of the study area were classified in to 11 use categories including medicinal uses for human and livestock ailments (Table 15).

Table 16: Eleven major use categories of plants in the study area

Use Category	No of Species used	% of Use Category	Rank
Medicinal (M)	156	100.00	1 <sup>st</sup>
Firewood & Charcoal (FW)	38	24.36	2 <sup>nd</sup>
Ornamental & Other Uses (OU)	37	23.72	3 <sup>rd</sup>
Livestock fodder/ forage (FD)	36	23.08	4 <sup>th</sup>
Food/ Drink (F)	35	22.44	5 <sup>th</sup>
Construction & Tools (CT)	15	9.62	6 <sup>th</sup>
Commercial (C)	15	9.62	7 <sup>th</sup>
Culture & Rituals (CR)	12	7.69	8 <sup>th</sup>
Bee Forage (BF)	10	6.41	9 <sup>th</sup>
Fence (F)	6	3.85	10 <sup>th</sup>
Environmental Use (EU)	6	3.85	11 <sup>th</sup>

The main sources of traditional medicinal plants for human and livestock were from the remnant natural forest patches, which account for 83 (53.90%) species. Out of the species collected from natural forest patches 35 (22.44%), 12 (7.69%) and 36 (23.08%) of the traditional medicinal plants were from *Gajilo*, *Yegana* and both remnant forests respectively. The remaining 73

(46.10%) traditional medicinal plant species to treat human and livestock ailments were reported to be harvested from different environments including home gardens, farm, grazing areas, forest edges, bush areas, roadsides and cultivated fields.

#### **4.3.1.3. Disease types treated and treatment methods**

The reported medicinal plants were used to treat 87 human and 16 livestock ailments in *Menz Gera* district for which traditional healers were visited at least once (Appendix 11 and 12 respectively). Based on the informant's data all reported diseases were categorized in to different disease categories. Therefore, in the study area, diseases were categorized into 15 categories for human diseases and 8 categories for livestock diseases (Table 16).

Visual observation, hand touching and interview were the commonly reported diagnosis methods for humans ailments prior to any herbal medicine prescription in the society. Based on the types of reported diseases, traditional practitioners and healers diagnosed patients with an interview for symptoms followed by observation of different parts of the patient such as skin, tongue, throat, the status of sores, bleeding, infections and sensing body temperature of their patients with their bare hands and by looking at their palms. Whereas, simple observation, touching the affected parts and interviewing owners were the main diagnosis methods for livestock ailments. Human patients with skin infections were reported to be treated by painting and/or pasting herbal preparations, whereas those with wounds were treated by chewing or squeezing the part of the medicinal plant and painting/tying the juice on the affected part (Appendix 11). For internal diseases, herbal preparations were mainly given to be taken orally whereas for evil illness and other general illness steam baths and vapor inhalation were commonly reported.

Table 17: Human and Livestock Disease categories of *Menz Gera* District

R. №	Human Disease Categories (DC)	R. №	Livestock Disease Categories (DC)
1.	Gastrointestinal and parasitic	1.	Gastrointestinal
2.	Dermatological/ Skin Disease	2.	Dermatological/Skin Disease
3.	Poisoning Snake Bite	3.	Snake Bite and Poisoning
4.	Respiratory & Common cold	4.	Viral/Rabies
5.	Oral, dental and pharyngeal	5.	Reproductive
6.	Urogenital and venereal/ Reproductive	6.	Fungal Skin Disease
7.	Musculoskeletal and nervous system	7.	External injuries & Abscess
8.	External injuries, Abscess or bleeding	8.	Evil & Others
9.	Blood and lymphatic system		
10.	Febrile illness		
11.	Ophthalmia -Eye		
12.	Evil spirit		
13.	Headache		
14.	Otitis / Ear		
15.	Viral / Rabies		

#### 4.3.1.4. Plant parts and condition used

The people of the study districts reported using various parts of plant species to treat both human and livestock ailments (Table 17). Most of preparations for treating human and livestock ailments were from leaf and root parts accounting for 50 (32.05%) and 48 (30.77%) respectively, followed by seed 18 (11.54%) and fruit 12 (7.69%) (Table 17).

Table 18: Plant parts used for remedy preparation to treat human and livestock ailments in *Menz Gera* District

<b>Plant Part</b>	<b>Abundance</b>	<b>Percentage</b>	<b>Rank</b>
Leaf	50	32.05	1 <sup>st</sup>
Root	48	30.77	2 <sup>nd</sup>
Seed	18	11.54	3 <sup>rd</sup>
Fruit	12	7.69	4 <sup>th</sup>
Leaf/Root	6	3.85	5 <sup>th</sup>
Latex	4	2.56	6 <sup>th</sup>
Bark	3	1.92	7 <sup>th</sup>
Bulb	3	1.92	7 <sup>th</sup>
Leaf/Seed	3	1.92	7 <sup>th</sup>
Shoot	3	1.92	7 <sup>th</sup>
Flower	2	1.28	11 <sup>th</sup>
Leaf/Fruit	1	0.64	12 <sup>th</sup>
Resin	1	0.64	12 <sup>th</sup>
Stem wood	1	0.64	12 <sup>th</sup>
Whole	1	0.64	12 <sup>th</sup>
	156	100.00	

Medicinal plants had their own conditions of preparations as fresh, dry and either fresh or dry. Dry plant parts were dominantly (209; 54.86%) used in remedy preparation followed by fresh parts accounting for 149 (39.11%) species, whereas the remaining 23 (6.04%) of remedies were reported to be prepared either as a dried or fresh parts of medicinal plant species.

#### **4.3.1.5. Modes of remedy preparation and application**

Traditional healers followed several ways of remedy preparations and this depended, according to their customer's explanations, on the type of ailment they encountered. The first mode of remedy preparation used by the healers for human ailments were grinding and tying the crushed part on the affected part (11.89%) followed by crushing, homogenizing with cold water and drinking (10.34%) and boiling and drinking the decoction (8.79%). The other 16 modes of preparations and applications for human ailments were 68.98% of the total (Table 18).

Table 19: Mode of Preparation and Application (MPA) (One species may have more than one mode of preparation)

MPA	Code	Used times	%	Rank
Boil and drink the decoction	1	34	8.79	3 <sup>rd</sup>
Grind and paint the powder or crushed part	2	21	5.43	10 <sup>th</sup>
Grind and tie the crushed part	3	46	11.89	1 <sup>st</sup>
Extract the juice/oil/latex and drink, paint it or pour/drop	4	30	7.75	5 <sup>th</sup>
Crush, homogenize with cold water and drink	5	40	10.34	2 <sup>nd</sup>
Hold with teeth and inhale its liquid	6	26	6.72	8 <sup>th</sup>
Crush, heat/ burn or boil the part and inhale its smoke or steam	7	33	8.53	4 <sup>th</sup>
Crush and sniff, smell the freshly crushed part	8	6	1.55	15 <sup>th</sup>
Crush and eat the part	9	30	7.75	5 <sup>th</sup>
Boil and do steam bath	10	2	0.52	19 <sup>th</sup>
Drink the concoction directly or after fermentation	11	29	7.49	7 <sup>th</sup>
Crush, heat burn and paint the powder on the affected part	13	19	4.91	11 <sup>th</sup>
Dry crush, heat burn homogenizes with cold water and drink	14	10	2.58	14 <sup>th</sup>
Clean directly the affected part	15	3	0.78	17 <sup>th</sup>
Paint the latex	16	3	0.78	17 <sup>th</sup>
Crush, mix/alone and tie/put externally	17	24	6.20	9 <sup>th</sup>
Boil with water and wash on the body	18	4	1.03	16 <sup>th</sup>
Add the concoction to the affected part	19	16	4.13	12 <sup>th</sup>
Paint the latex, milk, oil	20	11	2.84	13 <sup>th</sup>

The three modes of preparation and application that were the most used ways for livestock medicine preparation were, crushing, homogenizing with cold water and drinking (33.33%), crushing, mixing/alone and tying/put externally (24.44%) and drinking the concoction directly or after fermentation (20.00%). The other five modes of preparation and application account only for 22.22% of the total (Appendix 12).

#### 4.3.1.6. Routes of Administration

Informants use different ways of remedy administration for treating human and livestock ailments. For human ailments, oral application, 177 preparations (45.74%) were the most commonly used route of administration followed by dermal application, 111 preparations (28.68%) and nasal application, 40 preparations (10.34%). The remaining routes of administration (auricular, external tying and optical) account for 59 preparations (15.24%) only (Figure 14).

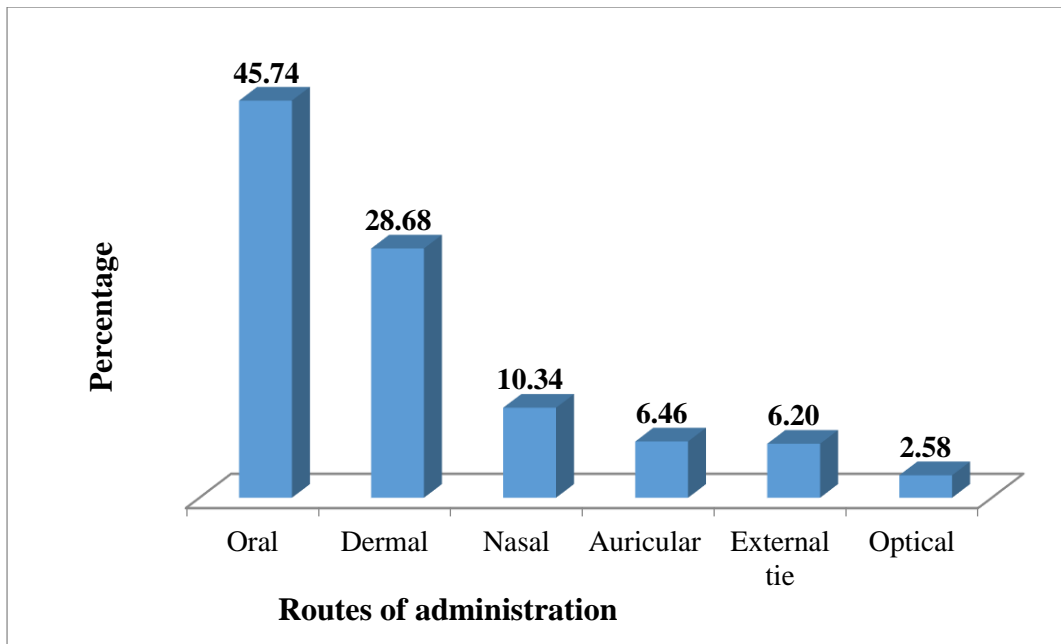


Figure 14: Routes of remedy administration for human ailments

Like the human route of administration, almost half of the livestock route of administration was via oral, which accounted for 23 preparations (48.94%). Followed by external Tying 12 (25.24%) and dermal, 10 preparations (10.64%). The remaining remedies were administered through auricular, 4 preparations (8%) and nasal 3 preparations (6%) (Figure 15).

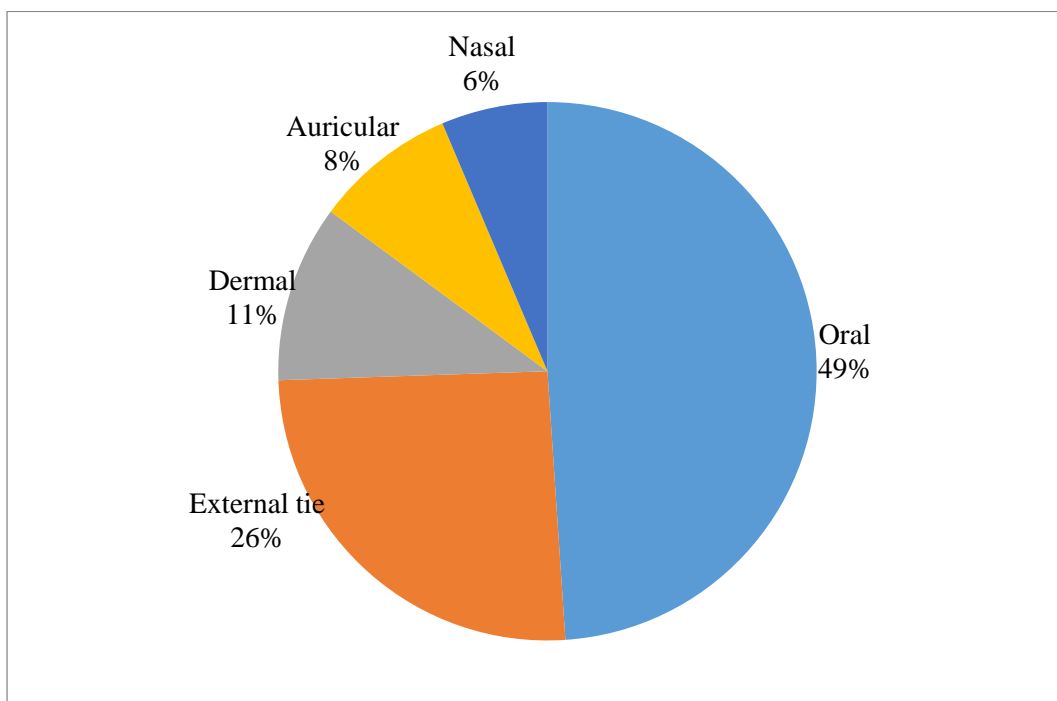


Figure 15: Routes of remedy administration for livestock ailments

#### 4.3.1.7. Dosages and antidotes

Results show that there was no agreement among informants in materials used for measurement or units used for traditional medicine. Most informants (80%) used cup, teacup, spoon, drops and fingers to determine doses, and different doses were reported even for the same or similar ailments by different traditional medicinal healers. Dosages were reported to be determined based on age, sex, pregnancy status and physical appearance of patients visiting local healers especially, by known local healers. Some medicinal plant preparations were mentioned to be measured in small cups locally known as “*yebuna sini*” (coffee cup) and “*Yeareke melkya*” referring to traditional cups used for drinking coffee and locally prepared alcohol “*Areke* in Amharic” respectively. In addition to this, they used to measure preparations by hand, as full hand and different finger sizes as well as by drops and by spoon. Some of the medicinal prescriptions are ordered with antidotes, locally called “*Markesha*”. *Phytolacca dodecandra*, *Salix subserrata*, *Croton macrostachyus*, *Clematis hirsuta*, *Clematis simensis*, and *Solanum incanum* were reported to be taken with different antidotes alternatively as per the healer’s recommendation. Chicken meat, cooked hen liver, coffee, milk, honey, yoghurt, butter and dissolved powder of roasted barley locally called “*Beso*”, were commonly reported antidotes for herbal preparations with adverse side effects.

#### 4.3.1.8. Marketability of medicinal plants

Market surveys showed that, only a small number, (21; 13.5%) of medicinal plants used in the district were available for sale at local markets. Thus, the majority (86.5%) of medicinal plants were harvested from their environment and used by those who need them. Most of the reported medicinal plants were found to be traded at local markets and sold for different purposes such as their use as spices, stimulants, agricultural tools, home materials, smoke flavor, foods and toothbrushes (Table 19). *Withania somnifera*, *Echinops kebericho* and *Hagenia abyssinica* species were sold for their medicinal purpose in addition to other cultural and spiritual services. The average unit price of the medicinal plant species varies from 1 to 21 Ethiopian Birr (1 ETB = 0.031 USD) for different species and measurements such as a jug of *Hagenia abyssinica* was sold 5 birr (Figure 16). The market survey was conducted in *Mehal Meda*, *Wejed*, and *Gey Mariam* local markets at different seasons.

Table 20: Medicinal plants collected from the markets of *Menz Gera* District for cash generation

Scientific Name	Family	Habit	Parts used	Measurement	Cost in ETB	Use
<i>Allium sativum</i>	Alliaceae	H	B	Medeb	10	Spice & Medicine
<i>Brassica oleracea</i>	Brassicaceae	H	L	Head	4	Food
<i>Catha edulis</i>	Celastraceae	S	L	Medeb	10	Stimulant
<i>Coffea arabica</i>	Rubiaceae	S	S	Cups	3	Stimulant
<i>Echinops kebericho</i> **	Asteraceae	H	R & L	Medeb	2	Medicine
<i>Hagenia abyssinica</i>	Rosaceae	T	Fl	Jug	5	Medicine
<i>Lens culinaris</i>	Fabaceae	H	S	Kilogram	21	Food
<i>Lepidium sativum</i>	Brassicaceae	H	S	Melekya	2	Spice
<i>Linum usitatissimum</i>	Linaceae	H	S	Cup	5	Spice/ edible/ oil/ food
<i>Lippia adoensis</i>	Verbenaceae	H	L & S	Cup	2	Spice & Medicine
<i>Ocimum lamifolium</i>	Lamiaceae	H	L	Cup	2	Spice & Medicine
<i>Olea europaea</i> subsp. <i>cuspidata</i>	Oleaceae	T	St	Medeb	1	Smoke flavors
<i>Otostegia integrifolia</i>	Lamiaceae	S	L	Medeb	1	Smoke flavors
<i>Pennisetum thunbergii</i>	Poaceae	H	Leaf	Medeb	2	Material
<i>Rhamnus prinoides</i>	Rhamnaceae	S	L	Jug	4	Medicine & Fermentation
<i>Ruta chalepensis</i>	Rutaceae	H	L & S	Medeb	5	Spice & Medicine
<i>Sesamum orientale</i>	Pedaliaceae	H	S	Teacup	5	Spice
<i>Thymus schimperi</i> **	Lamiaceae	H	L	Teacup	2	Spice, Medicine
<i>Trachyspermum ammi</i>	Apiaceae	H	S	Teacup	5	Spice & Medicine
<i>Trigonella foenum-graecum</i>	Leguminosae	H	S	Cup	8	Spice
<i>Withania somnifera</i>	Solanaceae	S	L	Medeb	2	Medicine

Key: Habit: Tree =T, Shrub= S, Herb= H; Parts Used: Bulb= B, Flower= Fl, Leaf= L, Root= R, Seed= S, Stem= St; “Medeb”: arbitrary grouping of materials with proportional size; “Melekya” =Measuring unit of a locally prepared alcoholic drink called “Areke” in Amharic; \*\*: Endemic to Ethiopia, 1ETB (Ethiopian Birr) = 0.031 USD



A. *Thymus schimperi*



B. *Echinops kebericho*



C. *Coffea arabica*



D. *Ruta chalepensis*



E. *Olea europaea* subsp. *cuspidata*



F. *Otostegia integrifolia*

Figure 16: Some medicinal plants in the markets of *Menz Gera* District

#### 4.3.1.9. Efficacy of medicinal plants

Based on data obtained from the local community, diseases such as abdominal pain, diarrhea and gastritis were the most reported human health problems under the “gastrointestinal diseases” category, which is the first disease category with ICF value of 0.78. Toothache and tongue disease were the most reported human health problems under the “oral, dental and pharyngeal diseases” category, which is the second with ICF value of 0.76. Abscess and head injury were commonly reported human diseases under the external injuries under the abscess or bleeding diseases category, which is the third diseases category with ICF value of 0.64 (Table 20). Dermatological/ skin disease category was the first in a number of plant species to treat ailments with 36 (23.38%) species followed by urogenital and venereal/ reproductive disease category which accounts 25 (16.23%) species and gastrointestinal and parasitic disease category and evil spirit disease category were the third, with 14 (9.09%) species each (Table 20).

Table 21: ICF values of traditional medicinal plants for treating human ailments and their disease categories in *Menz Gera* District

Disease Categories (DC)	nur (Use citations)	Use Citation %	nt (Species used)	Species used %	ICF (nur- nt/n-1)	Rank
Gastrointestinal and parasitic	60	15.79	14	9.09	0.78	1 <sup>st</sup>
Dermatological/ Skin Disease	74	19.47	36	23.38	0.52	10 <sup>th</sup>
Poisoning Snake Bite	31	8.16	12	7.79	0.63	4 <sup>th</sup>
Respiratory & Common cold	26	6.84	12	7.79	0.56	8 <sup>th</sup>
Oral, dental and pharyngeal	18	4.74	5	3.25	0.76	2 <sup>nd</sup>
Urogenital and sexually transmitted / Reproductive	54	14.21	25	16.23	0.55	9 <sup>th</sup>
Musculoskeletal and nervous system	7	1.84	4	2.60	0.50	11 <sup>th</sup>
External injuries, Abscess or bleeding	12	3.16	5	3.25	0.64	3 <sup>rd</sup>
Blood and lymphatic system	14	3.68	6	3.90	0.62	5 <sup>th</sup>
Febrile illness	15	3.95	7	4.55	0.57	6 <sup>th</sup>
Ophthalmia -Eye	9	2.37	5	3.25	0.50	11 <sup>th</sup>
Evil spirit	20	5.26	14	9.09	0.32	15 <sup>th</sup>
Headache	4	1.05	3	1.95	0.33	14 <sup>th</sup>
Otitis / Ear	24	6.32	11	7.14	0.57	6 <sup>th</sup>
Viral / Rabies	12	3.16	8	5.19	0.36	13 <sup>th</sup>

Key: nur: number of use citations in each disease category.  
nt: number of species used in each category.

The livestock diseases were categorized in eight disease categories. A fungal infection, which is under the fungal skin disease category, was the first reported livestock health problem with ICF

of 0.75. Abscess, wound and node pain were the second commonly reported livestock health problems under the external injuries and abscess disease category, which is the second disease category with ICF of 0.78 (Table 21). Gastrointestinal disease category was the first in number of plant species used to treat illness with 12 (35.29%) species followed by reproductive disease category, which accounts for 8 (23.53%) species (Table 21).

Table 22: ICF values of traditional medicinal plants for treating livestock ailments and their disease categories in *Menz Gera* District

Disease Categories (DC)	nur (Use citations)	Use Citation %	nt (Species used)	Species used %	ICF (nur-nt)/nur-1	Rank
Gastrointestinal	13	26.53	12	35.29	0.08	8 <sup>th</sup>
Dermatological/Skin Disease	4	8.16	3	8.82	0.33	4 <sup>th</sup>
Snake Bite and Poisoning	3	6.12	2	5.88	0.50	3 <sup>rd</sup>
Viral/Rabies	4	8.16	3	8.82	0.33	4 <sup>th</sup>
Reproductive	10	20.41	8	23.53	0.22	7 <sup>th</sup>
Fungal Skin Disease	5	10.20	2	5.88	0.75	1 <sup>st</sup>
External injuries & Abscess	6	12.24	3	8.82	0.60	2 <sup>nd</sup>
Evil & Others	4	8.16	3	8.82	0.33	4 <sup>th</sup>

Key: nur: number of use citations in each disease category.

nt: number of species used in each category.

#### 4.3.1.10. Healing potential of medicinal plants against human ailments

Fidelity level values for 16 commonly used medicinal plants of *Menz Gera* District against the corresponding human ailments categories were calculated and presented in (Table 22). The highest fidelity level (94.44%) was recorded for *Zehneria scabra*, followed by *Croton macrostachyus* (93.33%), *Inula confertiflora* (90.91%) and *Solanum incanum* (90.00%). *Zehneria scabra* and *Solanum incanum* were reported to be used against dermatological/skin disease category. Whereas *Croton macrostachyus* was reported for use against gastrointestinal and parasitic diseases, *Inula confertiflora* was reported for use against viral infections disease category (Table 22).

Table 23: Fidelity level values of medicinal plants commonly reported against a given human diseases category

Scientific Name	PU	Disease category	Ip	Iu	FL value in %	Rank
<i>Zehneria scabra</i>	L	Dermatological/ Skin Disease	34	36	94.44	1
<i>Croton macrostachyus</i>	B	Gastrointestinal and parasitic	28	30	93.33	2
<i>Inula confertiflora</i> *	L	Viral infections	20	22	90.91	3
<i>Solanum incanum</i> *	R	Dermatological/ Skin Disease	18	20	90.00	4
<i>Cucumis ficifolius</i>	Fr/R/L	Gastrointestinal and parasitic	33	37	89.19	5
<i>Kalanchoe marmorata</i> *	R	Respiratory & Snake bite	8	9	88.89	6
<i>Laggera tomentosa</i> *	L/R	Viral infections	14	16	87.50	7
<i>Satureja abyssinica</i> *	L/R	Nervous system & Snake bit	12	14	85.71	8
<i>Urtica simensis</i> *	R/L	Gastrointestinal and parasitic	10	12	83.33	9
<i>Osyris quadripartita</i> *	L	External injuries, Abscess or bleeding	12	15	80.00	10
<i>Leonotis ocyimifolia</i>	L	Dermatological/ Skin Disease	10	13	76.92	11
<i>Minuartia filifolia</i> *	R	Urogenital and Evil spirit	14	19	73.68	12
<i>Allium sativum</i>	Bu	Gastrointestinal and parasitic	18	25	72.00	13
<i>Artemisia abyssinica</i>	R	Respiratory, Common cold & Gastrointestinal	35	50	70.00	14
<i>Verbascum sinaiticum</i>	R	External injuries, Abscess & Snake bite	23	33	69.70	15
<i>Lepidium sativum</i>	S	Dermatological/ Skin Disease	16	30	53.33	16

Key: - Ip: Number of informants who independently cited the importance of a species for treating a particular disease; Iu: Total number of informants who reported the plant for any given disease;

\* Species selected for *in-vitro* antimicrobial test; PU: Parts Used; B: Bark, Bu: Bulb, Fl: Flower, L: Leaf, R: Root, S: Seed; FL %: (Ip/Iu\*100)

#### 4.3.1.11. Use diversity of medicinal plants

Based on their use of diversity in the study districts, six multipurpose plant species were selected by considering their relative highest contribution for the use diversities. Eleven use of diversities of these medicinal plants were listed for random 10 groups (averagely 5 members) of key informants from the study districts, to assess their relative importance by discussing them with consideration of the range of their contribution. Each group of the key informants was asked to assign one if it is used and zero if it is not used for the listed use diversities then scores of each species were summed up and ranked (Table 23). *Hagenia abyssinica* was the first in use diversity with 72.73% of the listed uses. Followed by *Eucalyptus globulus* with 63.64% of the use types, *Allophylus abyssinicus* and *Olea europaea* subsp. *cuspidata* scoring 54.55% of the use diversity each.

Table 24: Use Diversity matrix of some selected multi-purpose medicinal plants

Species Name	Use Diversity											Total Use	Use%	Rank
	M	FE	FW	CT	C	FD	CR	F	EU	BF	OU			
<i>Hagenia abyssinica</i>	1	0	1	1	1	1	0	0	1	1	1	8	72.73	1
<i>Eucalyptus globulus</i>	1	0	1	1	1	1	0	1	0	0	1	7	63.64	2
<i>Allophylus abyssinicus</i>	1	0	1	1	1	0	0	0	1	1	0	6	54.55	3
<i>Olea europaea</i> subsp. <i>cuspidata</i>	1	0	1	1	1	0	1	0	0	0	1	6	54.55	3
<i>Dovyalis abyssinica</i>	1	1	1	0	0	0	0	1	0	0	1	5	45.45	5
<i>Rosa abyssinica</i>	1	1	1	1	0	0	0	0	0	0	1	5	45.45	5

Key: - 1: used, 0: not used, M: Medicinal, FE: Fence, FW: Firewood & Charcoal, CT: Construction & Tools, C: Commercial, FD: Livestock fodder/ forage, CR: Culture & Rituals, F: Food/ Drink, EU: Environmental Use, BF: Bee Forage, OU: Ornamental & Other Uses

On the other hand, Direct Matrix Ranking (DMR) of ten multipurpose plant species against 11 use-values were also done using the randomly created 10 groups (averagely 5 members) of the key informants to rank the multipurpose medicinal plants by ranking the depth/range of contribution for each use diversity. Accordingly, *Hagenia abyssinica*, *Thymus schimperi* and *Olea europaea* subsp. *cuspidata* were ranked first, second and third respectively in the use diversity ranking. From the rank of use diversity of medicinal plants, firewood was at the first rank and Construction and charcoal as a second followed by construction and tools collected from the multipurpose medicinal plant scores (Table 24).

Table 25: Direct Matrix Ranking (DMR) score of ten groups of key informants for ten medicinal plant species with additional uses beside medicinal role

Use Category	Multipurpose medicinal plants											
	<i>Olea europaea</i> subsp. <i>cuspidata</i>	<i>Dovyalis abyssinica</i>	<i>Ekebergia capensis</i>	<i>Coffea arabica</i>	<i>Myrica salicifolia</i>	<i>Hagenia abyssinica</i>	<i>Thymus schimperi</i>	<i>Allophylus abyssinicus</i>	<i>Croton macrostachyus</i>	<i>Prunus africana</i>	Total for uses	Rank
Medicinal	4	3	2	3	2	5	4	2	4	3	32	5
Food/ Drink	0	4	3	5	0	0	4	0	0	0	16	8
Firewood & Charcoal	5	3	5	1	4	4	0	5	3	5	35	2
Construction & Tools	5	2	5	0	4	5	0	5	3	5	34	3
Commercial	3	0	4	4	3	5	4	4	2	4	33	4
Fodder	3	3	3	1	2	2	4	3	2	3	26	7
Culture & Rituals	3	0	0	5	0	1	3	1	2	0	15	9
Fence	1	5	0	0	1	2	0	2	2	1	14	10
Environmental Use	4	4	5	3	4	5	3	4	4	5	41	1
Bee Forage	0	0	0	2	0	3	5	0	0	0	10	11
Ornamental & Other Uses	3	2	1	5	2	4	5	2	2	3	29	6
Total for species	31	26	28	29	22	36	32	28	24	29		
Rank	3	8	6	5	10	1	2	6	9	4		

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

#### 4.3.1.12. Preference ranking of medicinal plants

Preference ranking was calculated for eight medicinal plants that were reported to be used against eczema (human illness), and the most frequently reported disease in the dermatological/skin disease category. *Clematis simensis* was the most preferred species to treat eczema followed by *Olea europaea* subsp. *cuspidata* and *Allium sativum* respectively (Table 25).

Table 26: Preference ranking to medicinal plants used for treating eczema

Medicinal plants	Informants labeled A to L												Total	Rank
	A	B	C	D	E	F	G	H	I	J	K	L		
<i>Olinia rochetiana</i>	4	5	4	4	5	3	2	3	6	7	8	1	52	5
<i>Duranta erecta</i>	3	1	3	1	4	4	1	1	2	4	3	2	29	8
<i>Olea europaea</i> subsp. <i>cuspidata</i>	7	8	7	8	7	5	8	6	1	3	7	7	74	2
<i>Aloe pulcherrima</i>	5	4	5	3	6	8	6	2	3	8	4	5	59	4
<i>Allium sativum</i>	8	6	8	7	1	6	5	7	8	5	5	6	72	3
<i>Oenanthe palustris</i>	2	2	1	2	3	1	4	4	4	6	2	3	34	6
<i>Clematis simensis</i>	6	7	6	6	8	7	7	8	7	1	6	8	77	1
<i>Combretum molle</i>	1	3	2	5	2	2	3	5	5	2	1	4	35	7

Key: - 12 informants were involved for ranking the medicinal plants (A to L)

Highest number (8) given for the medicinal plant which informants thought most effective in treating eczema and the lowest number (1) for the least effective plant

Preference ranking for livestock ailments was performed with ten key informants (selected randomly) for six medicinal plants that were reported to be used against diarrhea, the most frequently reported livestock disease under the gastrointestinal disease category. As per the key informants rank *Verbascum sinaiticum*, *Allium sativum* and *Salvia merjamie* were the most preferred species to treat the reported disease (Table 26).

Table 27: Preference ranking of medicinal plants reported for treating livestock diarrhea

Medicinal plants	Informants labeled A to L										Total	Rank
	A	B	C	D	E	F	G	H	I	J		
<i>Verbascum sinaiticum</i>	6	3	4	6	5	4	5	6	4	5	48	1
<i>Plectranthus cylindraceus</i>	4	2	2	2	6	1	6	3	1	1	28	5
<i>Allium sativum</i>	2	6	3	5	3	5	2	5	5	6	42	2
<i>Lobelia rhyngopetalum</i>	3	4	6	1	2	2	3	2	3	3	29	4
<i>Solanecio gigas</i>	1	5	1	3	1	6	1	1	2	2	23	6
<i>Salvia merjamie</i>	5	1	5	4	4	3	4	4	6	4	40	3

Key: - 10 informants were involved for ranking the medicinal plants (A to L)

Highest number (6) given for the medicinal plant which informants thought most effective in treating eczema and the lowest number (1) for the least effective plant

#### 4.3.2. Indigenous knowledge transfer on medicinal plants

In the study area, the traditional healers were not open to share their knowledge for everybody. The major way of indigenous knowledge transfer of medicinal plants and concepts of traditional diagnosis methods was by word of mouth to a family member, especially to an elder son. In *Menz Gera* District, indigenous knowledge of medicinal plants transfer was widely practiced from their parents (47.95%) and grandparents (36.92%) which are the main source of traditional medical knowledge (Table 27).

Table 28: Sources of indigenous knowledge on the practice of traditional medicine

Source of Knowledge	No of informants	% of informants
Parents	187	47.95
Grandparents	144	36.92
Uncle/ Aunt	23	5.90
Wife/Husband	16	4.10
Neighbor	12	3.08
Friends	8	2.05
<b>Total</b>	<b>390</b>	<b>100</b>

#### 4.4. Antimicrobial Activity of Selected Traditional Medicinal Plants

A total of eight medicinal plants were selected for extraction and antimicrobial activity testing for nine plant parts extraction. *Inula confertiflora*, *Urtica simensis*, *Osyris quadripartita* and *Satureja abyssinica* were extracted selected for their leaves while *Solanum incanum*, *Kalanchoe marmorata* and *Minuartia filifolia* were selected for root extraction, whereas, *Laggera tomentosa* was selected for both root and leaf extraction. The percent yield of (on a dry weight basis) using ethanol 80% as a solvent was calculated. *Osyris quadripartita* leaf has the highest yield, 19%, followed by that of *Laggera tomentosa*, (16.6%), and *Inula confertiflora*, (14%) whereas, the yield from *Minuartia filifolia* was 2.2% (Table 28).

The extracts were tested for antimicrobial activity against gram-positive Bacteria (*Listeria monocytogenes* and *Staphylococcus aureus*), gram-negative bacteria (*Escherichia coli* and *Salmonella typhimurium*) and fungus (*Candida albicans*). All the plant extracts showed antimicrobial activity at the concentration of 100 mg/ml to 12.5 mg/ml, against one or more of the five microbes (Table 28). Extracts of *Inula confertiflora* (leaf), *Laggera tomentosa* (root), and *Satureja abyssinica* (leaf), showed the broadest spectrum of action as they inhibited the growth of all the pathogens with MICs of 100mg/ml. Extracts of *Kalanchoe marmorata* (root) and *Laggera tomentosa* (leaf) showed the highest spectrum of inhibition against *Staphylococcus aureus* with MICs of 12.5 mg/ml to 100 mg/ml. On the other hand, extracts of *Inula confertiflora* (leaf) showed the widest inhibition action against three pathogens (*Listeria monocytogenes*, *Staphylococcus aureus* and *Candida albicans*) at the MICs of 25 mg/ml to 100 mg/ml.

The extracts of *Solanum incanum* (root), *Urtica simensis* (leaf), *Kalanchoe marmorata* (root), *Laggera tomentosa* (leaf) *Minuartia filifolia* (root) and *Osyris quadripartita* (leaf) did not show any inhibition effect against the fungus pathogen *Candida albicans*. On the other hand, *Inula confertiflora* (leaf), *Laggera tomentosa* (root) and *Satureja abyssinica* (leaf) were the only plant extracts, which showed inhibition against *Candida albicans* at MICs of 25 mg/ml, 50 mg/ml and 100 mg/ml respectively. The selected pathogens of gram-negative bacteria and fungus were generally found more resistant against the extracts than gram-positive bacteria especially at lower concentrations of the extracts (Table 28).

Table 29: MIC values of ethanol extracts of medicinal plant species with antimicrobial activities

Scientific name	Family	Habit	Parts Used	% Yield	Pathogen/ Inhibition zone (mm)					
					Conc. (mg/ml)	Gram + Bacteria		Gram - Bacteria		Fungus
						<i>Lm</i>	<i>Sa</i>	<i>Ec</i>	<i>St</i>	<i>Ca</i>
<i>Inula confertiflora</i> **	Asteraceae	S	Leaf	14.8	100	26	18	11	10	17
					50	20	11	-	-	14
					25	14	8	-	-	11
					12.5	-	-	-	-	-
<i>Solanum incanum</i>	Solanaceae	S	Root	4.5	100	13	10	9	-	-
					50	11	9	-	-	-
					25	-	-	-	-	-
					12.5	-	-	-	-	-
<i>Urtica simensis</i>	Urticaceae	H	Leaf	9.25	100	11	9	9	8	-
					50	-	8	-	-	-
					25	-	-	-	-	-
					12.5	-	-	-	-	-
<i>Kalanchoe marmorata</i>	Crassulaceae	H	Root	6.5	100	-	22	17	12	-
					50	-	17	-	-	-
					25	-	13	-	-	-
					12.5	-	12	-	-	-
<i>Laggera tomentosa</i> **	Asteraceae	S	Leaf	16.6	100	11	11	-	9	-
					50	-	9	-	-	-
					25	-	8	-	-	-
					12.5	-	8	-	-	-
			Root	4.2	100	8.5	11	9.2	7.5	11
					50	-	-	-	-	9.5
					25	-	-	-	-	-
					12.5	-	-	-	-	-
<i>Minuartia filifolia</i>	Caryophyllaceae	H	Root	2.2	100	10.5	9.5	-	9.2	-
					50	-	8	-	-	-
					25	-	-	-	-	-
					12.5	-	-	-	-	-
<i>Osyris quadripartita</i>	Santalaceae	T	Leaf	19	100	8.5	13	-	9	-
					50	-	-	-	-	-
					25	-	-	-	-	-
					12.5	-	-	-	-	-
<i>Satureja abyssinica</i>	Lamiaceae	H	Leaf	7.4	100	11	16.5	9.4	8.6	9
					50	-	14	-	-	-
					25	-	12.5	-	-	-
					12.5	-	-	-	-	-
Positive Control	Ampicillin 10 µg /ml				11	11.5	7	14	10.5	
	Chloramphenicol 30 µg/ml				24.5	25.5	24	31.5	32.5	
Negative Control	DMSO 5%				-	-	-	-	-	

Key: \*\*: Endemic Species; H: Herb, S: Shrub, T: Tree; *Lm*: *Listeria monocytogenes*, *Sa*:

*Staphylococcus aureus*, *Ec*: *Escherichia coli*, *St*: *Salmonella typhimurium*, *Ca*: *Candida albicans*

## CHAPTER FIVE

### 5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

#### 5.1. Discussion

##### 5.1.1 Plant Diversity

The vegetation of *Menz Gera* District is rich in plant diversity. The study area was rich in species composition as shown by the presence of 284 species distributed in 213 genera and 89 families. The observed diverse flora of *Menz Gera* District is in line with the general pattern of rich species presence in East African montane forests. According to Gentry (1995), east African mountains (found in Ethiopia, Kenya, Tanzania and Uganda) have the richest and most diverse flora. The study area is also rich in traditional medicinal plants, which contains 156 species belonging to 136 genera and 67 families. From the reported forest species, 84 (35 from *Gajilo* forest patch, 12 from *Yegana* forest patch and 37 from both forests) were reported for one or more of the traditional medicinal uses in the District. The study area is a reservoir for 25 endemic species and this shows the area is highly important. This implies *Menz Gera* natural forest patches are a good reservoir for traditional medicinal plants and associated indigenous knowledge. Studies also confirmed that there is high floristic richness and diversity in the central highland of Ethiopia (Hedberg, 1951; Ermias Lulekal *et al.*, 2013 and Hussen Adal, 2014).

##### 5.1.1.1 Floristic Composition of the Remnant natural forest patches (*Yegana & Gajilo*)

*Menz Gera* Forests are rich in species composition as shown by the presence of 212 species belonging to 154 genera and 72 families. The observed rich plant species of the forests might be due to the inaccessible topographic heterogeneity that includes deep gorges, several peaks, plateau, and rivers that create a specific multitude of microhabitats and nest different set of organisms, which in turn accounted for the distribution patterns and variations in species composition. The higher species diversity of the forest was due to the herbaceous species richness (59.91%) favored by a strong anthropogenic disturbance in the forest even if it is difficult to access. This was evidenced by the frequent prevalence of disturbance indicator shrub species such as *Maesa lanceolata*, *Berberis holstii*, *Dodonea angustifolia*, *Croton macrostachyus*, *Clutia abyssinica* and *Asparagus africanus* (Abiyou Tilahun, 2018). Generally conducting a comparison of species richness of one forest with others is a very difficult task as there might be differences in forest size, data collection methodology and objectives of the studies. However, to give a general impression of the species richness of *Menz Gera* forests, the

results of the present study were compared with results from other Afromontane forests in Ethiopia.

The study area has higher species richness than other Afromontane forests in Ethiopia such as *Jibat* (131 species) (Tamrat Bekele, 1994), *Zegie* (113 species) (Alemnew Alelign *et al.*, 2007), *Dense* (158 species) (Ermias Lulekal, 2014), *Tara Gedam* (111 species) and *Abebaye* (88 species) (Haileab Zegeye *et al.*, 2011). This may be due to the inaccessible nature of the forest patches in comparison to the stated forests. On the other hand, its richness is less than *Yayu* forests (220 species) (Tadesse Woldemariam *et al.*, 2008) and *Wof Washa* forest (394 species) (Abiyou Tilahun, 2018). This may be due to high anthropogenic pressure, which causes settlement expansion, agriculture expansion, selective cutting for home services and firewood and timber collection from the local community than the other forests. The distribution pattern of plant species over different habitats of the forest could be attributed to several environmental factors, which impose impacts in both temporal and spatial scales (Shmida and Wilson, 1985). Thus, environmental heterogeneity, regeneration capacity, moderate disturbance, and competition might shape and determine species richness of the forest. Moreover, forests with a high degree of anthropogenic and natural disturbances for prolonged periods may show relatively lower species richness due to seedling grazing and damage of viable seeds.

Family Asteraceae has the highest representation, with 38 (17.92%) species belonging to 22 genera and this could be attributed due to the efficient and successful dispersal strategies and better structural and physiological adaptation to a wide range of ecological conditions. This finding has been related to the wider presence of the species of this family in the flora area, Ethiopia (Mesfin Tadesse, 2004).

Asteraceae was also shown to be well represented in other mountain forests in Ethiopia, such as *Dense* (20 species) (Ermias Lulekal, 2014), *Wof Washa* (62 species) (Abiyou Tilahun, 2018) *Adelle* and *Boditi* (39 species) (Haile Yineger *et al.*, 2008a) and *Mana Angetu* (13 species) (Ermias Lulekal *et al.*, 2008b) forests. The second large representation of species was recorded from *Poaceae* family with 16 (7.55%). This might be attributed to the reduced floral structure, ability to produce more seeds and suitability for wind pollination and dispersal that have enabled the species in the family to be extremely successful in a wide ranges of elevation, which is also reported from *Wof Washa* forest (Abiyou Tilahun, 2018).

From the remnant natural forest patches of *Menz Gera* District 84 species (35 from *Gajilo* forest patch, 12 from *Yegana* forest patch and 37 from both forest patches) were reported for one or

more of their traditional medicinal uses. This shows the remnant natural forest patches are potential reservoirs for traditional medicinal plants and associated indigenous knowledge. A higher number of traditional medicinal plants were recorded from *Gajilo* forest patch (72 species) this may be due to altitudinal variation and less anthropogenic disturbance when compared to *Yegana* forest patch. The same reports were also recorded from Ankober District, Central high lands of Ethiopia (Ermias Luleka *et al.*, 2013). The results of this finding have also shown the highest representation of herbaceous species with 127 (59.91%) species in *Menz Gera* forests as compared to the other growth forms. This agrees with similar patterns of the dominance of herbaceous species in the other Ethiopian mountain forests (Ermias Lulekal *et al.*, 2008b; Haile Yineger *et al.*, 2008; Ermias Lulekal, 2014, Abiyou Tilahun, 2018).

With regard to endemism, 25 (11.8%) endemic species were identified in *Yegana* and *Gajilo* forest patches and is within the range of endemic plant species of Afromontane forests of Ethiopia (10-15 %) (Friis and Sebsebe Demissew, 2001; Fekadu Gurmessa *et al.*, 2013). This result agrees with the basic features of Eastern Afromontane forests and Horn of Africa biodiversity hotspots known to harbor diverse endemic species (White, 1978). This high endemism might be due to diverse topographic features since those forest patches are the extensions of *Menz Guassa* Community conserved area, which is highly protected by the community and rich in species composition (Habtamu *et al.*, 2016). According to White (1978), the Afromontane region is an important center of endemism housing over 3000 endemic plant species. However, the number of endemic species recorded in this study is lower than those recorded in some Dry Afromontane forest of Ethiopia, for example, *Wof Washa* forest 46 species (11.68%) (Abiyou Tilahun, 2018).

#### **5.1.1.2 Plant community types of *Menz Gera* Natural Forests Patches**

*Menz Gera* forests are stretched on a mountain especially at hilly peaks with clear altitudinal variation, altitudinal drops/rises and disturbances will always be accompanied by varying degrees of differences in microclimatic conditions, which mainly influence temperature and soil moisture, and hence result in variations in community structure. The observed variation in species diversity could be explained by the difference in altitudinal gradients, slope, aspect, habitat disturbance reflected by cattle barns and grazing, the presence of traditional beekeeping, and the presence of tree cuts and undulated peaks, which lead to sliding soil and plants (Feyera Senebeta, 2006). Altitude affects atmospheric pressure, moisture and temperature in an area, which directly influence the growth and development of plants and the corresponding patterns

of vegetation distribution. Plants in mountainous regions respond to small-scale variations related to elevation changes that affect microclimatic conditions (Feyera Senebeta, 2006; Ermias Lulekal, 2014).

The three identified community groups occupy different regions of species space, as shown by the strong chance correction within the group (A) and test statistic (T) thus confirm the existence of three distinct plant community types in *Menz Gera* forests. According to Kent (2012), plant species growing together in a particular location shows a definite association or affinity with each other.

Community one (*Juniperus procera* - *Olea europaea* subsp. *cuspidata* community type), *Juniperus procera*, *Olea europaea* subsp. *cuspidata*, *Osyris quadripartita*, *Dodonea angustifolia*, *Myrica salicifolia*, *Maytenus arbutifolia* and *Rosa abyssinica* from the woody species and *Thymus schimperi* subsp. *schimperi*, *Bidens macroptera* and *Andropogon abyssinicus* from herbaceous species were the characteristic species for this community. This community type shows overlaps of altitude between communities two and three at different altitudinal gradients. The overlaps of plant community one over plant community two and three indicates the presence of shared species among the community types showing similar adaptation tolerance and requirements. Community type one has the highest number of plant species with 157 (74%) species, collected from 35 (48.6%) quadrats, with Shannon diversity index 4.1 and covers large altitudinal range (2403 – 3560 m.a.s.l) compared to the other two communities in the study area. This could be attributed to their location away from human disturbances, being available in area that are found within the inaccessible parts of *Yegana* and *Gajilo* remnant forests. Naturally, this community is located in difficult terrain (sloppy and deep gorges) which are not frequently exposed or accessible to anthropogenic disturbances. This community contains economically and ecologically important plant species such as *Olea europaea* subsp. *cuspidata*, *Osyris quadripartita*, *Thymus schimperi* subsp. *schimperi*, *Dodonea angustifolia*, *Myrica salicifolia*, *Maytenus arbutifolia*, *Rosa abyssinica*, *Aloe debrana*, etc. Furthermore, the community contains species important for honey production such as *Erica arborea*, *Hagenia abyssinica* and other ecologically and culturally important species.

The dominance of the upper tree layer of community one by *Juniperus procera*, *Olea europaea* subsp. *cuspidata* and *Osyris quadripartita* tree species indicates that there is much presence of characteristic species of Dry Afromontane forests in the study area. These species were also mentioned to form the upper canopies of different dry montane forests in Ethiopia (Tamrat

Bekele, 1993; Demel Teketay and Tamrat Bekele, 1995; HaileYineger *et al.*, 2008; Ermias Lulekal, 2014). These species and other indigenous tree species like *Hagenia abyssinica* - *Ekebergia capensis* (characteristic of community two) and *Podocarpus falcatus*- *Galiniera saxifraga* (characteristics of community three) were distributed through the study area. However, these species were subjected to anthropogenic pressure (due to their multipurpose roles in the community) as evidenced by a number of stumps for timber, firewood, agricultural utensils; damaged seeds and seedlings due to grazing of the species in the forests.

Community two (*Hagenia abyssinica* - *Ekebergia capensis* community type): in this community type *Hagenia abyssinica*, *Ekebergia capensis*, *Hypericum revolutum*, *Erica arborea*, *Myrsine africana*, *Helichrysum splendidum*, *Olinia rochetiana*, *Pittosporum viridiflorum*, *Croton macrostachyus* were the dominant species. This community was exclusively found in Yegana remnant forest with 93 species from 19 quadrats placed at an altitudinal range of 2340 – 2701 m. a.s.l. *Asparagus africanus*, *Clematis hirsuta* and *Solanum benderianum* were found to be the dominant liana species in this community, which were very rare in the other two community types of the study area. Quadrats of this community were found somewhat far from settlements of the boundary *Kebeles*. The quadrats had high canopy covered by trees and lianas, which hindered the natural germination of higher tree seeds. In addition to this, fewer indicators of grazing were observed but a lot of cut tree stumps were recorded for timber, agricultural utensils and charcoal extractions. This community was the least in species richness and Shannon diversity (3.8) but the second in quadrat numbers distributed over the lower to medium altitudinal range pertinent to the study area. This community had a very dense shrub layer, abundant trees and less coverage of herbs when compared with the other communities. Some of the ground species community includes *Poa simensis*, *Anchusa affinis* and *Pennisetum villosum*. This Community was surrounded by steeper slopes with an average of 52% and bare rocky areas, thus little disturbance by cattle and deliberate selective cutting of trees was encountered. Such disturbance and canopy cover affect species composition and diversity by affecting certain species and size classes and by changing the light environment of the understory tropical rain forests (Slik, 2004; Engelbrecht *et al.*, 2007). This community contained medicinal plants including species with the higher indicator value species like *Hagenia abyssinica*, *Ekebergia capensis*, *Asparagus africanus*, *Clematis hirsuta* and others.

Community three (*Podocarpus falcatus* - *Galiniera saxifraga*) was represented by 95 species from 18 quadrats placed at an altitude range of 2635 – 3256 m. a.s.l exclusively from *Gajilo* remnant natural forest patch. This community was with the least number of quadrats and the

second in species abundance distributed over the Dry Afromontane to Afroalpine vegetation type. There were no overlapping quadrats with community type two, indicating that there were differences in altitudinal gradients, slope, aspect, habitat disturbance and anthropogenic disturbance. *Podocarpus falcatus*, *Galiniera saxifraga*, *Nuxia congesta*, *Olea capensis* subsp. *macrocarpa*, *Bersama abyssinica*, *Polyscias fulva*, *Rhus natalensis* were the dominant tree species in the community. Whereas *Maytenus gracilipes* subsp. *arguta*, *Maytenus obscura*, *Dombeya torrida*, *Debregeasia saeneb*, *Discopodium penninervium*, *Pennisetum villosum*, and *Buddleja polystachya* were the dominant shrub species in this community. Community type three includes the most degraded area in *Gajilo* forest and free grazing was extremely persisting. Scattered and few trees with open grazed fields with rare seedlings, saplings, and medium distribution of shrubs and larger herbaceous species cover were recorded. As per the field observation, it was evident that community type three was found heavily affected by the local people who were involved in clearing forest species for farm implements, fuel wood, fence, construction and selective cutting for timber production. The main reason for this was forest resource competition among the surrounding different districts. The community was surrounded by *Kechene* river from the South Welo zone to the west, *Geshe Rabel* District to the North and *Antsokiya Gemza* District to the Northeast. Thus, anthropogenic disturbances could be attributed to the low woody species diversity, low seedling, and sapling density as well as low overall tree plant abundance. The herbaceous layer of this community type was invaded by *Impatiens rothii*, *Pteris cretica*, *Hypoestes forskalii* and *Zehneria scabra*. The same reports were mentioned for almost similar agro-ecological zone of the *Wof-Washa* forest by Abiyoh Tilahun (2018) and the *Dense* forest by Ermias Lulekal (2014). This indicates that the central highland forests of Ethiopia are under high pressure of anthropogenic disturbances.

### **5.1.1.3 Species diversity, Richness and Evenness of *Menz Gera* Forests**

The Shannon diversity index of the communities in this study ranges from 3.84 to 4.10 with the average being 3.92, which shows high diversity in the study forest. The values of the Shannon diversity index usually fall between 1.5 and 3.5 and only rarely exceed 4.5 (Kent, 2012). The current index is higher than those calculated for other Ethiopian mountain forests such as *Chilimo* ( $H'=2.72$ ) (Tadesse Woldemariam *et al.*, 2000), *Zegie* ( $H'=3.72$ ) (Alemnew Alelign *et al.*, 2007), *Abebaye* ( $H'=1.31$ ) and *Tara Gedam* ( $H'=2.98$ ) (Haileab Zegeye *et al.*, 2011) forests. Whereas it was less than of the nearby natural mountain forests such as *Wof Washa* ( $H'=4.09$ ) (Abiyoh Tilahun, 2018) and *Dense* ( $H'=4.07$ ) (Ermias Lulekal, 2014).

The three plant communities showed a variation in their species richness, diversity and evenness. Relatively, community type 1 was the richest with respect to species richness and diversity while community types 2 and 3 had almost the same species richness and diversity. The differences in species richness among the three communities showed the dissimilarities of the communities in terms of location, altitude, human impact, rainfall, and other biotic and abiotic factors.

The results of Shannon evenness index (J) of the plant communities ranges from 0.84 to 0.87 with the average being showed 0.85. The results also evidenced better overall species evenness (J=0.85) in *Menz Gera* forests than in Chilimo (J=0.68) (Tadesse Woldemariam *et al.*, 2000), Tara Gedam (J=0.65) and Abebaye, (J=0.31) (Haileab Zegeye *et al.*, 2011), Dense (J=0.80) (Ermias Lulekal, 2014) indicating relatively much equitable distribution of individuals among various species in the study area. This indicates a slight difference in evenness among the identified plant communities. Species evenness shows the relative abundance of a species in quadrats. Low evenness value implies the dominance of the environment by few species. Based on this, almost all of the communities in this study area have high evenness value and this reflects the repeated coexistence of species overall quadrats but with little dominance by any single species in these communities (Kent, 2012). This indicates the forest patches have heterogeneous species composition which leads to species diversity and consequently will be a good source of seeds for the managing degraded areas of the district.

## **5.1.2 Vegetation Structure**

### **5.1.2.1 Density of trees and shrubs**

The total density of mature woody species with DBH > 2.00 cm and height >3 m in *Menz Gera* forest was 1,113 individuals ha<sup>-1</sup>. Almost 60% of woody individuals were found in density class E (1.01 – 10) (32 (44.44%) species) and D (10.01 – 20) (11 (15.28%) species) as a first and second respectively. Whereas the least proportion of woody individuals were recorded in density class F (≤1.00) (3 (4.17%) species). *Erica arborea* and *Myrsine africana* were found as the most abundant species, with 453 (20%) and 429 (19%) individuals ha<sup>-1</sup>, respectively followed by *Hypericum revolutum*, *Osyris quadripartita* and *Dodonea angustifolia* with 134 (6%), 80 (4%) and 78 (3%) individuals ha<sup>-1</sup>, respectively.

Five shrubby species were found to cover more than half of the total density of the woody species in the study area, showing that the study area was dominated by small-sized woody species. In general, it was found that most of the woody species included in the higher and lower density classes (A and F) are represented by a small number of individuals contributing relatively smaller

amounts to the total density of the woody species. Intermediate density classes (B, C, D and E) contained many species and contributing a large percentage to the total density. Few numbers of species contribute more to the total density of the forest. This indicates that even if the forest patches are rich in species diversity, they are not fairly distributed throughout the forest patches. Therefore, through time this forest may be over dominated by the species with high-density abundance like *Erica arborea*, *Myrsine africana*, *Hypericum revolutum*, *Osyris quadripartita* and *Dodonea angustifolia*, which are shrubby in their growth nature. The difference in density could be attributed to the variations and influence of altitude, habitat preferences of species and the degree of anthropogenic disturbances in the forest (Whittaker *et al.*, 2003). The density of mature woody species in *Menz Gera* forests was lower than *Dense* (1138 individuals ha<sup>-1</sup>) (Ermias Lulekal, 2014); and *Dindin* (1750 individuals ha<sup>-1</sup>) (Simon Shibru and Girma Balcha, 2004). However, the *Menz Gera* forests showed higher woody species density (1,112 individuals ha<sup>-1</sup>) when compared to some other Afromontane forests such as *Adelle* (898 individuals ha<sup>-1</sup>) and *Boditi* (498 individuals ha<sup>-1</sup>) (Haile Yineger *et al.*, 2008a).

#### **5.1.2.2 Species population structure (DBH & Height) class distribution**

Population structure dictates the general trends of population dynamics and the recruitment process of each species. Based on the diameter at breast height and height class distribution, tree species recorded from *Menz Gera* forests reveals variation in patterns of population structures. The pattern of DBH and height class distributions indicates the general trends of population dynamics and recruitment processes of species in each forest (Silvertown, 1982). The results on DBH class and height distribution of trees and shrubs across the ten and six classes respectively in *Menz Gera* forests indicate an inverted J-shaped distribution. This is a general pattern of normal population structure where most of the species had the highest number of individuals at lower classes with a gradual decrease towards the higher classes.

Most tree and shrub species (69.63% of the total individual species) were found in DBH classes < 30 cm while a very small proportion (5.18%) attain diameters greater than 70 cm. This shows most species had the highest individuals in the lower DBH classes with a gradual decrease towards the higher DBH classes. This result distributional trend agrees with that of *Dense* forest (44.58 % of individuals in < 20 cm DBH) (Ermias Lulekal, 2014) and *Wof Washa* forest (70.56% of individuals in < 20 cm DBH) (Abiyou Tilahun, 2018). Large DBH size was scored by *Podocarpus falcatus* (382 cm), *Juniperus procera* (143 cm), *Ekebergia capensis* (98 cm), *Olea europaea* subsp. *cuspidata* (98 cm) and *Hagenia abyssinica* (90 cm) which implies that few large

sized remnant of these species have large area coverage in the study forest. In this study, the ratio of DBH 2 – 10 cm to DBH 10.1 – 20 cm (2:1) and the ratio of DBH 10.1 – 20 cm to >20 cm (1:1.4) indicates the predominance of small-sized individuals followed by the large-sized individuals whereas the medium-sized individuals were less abundant relative to the small-sized and large-sized ones. This indicates there were selective cuttings for different purposes mainly for agricultural utensils, firewood and house and fence constructions.

Population structures also help to understand population dynamics or patterns in the forests and identify the regeneration status of specific species. In this study, four population structure patterns were recorded. The first pattern was inverted J-shape represented by *Juniperus procera*, which shows a pattern where species frequency distribution has the highest frequency in the lower diameter classes and a gradual decrease towards the higher classes. *Pittosporum viridiflorum*, *Galiniera saxifraga* showed this pattern. Such a population pattern is an indication of a stable population structure and good regeneration status (Getachew Tesfaye *et al.*, 2010). The second pattern was skewed bell-shaped, where some DBH classes had a small number of individuals while other DBH classes had many individuals represented by *Hagenia abyssinica* (Figure 10 b). Species that showed such patterns were *Podocarpus falcatus*, *Celtis africana* and *Croton macrostachyus*. The third type is also a skewed bell-shaped pattern, indicating a frequency distribution in which the number of individuals in the middle diameter classes gets lower in the smaller and larger diameter classes which were represented by *Myrica salicifolia*. *Ekebergia capensis* and *Olinia rochetiana* showed this type of population distribution. The fourth pattern was a J-shaped, represented by *Olea europaea* subsp. *cuspidata* and *Allophylus abyssinicus*. This pattern represents abnormal population dynamics and showed poor reproduction and hampered regeneration because either most trees were not producing seeds due to age or there were losses due to herbivores after reproduction, it may also be due to immediate grazing after germination. Feyera Senbeta and Demel Teketay (2001), Haile Yineger *et al.* (2008a) and Ermias Lulekal (2014) reported similar findings at different Afromontane forests of Ethiopia.

The species distribution of height class showed similar trends with the species distribution in DBH classes. The inverted J-shaped distribution pattern that contains (62.45%) of individuals was recorded in the lowest height class (3-15 m). This indicates selective cutting in the medium and larger size individuals, which was related to human-induced pressures, and leads to such structural dynamics of species in the forest. This kind of pattern was reported for *Wof-Washa*, *Chilimo* and *Menagesha Suba* Forests (Tamrat Bekele, 1993); *Dense* Forest (Ermias Lulekal,

2014) and updated studies of *Wof Washa* Forest (Abiyou Tilahun, 2018). The tallest height of trees in the study area was recorded for *Podocarpus falcatus* (59 m), *Juniperus procera* (56 m), *Bersama abyssinica* (55 m), *Hagenia abyssinica* (55 m) and *Ekebergia capensis* (50 m).

The presence of more trees and shrubs density in small-sized DBH and height than large-sized DBH and height classes has been considered a characteristic of secondary forests. A similar distribution of individuals in the DBH and height classes were recorded in *Menz Gera* forest patches and such population structure could be considered an indicator for aged/seasoned forest. The decline in the number of individuals in each DBH and height class towards the highest classes indicates the dominance of small-sized individuals in the forest especially the shrubs. Both in height and DBH class distribution, presence of few small sized tree and many shrub species is attributable to abundant presence species such as *Erica arborea*, *Dodonea angustifolia*, *Berberis holstii*, *Discopodium penninervium*, *Myrsine africana*, *Hypericum revolutum*, *Rosa abyssinica*, *Clusia abyssinica*, *Maytenus obscura*, *Olinia rochetiana*, *Hypericum revolutum*, *Buddleja polystachya* and *Maesa lanceolata*. A similar result was also reported for *Denkoro* (Abate Ayalew *et al.*, 2006), *Wof Washa* (Gebremicael Fisaha *et al.*, 2013).

### 5.1.2.3 Basal area (BA)

The results of this study showed that the basal area of the *Menz Gera* forest patches is very high ( $57.56 \text{ m}^2 \text{ ha}^{-1}$ ) when compared to the normal basal area value for virgin tropical forests in Africa which is  $23\text{-}37 \text{ m}^2 \text{ ha}^{-1}$  (Lamprecht, 1989). The plant species in the natural forest patches occupy large surface areas even if much of the area coverage was dominated by few large-sized tree species. *Hagenia abyssinica*, *Juniperus procera*, *Podocarpus falcatus*, *Galiniera saxifraga*, *Olea europaea* subsp. *cuspidata*, *Ekebergia capensis*, *Nuxia congesta* and *Olinia rochetiana* covered 65.53% of the total basal area of the forests. The basal area provides a better measure of the relative importance of species than simple stem count (Cain and Castro, 1959). Thus, species with the largest contribution in basal area can be considered the most important woody species in the study area. Accordingly, the above eight species are the most important species in the study areas (Lamprecht, 1989).

According to Feyera Senbeta (2006), a higher basal area of the Afromontane rain forests in Ethiopia compared to those reported for tropical forests is due to a high density of individuals in the forests studied. Comparison of the basal area of the *Menz Gera* Forest with other Afromontane forests in Ethiopia showed that it is higher than *Chilimo* ( $30.1 \text{ m}^2 \text{ ha}^{-1}$ ), *Menagesha* ( $36.1 \text{ m}^2 \text{ ha}^{-1}$ ) and *Jibat* ( $49.8 \text{ m}^2 \text{ ha}^{-1}$ ) (Tamrat Bekele, 1993), *Denkoro* ( $45 \text{ m}^2 \text{ ha}^{-1}$ ) (Abate Ayalew

*et al.*, 2006), and *Komto* (50.72 m<sup>2</sup>ha<sup>-1</sup>) (Fekadu Gurmessa *et al.*, 2013). However, the recorded basal area was lower than that of *Dodola* (129 m<sup>2</sup>ha<sup>-1</sup>) (Kitessa Hundera *et al.*, 2007), *Dense* (66.5 m<sup>2</sup>ha<sup>-1</sup>) (Ermias Lulekal, 2014) and *Wof Washa* (153.26 m<sup>2</sup>ha<sup>-1</sup>) (Abiyou Tilahun, 2018). This may be due to variations in the conservation of the forests, exposure to deforestation and geographical location of the forests.

#### **5.1.2.4 Frequency of Woody species**

Frequency gives an approximate indication of the homogeneity and heterogeneity of a stand under consideration (Kent, 2012). In this study, 42 of the 72 woody species (58.33%) were found in lower frequency that was less than 10% of the total quadrats and hence they were less frequent. In this study, species with high-frequency values mean found in more than 50% of the quadrats. Accordingly, only three (4%) of the woody species were found in more than 50% of the quadrats but 69 (96%) of the woody species were recorded in less than 50% of the quadrats, which shows high degree existence of floristic heterogeneity in the study forests. *Erica arborea* and *Myrsine africana* were found the most frequent species in the forests occurring in 55.56% of the sampled quadrats followed by *Ekebergia capensis* (50%), *Juniperus procera* (45.83%), *Olea europaea* subsp. *cuspidata* (40.28%), *Osyris quadripartita* (37.50%), *Podocarpus falcatus* (34.72%), *Hagenia abyssinica* (31.94%) and *Olinia rochetiana* (31.94%). According to Rey *et al.* (2000), the occurrence of most frequent species in a natural forest patch could be attributed to the usual occurrence of plant species at the wide range of altitude, seed dispersal capacity, germination vigor, resistant to pests and pathogens, habitat preferences, adaptation, the degree of exploitation and availability of suitable environmental conditions for regeneration.

#### **5.1.2.5 Importance Value Index (IVI)**

Important value index is a good index for summarizing vegetation characteristics and ranking species for management and conservation practices. The importance value index of tree species in the study area ranged from 0.85 to 74.42.

Considering the IVI value of species of the entire study area, the most ecologically important woody species based on their higher IVI values were *Juniperus procera*, *Hagenia abyssinica*, *Ekebergia capensis*, *Podocarpus falcatus* and *Olinia rochetiana* comprising of 56.47% of the total IVI. On the other hand *Rhus natalensis*, *Celtis africana*, *Rhus quartiniana*, *Rhus glutinosa* subsp. *neoglutinosa* and *Euphorbia ampliphylla* were the list dominant tree species in the study area, accounting only for 1.07% of the IVI of tree species in the forests. The high important value

index of the three species *Juniperus procera*, *Hagenia abyssinica* and *Ekebergia capensis* contributed 39.34% was due to their abundance, high basal area and density in the forests.

Moreover, important value index of woody species showed that a very few species dominated the study forest patches. These woody species contributed the highest proportion of all species recorded. The dominance of these species may be attributed to their success in regeneration, least preferred by browsing, pathogen resistance and better seed dispersal mechanism. High density and high frequency coupled with high basal area indicates the overall dominance of a species in a vegetation (Lamprecht, 1989)

### 5.1.3 Natural Regeneration Status of Tree Species of *Menz Gera* Forests

Densities of age classes (seedlings, saplings and adult plants) of forest species are indications of present and future status of regeneration of species and they provide evidence or basic information for conservation priorities of forest species. When the forest has a high number of seedlings but most of them do not attain the next age classes, there could be disturbances in the form of trampling which selectively removes juvenile and mature stages (Demel Teketay, 1997; Demel Teketay, 2005).

In this study, the total densities of seedling, sapling and adult trees were 2,722 ha<sup>-1</sup>, 390 ha<sup>-1</sup> and 458 ha<sup>-1</sup> respectively derived from 26 tree species. Out of the 26 tree species, 13 were not represented in the seedling stage and 11 were not represented in the sapling stage. Five species contributed 79.85% and 80.91% of the total seedling and sapling count respectively. Those are *Erythrina brucei*, *Galiniera saxifraga*, *Myrica salicifolia*, *Ficus sur* and *Croton macrostachyus*. According to Feyera Senbeta and Demel Teketay (2001) and Shankar (2001) regeneration statuses of the study forest patches were evaluated based on the following five regeneration categories.

The first distribution category of regeneration status showed good regeneration and recruitment potential if the presence of seedling > sapling > mature strata. The presence of good regeneration potential confirms the stability of the species to the environment. Higher seedling stage density values get reduced at sapling stage density due to biotic disturbances and competition for space and nutrients (Dhaukhandi *et al.*, 2008). This regeneration status pattern also indicates the possibility of replacement of mature plants in the future and hence shows relatively better regeneration status. This pattern was exhibited by *Erythrina brucei*, *Myrica salicifolia*, *Ficus sur*, *Croton macrostachyus*, *Rhus quartiniana*, *Rhus natalensis* and *Pittosporum viridiflorum*.

The second category of regeneration represents fair regeneration and recruitment of the species if the presence of seedling > sapling < mature strata. At this category, saplings are suffering anthropogenic factors especially by selective cutting before reaching to the mature seed-bearing stage. This pattern was exhibited by *Galiniera saxifraga*, *Buddleja polystachya*, *Juniperus procera*, *Ekebergia capensi*, *Podocarpus falcatus* and *Euphorbia abyssinica*. The third distribution pattern of regeneration status shows the survival of sapling stage only, but not as seedlings (even though saplings may be less than, more than, or equal to mature ones) (poor). This exhibited poor regeneration pattern probably due to poor stocking, adverse conditions in the forest, continuous and selective cutting and human disturbance in the form of livestock grazing, seed predators and trampling (Demel Teketay, 2005). This category was represented by *Hagenia abyssinica*, *Allophylus abyssinicus* and *Olea capensis* subsp. *macrocarpa*. In this type of regeneration category prevention of livestock grazing and overexploitation could improve the regeneration status of tree species. Species in the fourth category of regeneration status are those that are not regenerating (none) since they survive only at adult or mature tree level (Dhaulkhandi *et al.*, 2008). Thus, this situation calls for conservation and management action to sustain their life by giving them time to rejuvenate themselves from seed deposited in the soil. Even though, species like *Olinia rochetiana*, *Olea europaea* subsp. *cuspidata*, *Bersama abyssinica*, *Prunus africana*, *Nuxia congesta*, *Canthium lactescens*, *Polyscias fulva*, *Celtis africana*, *Euphorbia ampliphylla* and *Rhus glutinosa* Subsp *neoglutinosa* exhibit this pattern of regeneration, it is difficult to conclude that these species were not regenerating. Since they were recorded at their mature stage during this study data collection times and their regeneration time may not be matched with the study data collection times at their seedling and/or sapling stage due to missing of representation of sapling and seedling in the sampled quadrats and seasons of data collection times.

## **5.1.4 Ethnobotanical Study of Medicinal Plants**

### **5.1.4.1 Medicinal plants for human and livestock ailments**

#### **5.1.4.2 Informant background information**

The average number of medicinal plants reported by different age groups compared in this investigation showed that indigenous knowledge on the use of medicinal plants is strong with the elderly (>34 years of age, 69%) than in the younger (aged 18-34, 31%) generation. The result shows the gap between the respondents' age classes, a decline in the indigenous knowledge of medicinal plants towards the young generation. This could be due to the impact of modernization like urbanization, the start of formal education, the very poor system of documentation and

sharing of indigenous knowledge on medicinal plants, which is mainly by word of mouth, with extreme secrecy and mostly along family lines to the younger generation. The same findings were reported from different corners of Ethiopia (Ermias Lulekal *et al.*, 2008a; Haile Yineger *et al.*, 2008b; Mirutse Giday *et al.*, 2009; Ermias Lulekal *et al.*, 2013). This finding calls for strong intervention to document the traditional medicinal plants and associated indigenous knowledge of the local community for continuous indigenous knowledge transfer across the age classes and conservation of such plants. The interventions should be in community awareness raising through training, seminars and by incorporating in the school curriculum to add value starting from the grass root of the community. Such intervention scans fill the generation gap in preserving its traditional health knowledge and associated natural resources through systematic documentation.

The respondents' profile, showing literate (28%) and illiterate (72%) informants, could correlate to the impact of age-old experience in the absence of formal education, and modern health centers in the study area. The knowledge and experience of the key (13%) and general informants (87%) have also generated a difference. This is due to the maximum degree of secrecy and a high level of exposure with plants, which is extremely high in key informants than in the general informants in the community of the study area. Ermias Lulekal *et al.* (2013) and Mirutse Giday *et al.* (2009) have also reported similar results.

Male informants (67%) were by far more than women (33%) informants in this study. The result indicated that men informants are more knowledgeable on the use of traditional plant remedies than women informants and this could relate to the traditional flow of information along the male line in the community. Unlike this report, Ermias Lulekal *et al.* (2013) reported men and women informants were almost the same proportion in Ankober District, central Ethiopia. This difference tells us the knowledge of traditional medicinal plants in *Menz Gera* District flows on the male lines; this may be the association of indigenous knowledge with orthodox churches and associated religious books, which could be accessed by priests in the local community. According to Voeks (2007) gender-based differences in medicinal plant knowledge can be derived from experience and degree of cultural contact with therapeutic plants. In addition to this, those communities which reside far from health centers were more knowledgeable in medicinal plants than those which reside near and/in towns that can relatively easily access health centers. Because more of the urban and peri-urban communities are educated, they have less exposure to plants and consist of relatively globalized communities, as a result, they are less

dependent on traditional medicinal plants. They they use modern drugs since they have better access than the village community.

#### **5.1.4.3 Diversity of medicinal plants used to treat human and livestock ailments**

The people in *Menz Gera* District have a rich tradition of using diverse medicinal plant species in their herbal medical system as shown by their report of 156 species belonging to 136 genera and 67 families for human and livestock ailments. From the reported medicinal plants, 122 were used for human ailments only and 2 for livestock ailment only. Whereas, 32 species were used for both human and livestock ailments. This showed that a considerable number of traditional medicinal plants were used to treat human and livestock health problems in the study districts. It also shows that traditional medicinal plants and the local community holding traditional health knowledge play a major role in assisting the primary human and livestock healthcare needs of the district. The number of medicinal plants collected from the district was higher than that of other areas in the country investigated for their ethnomedicinal reports (Haile Yineger *et al.*, 2008a; Mirutse Giday *et al.*, 2010; Ermias Lulekal *et al.*, 2013) who reported 101, 124 and 135 species respectively. According to Ermias Lulekal *et al.* (2013), the ease of accessibility, economic, cultural acceptance and efficacy related aspects might have played key roles for the people to rely on traditional medicine. However, as informants stated, more medicinal plants were used in the past than today because of the loss of knowledgeable elders through death and without sharing their knowledge and through naturally induced and anthropogenic causes of deforestation which resulted in the loss of medicinal plants and associated indigenous knowledge in the study area.

In the local ethnoveterinary healing system, 34 plant species were used to treat 16 ailments of cattle, goats, sheep, donkeys, horses and mules in *Menz Gera* district. Less number of livestock medicinal plants were reported in this study than in other reports such as from Ankober district (51 species) by Ermias Lulekal *et al.* (2014) and Yared Yigezu *et al.* (2014). The latter report is for four districts of Jima Zone (74 species) and not one as in this case and of the first cited report. The current report is higher than that of Azam *et al.* (2012) from that reported from Pakistan (19 species). Most of the ethnoveterinary plant species documented from *Menz Gera* District were used to treat ailments of cattle, goats and sheep. This clearly showed that the local people of the study area are highly concerned about the health of these livestock groups because their livelihoods are directly or indirectly dependent on them. The community life in the district gets a lot of products from livestock like meat, milk and milk products, leather making and for

vending for cash to buy crops, services of transportation, agricultural activities and other commodities.

The high usage of herbs (more than 55%) in the study area could be a result of their relative abundance as compared to trees and shrubs. Where the later have been exploited for different services and thus are rare. Herbaceous species are easily accessible in the nearby areas than trees and shrubs which are often harvested from patches of forests, agricultural land and home gardens (Gidey Yirga, 2012; Abraha Teklay *et al.*, 2013; Ermias Lulekal *et al.*, 2013; Birhane Mengiste *et al.*, 2014). Moreover, the patterns of growth could also contribute to the high frequency of herbaceous plant usage since herbs are the dominant plant growth forms in the flora area. This study agrees with similar studies conducted at different corners of Ethiopia with the general pattern of herbaceous species dominance (Mirutse Giday *et al.*, 2003; Haile Yineger *et al.*, 2007; Mirutse Giday *et al.*, 2009; Mirutse Giday *et al.*, 2010; and Ermias Lulekal *et al.*, 2013).

Six species, each of the Asteraceae, Lamiaceae, Solanaceae, Fabaceae, Apiaceae, Poaceae and Euphorbiaceae were used as herbal medicine in the study area. The relatively high representation of species from these families could be attributed to their wider distribution and abundance in the flora area (Hedberg and Edwards, 1989; Hedberg *et al.*, 2006; Mesfin Tadesse, 2004). Other studies conducted elsewhere in the country (Mesfin Tadesse *et al.*, 2005, Mirutse Giday *et al.*, 2009 and Ermias Lulekal *et al.*, 2013) also revealed the highest contribution of these families to the Ethiopian medicinal flora.

Concerning the source of the medicinal plant species, wild environments yielded more medicinal plant species than home-gardens, farmlands and grazing areas. Thus, the greater proportion of the traditional medicinal plants used in the study area were found from the natural forest patches. The results of this study concur with other studies conducted within Ethiopia (Ermias Lulekal *et al.*, 2008; Gidey Yirga *et al.*, 2012; Ermias Lulekal *et al.*, 2013 and Moa Megersa *et al.*, 2013). The communities of *Menz Gera* District were highly dependent on the remnant natural forest patches as source of medicinal plants. Forests are the most precious gifts that, nature has provided to us, meeting all kinds of essential requirements of human beings in the form of medicine, food, fodder, fuel, construction materials, etc. In this study, the main sources of traditional medicinal plants for human and livestock use were the remnant natural forest patches, which accounted for 54% of species of the total medicinal plant species. The greater proportion (47%) of the traditional medicinal plants used in the study area were found from the natural forest patches especially within *Gajilo* natural forest patch. However, the investigation of this research showed

that these remnant natural forest patches are subjected to anthropogenic and natural pressures and consequently shrinking in size due to rapidly increasing population growth in the area resulting in the loss of many medicinal and other plant species sheltering in the forest patches.

As per the key informants of this research, the time required in collecting plant species for medicinal use varies from plant species to plant species as well as from place to place. Consequently, the key informants of the study districts spent plenty of time currently to collect some medicinal plant species for medicinal use than a few years ago due to their limited abundance and difficult to access them because of distance. This indicated that the medicinal plant species are at risk at least in the study district thus need conservation attention. Results show that the main species that need conservation priority are *Inula confertiflora*, *Kalanchoe marmorata*, *Satureja abyssinica* and *Leonotis ocymifolia* because informants reported that they have become rare. Other studies (Mirutse Giday *et al.*, 2010 and Ngarivhume *et al.*, 2015) also confirmed that the time needed to collect medicinal plants varies across species and from area to area which is very important for sustainable management of traditional medicinal plants. According to Zemedu Asfaw (2006), the people of Ethiopia are knowledgeable about the name and classification of their environment, plants in their surroundings and their value for the local people, which they have gained orally from generation to generation which helps for conservation. Accordingly, the knowledge of local people on plants is developed over time involvement, reflection and discussion that affect their beliefs and attitudes towards forest management practices (Cotton, 1996).

#### **5.1.4.4 Human and livestock disease types treated and treatment methods**

Results showed that traditional practitioners of the study area use herbal medicine to treated 87 human and 16 livestock ailments. Traditional healers were visited by many patients which indicating a long-lasting culture of local people in the study area visiting traditional healers. Most probably, the local people's preferences of traditional healthcare practitioners services might relate to economic, cultural acceptance, efficacy and accessibility factors. Visual and hand touching inspection of patients was the most obvious diagnostic method practiced by all local healers in the study area. Changes in body temperature, skin and eye color, appetite and physical appearance helped traditional healers to detect which patients face disorders and what type. Similar findings were reported by Ermias Lulekal *et al.* (2008b); Haile Yineger *et al.* (2007); Fisseha Mesfin *et al.* (2009) and Ermias Lulekal *et al.* (2013) for different communities of Ethiopia. There were no consistent diagnostic methods among the traditional healers in the study

area. Such lack of consistency can lead to misidentification of diseases, which, in turn, may lead to mis-prescription ending in adverse side effects on patients. Overdose of remedies was also reported to bring adverse effects like vomiting, diarrhea, burning sensations and sometimes fainting, as also reported by Ermias Lulekal *et al.* (2013). The findings revealed that the same types of medicinal remedies for the same types of ailments were given with different measurements in the study districts. This indicates the lack of uniformity in the treatment of diseases in the traditional healthcare system.

#### **5.1.4.5 Plant parts used**

Plant parts such as leaves, roots, seeds, fruits, latex, bark, bulb, shoot, flower, resin, stem wood alone or by mixing with others and optional leaves or roots, leaves or seeds and leaves or fruits were used to treat human and livestock health problems in the study districts. Leaves (32.05%) were the most used parts to treat both human and livestock ailments. Many studies conducted elsewhere in Ethiopia also showed the dominance of leaves in the preparation of remedies (Mirutse Giday *et al.*, 2009; Gidey Yirga *et al.*, 2012 and Abraha Teklay *et al.*, 2013). This practice helps to reduce the rate of threat on plant species or helps in sustainable harvesting of plants as compared with utilization of the roots, stems or whole part. From this evidence, the leaf is a very important part of plants in terms of the medicinal value of the local people because of relative ease to find and to collect this plant part as compared to other plant parts. This report concurs with that of other reports conducted in Ethiopia e.g., (Mirutse Giday *et al.*, 2009 and Ermias Lulekal *et al.*, 2013).

Root parts (30.77%) were the second choice in human medicinal plant preparations. The popularity of roots might be due to easiness for use, as they were mainly chewed, squeezed for their liquids or put on fire to inhale the smoke produced. Roots can be also dried and powdered or homogenized in with water for use. The common use of root parts in the community could seriously affect the survival of individual plants if special care is not given during the harvest. Some traditional practices that require only limited amount of the root of a certain plant removed at a time and the covering, the damaged part with soil allows the species to survive even if it is a rare practice rather; many collect the whole root for the purpose of storing it for their later use. Such extensive root mining of the plant can be devastating and can lead to a threat of the species survival or extinction (Ermias Lulekal *et al.*, 2013 and Moravec *et al.*, 2014).

The informants in the districts agreed that the medicinal plants were harvested with no specific preference to any maturity level. Most of the key informants (70%) responded that they had no

special seasonal preference in collecting and using of herbal medicine rather they simply consider their availability and demand of their customers or their families. Nevertheless, according to Singh (2008) some plants were better to harvest after parts were at their full maturity or at their young stage. On the other side, harvesting depends on the best possible quality of the plant part to be used (Sharma *et al.*, 2013) which shows that seasonal variations affect the physico-chemical composition and amount in the medicinal plant species. Therefore, such harvesting method with no preference any season or maturity level of plants may reduce the efficacy of herbal medicine. The season has an impact on the availability of active principles in medicinal plants (Singh, 2008).

#### **5.1.4.6 Modes of remedy preparation**

The result showed that most remedies were prepared from dry plant parts (55%) only. Some remedies were prepared from fresh materials (39%) only and other remedies were prepared from either dried or fresh materials (6%). The frequent use of dried collected medicinal plants could be attributed to the wide experience of attaining long time storage for later use than fresh remedies preparations, which is difficult to access during the dry season. Unlike this report, other studies conducted within and outside Ethiopia indicated the wider use of fresh materials (Bussmann and Sharon, 2006; Mirutse Giday *et al.*, 2010 and Ermias Lulekal *et al.*, 2013). This difference may have happened due to the habit of the traditional medicine practitioners and lack of accessibility for fresh collection at their interest in quality and quantity because of frequent drought and fast deforestations in the study area. The mode of traditional medicinal plant preparation and application for livestock ailment remedy were smaller than used for humans since the plant species collected for humans are by far more in number (154) than collected for livestock (34) ailment treatment.

#### **5.1.4.7 Routes of administration**

Administration of traditional medicinal plant remedies was practiced in the district in various ways such as drinking, bandaging, chewing, rubbing, spraying, brushing and externally tying the remedy. For human ailments grinding and tying the crushed part on the affected part; crushing, homogenizing in cold water and then drinking and decoction were the most modes of remedy preparation in the study area. This clearly indicates that the local traditional medicinal plant practitioners have been administering traditional herbal medicines in different ways to patients based on the type of ailment and part of the body to be treated. Considerable preparations were made from a mixture of different plant species mixed in water, which is the most popular solvent.

The same reports were reported by Mirutse Giday *et al.* (2010) and Ermias Lulekal *et al.* (2014). Oral (46%) and dermal (28.68%) route of administration were the most commonly used in the study area, which is also a frequent phenomenon elsewhere in Ethiopia (Mirutse Giday *et al.*, 2009; Abraha Teklay *et al.*, 2013 and Ermias Lulekal *et al.*, 2013). Most of the traditional medicines (48.94%) prepared for livestock from plants were applied orally followed by external tying (25.24%) in the districts.

Most of the remedies for human and livestock remedies were taken orally; this could be attributed to the high prevalence of gastrointestinal and parasitic diseases followed by the dermal route of administration which is applied externally on the affected part. The frequent application of medicinal plants topically on the skin could also be related to the fact that there is relatively less risk of being poisoned when medicinal plant preparations are applied on the skin than taking them through the other routes of administration. The results of this study agreed with similar studies undertaken elsewhere (Mirutse Giday *et al.*, 2010; Tantiado, 2012; Gidey Yirga, 2012; Ermias Lulekal *et al.*, 2013 and Ermias Lulekal *et al.*, 2014).

#### **5.1.4.8 Dosages and antidotes**

Traditional medicine practitioners of the *Menz Gera* district used different materials to measure the amount of administered herbal medicine. However, some of the herbal medicine practitioners simply use estimation to administer remedies for their patients. Even if they did not have a proper and consistent dosage, they administered some herbal medicines using different devices and methods to measure the amounts such as coffee cups, local alcohol cup or “*Yeareke melekyä*”, the palm of a hand, spoon, counting plant parts, finger size, glass, teacup and drops both for the treatment of human ailments. Whereas precision is even less in dosage administration of livestock ailments, they simply use counting plant parts, painting the part, glass and tying on the affected part. Inaccurate use of herbal medicine can lead to serious health problems of patients (Kitula, 2007). The traditional medicine users frequently noted lack of the accuracy of doses among informants of the communities on certain remedies. The variation in quantity, unit of measurement, the concentration of remedies and duration of treatment of prescribed plant preparations were the main traditional medicine use problem, which is also a frequent phenomenon in the other cultures (Teshale Sori *et al.*, 2004; Mirutse Giday *et al.*, 2009; Abraha Teklay *et al.*, 2013). The most used antidotes in the study area were chicken meat, cooked hen liver, coffee, honey, butter, dissolved powder of roasted barley locally called “*Beso*” and yogurt.

Most of those antidotes were reported elsewhere in the country (Mirutse Giday *et al.*, 2010 and Ermias Lulekal *et al.*, 2013).

#### **5.1.4.9 Marketability of medicinal plants**

This finding indicated that there was no widely observed trade of medicinal plants in the markets available in the study area. From the medicinal plants, 13.5% sold in the market were mainly associated with other uses such as their use spices, stimulants, materials, smoke for its flavor, foods and tooth stick. Very few (19%) of the traditional medicinal plants have direct market demands for medicinal purposes in the study area. *Withania somnifera*, *Echinops kebericho* and *Hagenia abyssinica* were the only species sold or purchased for their sole traditional medicinal uses. The results of this study are in line with other studies made in Ethiopia (Miruts Gidey *et al.*, 2009, Mirutse Giday *et al.*, 2010, Abraha Teklay *et al.*, 2013 and Ermias Lulekal *et al.*, 2013)

The market values of these species were varying from market to market in the study area. The prices of those species were cheaper in small markets at the three *Kebeles* than the administrative town (*Mehal Meda*). For example; *Hagenia abyssinica* has been sold for 4 Birr for a *jug* at *Kebele* markets but 6 Birr at *Mehal Meda* town. This indicates the accessibility of those species were rare in the administrative town of the district than the *Kebele* markets. Such marketability of selected species could also indicate that the plants are under pressure since they were purposefully hunted. This finding can be used as a baseline for the sustainable management intervention of such medicinal plants because most of the medicinal plants sold were harvested for their flowers or roots which is a very serious problem for their survival and reproduction. Other reports also confirm that marketable medicinal plants were mainly sold for their non-medicinal uses but occasionally applied as a medicine when the need arise (Moa Megersa *et al.*, 2013) and Getu Alemayehu *et al.*, 2015).

#### **5.1.4.10 Healing potential of medicinal plants**

Some of the categories of diseases have high informant consensus factor (ICF) than other disease categories. High informant consensus value were observed for treating the human gastrointestinal disease category (78%) and fungal infection disease category (75%) of livestock ailments in the study area. Followed by oral, dental and pharyngeal diseases category and external injuries, abscess or bleeding diseases category respectively. Fungal skin disease category and abscess/external injuries disease category were the first and second reported livestock health problems in the study area. The result showed that only a few medicinal plant

species were used by a very high proportion of informants to treat the stated disease categories. The human ICF values for the 15 disease categories ranged between 0.36 to 0.78, whereas livestock ICF value for 8 disease categories ranged between 0.08 to 0.75. Since the values of ICF normally ranged between 0.00 at its lowest and 1.00 at its highest (Andrade-Cetto and Heinrich, 2011), current results implies there is a strong agreement among informants ( $\geq 50\%$ ) for 12 of the 15 human disease categories whereas, low agreements among informants ( $< 50\%$ ) for 5 of the 8 disease categories for livestock ailments. More than 75% of ICF value was obtained for gastrointestinal disease category and oral, dental and pharyngeal diseases category for human ailments and only fungal skin disease category for livestock ailments. The observed highest informant agreement coupled with high plant use citations for these ailment categories could also indicate the relatively high incidence of the ailments in the area. High ICF values were important in identifying plants of particular interest in the search for bioactive compounds (Heinrich *et al.*, 1998 and Ermias Lulekal, 2013).

Fidelity level (FL) of medicinal plants represents the relative healing potential of medicinal plants against given ailments. In the current study, the relative healing potential or fidelity level of most cited medicinal plants with relatively higher FL values for treating humans were *Zehneria scabra* (94.44%) against dermatological disease, *Croton macrostachyus* (93.33%) against gastrointestinal and parasitic and *Inula confertiflora* (90.91%) against viral infections. The fact that these medicinal plants had the highest FL values could be taken as an indication of their good healing potential at least in the study area. According to Trotter and Logen (1998), plants that are used again and again are more likely to be biologically active. Taking this in to consideration, different authors such as Haile Yineger, 2008b; Mirutse Giday *et al.*, 2009, 2010; Mersha Ashagre, 2011 and Ermias Lulekal *et al.*, 2013 included fidelity level values in their reports.

Plants with higher FL values may be prioritized for conservation, management and sustainable use after their bioactivities or phytochemical profiles are determined. In this study, medicinal plant species that scored higher FL value greater than 73% were selected for antimicrobial activity testing except *Zehneria scabra*, *Croton macrostachyus* and *Cucumis ficifolius*. Because the two species (*Zehneria scabra*, *Croton macrostachyus*) were earlier investigated for their antimicrobial activity (Ermias Lulekal *et al.*, 2013), whereas *Cucumis ficifolius* was not included in the present test since its sample was not in sufficient amount to run fruit extraction.

#### **5.1.4.11 Ranking of medicinal plants**

Results of direct matrix ranking exercise showed that *Hagenia abyssinica*, *Thymus schimperi* and *Olea europaea* subsp. *cuspidata* were medicinal plants with multiple uses and hence the most preferred medicinal plants by local people of the study area. This finding clearly indicates that such medicinal plants were excessively harvested for their multiple uses in the study area. Thus, sustainable uses of these highly used and top-ranked species are highly threatened, as the pressure on their consumption is intensified in the area. *Hagenia abyssinica*, and *Olea europaea* subsp. *cuspidata* were exploited for construction, agricultural tools, firewood, charcoal and medicine for their home consumption and for cash collection. *Thymus schimperi* was highly exploited for cash collection and home use purposes that has a good market for its use as a spice for different types of food and tea drinks that are believed to serve as medicine for diabetes and other illness. Direct matrix analysis was done in Ethiopia to identify the most used and threatened plant species by different authors (Ermias Lulekal *et al.*, 2008; Mirutse Giday *et al.*, 2010; Abraha Teklay *et al.*, 2013 and Ermias Lulekal *et al.*, 2013). Haile Yineger *et al.*, (2007) have also reported the same pattern of highest exploitation of multipurpose medicinal plants for uses other than their traditional medicinal importance in southeastern Ethiopia.

Preference ranking exercise helps to determine whether a particular medicinal plant is more preferred by the local people to treat a particular ailment or not. The most favored species to treat a particular disease reflects its high efficacy, at least in the local area of the people who use it. The results of the preference ranking of this study shows *Clematis simensis* was the most preferred species to treat eczema followed by *Olea europaea* subsp. *cuspidata* and *Allium sativum*. Whereas *Verbascum sinaiticum*, *Allium sativum* and *Salvia merjamie* were the most preferred species to treat the livestock diarrhea. Ethnobotanical investigation done elsewhere in central Ethiopia (Ermias Lulekal *et al.*, 2013) reported the use of *Olea europaea* subsp. *cuspidata* for treating human eczema and Ermias Lulekal *et al.* (2014) reported high use of *Embelia schimperi* and *Rubus steudnerii* for treating livestock diarrhea.

#### **5.1.5 Ways of Indigenous Knowledge Transfer in Menz Gera District**

It was revealed that many ailments are diagnosed and treated at the household or family level. If people do not solve their health problems at a household level, they could request the help of other people in their respective communities especially those known local traditional medicinal plant healers. The fact that most treatments are given at a household level simply by collecting medicinal plants from their environment, whereas, some serious health problems demand

specialized healers. The same reports were also reflected in the findings of other works (Mirutse Giday *et al.*, 2010; Abraha Teklay *et al.*, 2013)

It was widely demonstrated in the study area that the sources of indigenous medicinal knowledge were mainly parents and grandparents. Such knowledge has frequently been transferred to the eldest son and trusted family members. It was transferred orally from generation to generation and kept secret as it was shared only within the family circle. Other studies conducted elsewhere in Ethiopia also indicated similar results (Mirutse Giday *et al.*, 2009 and Ermias Lulekal *et al.*, 2013).

However, currently, there were problems in interest of the youth to learn indigenous knowledge from its families or/and parents and use it carefully and properly; rather they prefer modern education and healthcare centers. On the other hand, most of the key informants (89%) agreed that knowledge on the use of medicinal plants was mostly kept secret, its free exchange was taking place only within family members. Because they thought that their income and respect could lose if they reveal their knowledge to other people in the study area. A study conducted elsewhere in the country (Mirutse Giday *et al.*, 2003) revealed similar results.

#### **5.1.6 Antimicrobial Activity of Selected Traditional Medicinal Plants**

From the selected traditional medicinal plants, three (37.5%) of the eight ethanol extracts have been proven to show antimicrobial activity against all the selected microbial strains. However, all of the plant extracts tested inhibited the growth of one or more of the selected bacterial and fungal pathogens, indicating a broad spectrum of bioactive nature of selected plant species at least at the higher concentration (MIC 100mg/ml). This finding also confirms the importance of considering ethnomedicinal background knowledge of the local community to run antimicrobial activity tests. Similar investigations on antimicrobial activity tests based on ethnomedicinal background knowledge have also reported the successful identification of traditional medicinal plants in Ethiopia and abroad (Hussain *et al.*, 2010; Tekwu *et al.*, 2012; Singariya *et al.*, 2012; Ermias Lulekal *et al.*, 2013 and Berhan Mengiste *et al.*, 2014).

The broad-spectrum antimicrobial activity of extracts was shown by *Inula confertiflora* (leaf), *Laggera tomentosa* (root) and *Satureja abyssinica* (leaf) which inhibited the growth of the selected microbes (*Listeria monocytogenes* and *Staphylococcus aureus* from gram-positive bacteria, *Escherichia coli* and *Salmonella typhimurium* from gram-negative bacteria and *Candida albicans* from fungus) at a MIC of 100 mg/ml. This result is in agreement with other

traditional medicinal plant species based on antimicrobial activity testing reported from Ethiopia and other countries (Singariya *et al.*, 2012 and Ermias Lulekal *et al.*, 2013).

Leaf extract of *Laggera tomentosa* showed a high spectrum against *Staphylococcus aureus* with 8 - 11 mm zone of inhibition at MIC 12.5 – 100 mg/ml. The result indicated that ethanol extracts of *Laggera tomentosa* leaf exhibited more promising activity against the *Staphylococcus aureus* strain than its root extracts and other plant extracts. This attaining of high efficacy from leaves remedies could be due to the higher presence of active ingredients in the form of secondary metabolites. In addition to this, highest antibacterial activity (12 - 22 mm zone of inhibition) was demonstrated by ethanolic root extracts of *Kalanchoe marmorata* against *Staphylococcus aureus* at MIC range of 12.5 – 100 mg/ml. This suggests that the extract of this plant has a broad spectrum of antibacterial activities. However, these antibacterial activities were observed to be slightly lower than ampicillin 10µg/ml and significantly lower than that of Chloramphenicol 30µg/ml, the standards of antibacterial drug used as a positive control in this study. This could be because the sample extracts used in the test were crude preparation which may not necessarily contain enough of the active chemicals. Further purification and fractionation are recommended to yield more isolated bioactive compounds. The result indicated that ethanol extracts of *Laggera tomentosa* and *Kalanchoe marmorata* showed more promising activity against *Staphylococcus aureus* strains than other plant extracts and the finding allied to the reported traditional uses mentioned for treating vomiting and diarrhea in the study area.

*Candida albicans* showed less susceptibility to the tested traditional medicinal plant extracts than the gram-positive and gram-negative bacteria. *Inula confertiflora*, *Laggera tomentosa* (root) and *Satureja abyssinica* (leaf) were the only plant extracts that showed inhibition against *Candida albicans* at MICs of 25 mg/ml, 50 mg/ml and 100 mg/ml respectively. Gram-negative bacteria were more resistant than the gram-positive bacteria towards the plant extracts which could relate to the presence of lipopolysaccharides in their outer membrane (Gao *et al.*, 1999). Furthermore, the bacterial pathogen *Salmonella typhimurium* was found less susceptible to all extracts whereas, *Staphylococcus aureus* was found more susceptible almost to all extracts this could also partly be attributed to the nature of cell wall permeability (Gao *et al.*, 1999). Multi drug resistance of gram-negative bacteria was also reported by Ermias Lulekal *et al.* (2013). Other reports also confirmed that gram-negative bacteria are less susceptible to diverse medicinal plant extracts than gram-positive bacteria (Singariya *et al.*, 2012 and Fentahun *et al.*, 2017) and hence supporting the present result.

## 5.2. Conclusion

As evidenced by the results of this study, findings give full support to all the central hypotheses set for this research. The *Menz Gera* remnant natural forest patches have diverse plant species and they are very important components of the ecosystem in the region, which positively supports the first hypothesis of this research. However, the efforts to conserve these remnant forests have not been as desired, which resulted in fragmentation and patchiness of the natural forests in the past. The study area is endowed with high plant species diversity, richness and composition. This richness corresponds to habitat heterogeneity due to topographic variables, which suit different plant species associations. The study area was found to be home for some endemic and indigenous plant species due to differences in altitude and variable landscape features. The presence of endemic and indigenous plant species in the forest indicates the potentiality of the area for biodiversity conservation.

Three plant community types were identified in this study. The patterns of community distribution in the study area are influenced by gradients of altitude, patch location and other environmental factors. This was confirmed by outputs of hierarchical cluster analysis in combination with Multi-response Permutation Procedures of the whole data set. Diversity analyses showed changes occurring in species diversity along altitudinal gradients. The variations in species diversity between the vegetation units compared are due to differences in species abundance and dominance, the proximity of sampling quadrats, habitat heterogeneity and/or historical disturbance factors.

Analysis of vegetation structure has shown the predominance of small-sized individuals in the lower DBH and height classes with a gradual decline towards the higher classes indicating good reproduction potential of the forests. However, shrubs than tree species dominated the small-sized individuals. Such trend is probably caused by past disturbance of the original vegetation resulting in a stage of secondary vegetation development. The population structure of representative tree species also indicates abnormal population structure (no or few individuals at different size classes) which happened due to selective removal of preferred sized individuals by the local people for different purposes. Moreover, assessment of the regeneration status of the forest patches reveals that only a few mature plants represent a large number of species without any sapling and/or seedling stage indicating that these species are on the edge of local extinction and demanding high conservation priority.

Investigation on the *Menz Gera* remnant dry montane forest patches indicates that the forests are a major reservoir for several medicinal plant species utilized by the local community, which supports the first hypothesis positively. The three-plant community types in the study forests consists traditionally used medicinal plants besides other economically important species. Since these forests are currently being severely exploited by the local people and illegal sawmills for different purposes, it calls for serious attention to conservation action and sustainable management too. Since the remnant forest patches are homes for medicinal plants and wild animals sheltering in them.

The findings of this study shows poor natural regeneration of indigenous trees including *Allophylus abyssinicus*, *Olea capensis* subsp. *macrocarpa* and *Olea europaea* subsp. *cuspidata*, and none in the cases of *Hagenia abyssinica*, *Olinia rochetiana*, *Bersama abyssinica*, *Celtis africana*, and *Prunus africana*. This could be mainly due to anthropogenic interference, which confirms the second hypothesis of this research. Therefore, it is important to minimize the anthropogenic influences in the forest and promote the natural regeneration of the plant species. If the remnant forests continue being over-exploited as shown by past events, there will be an increase of edge related habitats, which will cause changes in structural and floristic composition due to increased edge effect and the forest will face a great threat of losing its original biota especially the rare species.

Results revealed that *Menz Gera* District is very rich in its medicinal plant diversity and associated indigenous knowledge; this finding gives full support to the third hypotheses set for this research. It was also shown that there is paramount importance of traditional medicinal plants and the local community holding indigenous medicinal knowledge in assisting the primary healthcare needs of both humans and livestock in the study area. Long time cultural acceptance of traditional medicine and limited access to modern healthcare facilities could be taken as the main factors for the continued reliance of the communities on local medicinal plants. The people in the study area reported using diverse plant species (156 plant species that belong to 136 genera and 67 families) for in traditional herbal medical system; that were used to treat 87 human and 16 livestock ailments. This finding clearly indicates the rich knowledge of medicinal plant use and ethnomedicinal practices in the study area.

The family Asteraceae had the highest number of medicinal plants with 9.62% species, followed by Lamiaceae with 6.41% species and Solanaceae with 5.77% species in the district. Most of the medicinal plants used in traditional medicine are herbs (55.13%) mainly harvested from the wild.

The findings also showed that most of the local people agreed on the importance of traditional medicinal plants since they consider them as effective, cheap and easily reachable from their environment. Most of the plant parts used for medicine were leaves (32.05%) and roots (30.77%) which play a vital role in the life cycle of the plants for the continued functioning.

The local people of the study districts used some materials such as a coffee cup, teacup, spoon, drops, finger size and count for leaves, seed and fruits to measure dosage for the prescribed traditional medicines. Age, gender, pregnancy and stage of illness were also considered by some healers to determine the amount of remedies to be given. There were variations also in the unit of measurement, duration and the prescription by healers for the same kind of health problems among different healers.

Higher numbers of medicinal plants were reported by men (66.92%) than women (33.08%), by older people (69.23%) than younger ones (30.77%) and by illiterate people (71.54%) than the literate ones (28.46%). The fact that proper transfer of medicinal plant knowledge takes place through the illiterate male line could have contributed to the women having significantly less ( $p < 0.001$ ) knowledge as compared to men. The fact that younger and literate people are more exposed to modernization and urbanization than older and illiterate ones could have contributed to the former to have less medicinal plant knowledge. Such illiterate, less modernized aged healers lead to conclude that the traditional medicinal plant's knowledge of the community is threatened due to lack of documentation since knowledge of the traditional healers has been orally transmitted from generation to generation and this is shown in high disparity among the present generation.

Informants explained that except *Withania somnifera*, *Echinops kebericho* and *Hagenia abyssinica* plant species used for traditional medicinal purposes are not sold in the open market. Traditional medicinal practitioners did not attempt to conserve the traditional medicinal plants they use; rather they collect by considering their immediate needs only except five (1.28%) informants. Planting of traditional medicinal plants especially like shrubs and trees should be practiced in home gardens and nearby areas like what they did for cash plants (*Eucalyptus globulus*). Caring and protecting plant communities that accommodate medicinal plant species is the best way for conservation and sustainable use of traditional medicinal plants and associated indigenous knowledge.

The antimicrobial activity testing results show that all extracts of the eight selected traditional medicinal plants exhibited antimicrobial effect against one or more of five different types of

microbial strains. It was found that *Inula confertiflora* (leaf), *Laggera tomentosa* (root) and *Satureja abyssinica* (leaf) would be the most promising plants for potential discovery of modern drugs against microbes since they show good inhibition at 100 mg/ml against *Listeria monocytogenes*, *Staphylococcus aureus*, *Escherichia coli*, *Salmonella typhimurium* and *Candida albicans* pathogens. The antimicrobial activity of extracts from *Kalanchoe marmorata* (root) and *Laggera tomentosa* (leaf) showed promising inhibition at MIC of 25 mg/ml and 12.5 mg/ml respectively against *Staphylococcus aureus*.

*Yegana* and *Gajilo* forest patches of *Menz Gera* District are water catchment mountains to both Abay and Awash watersheds. Therefore, the output of this research will help for rehabilitating the degraded area of the water catchments to both rivers using the floristic checklist of the remnant natural forest patches for the sustainability of those potential rivers and the habitat. Moreover, this study has documented the traditional medicinal plants with their associated indigenous knowledge followed by testing the antimicrobial effect of selected traditional medicinal plants with high fidelity level value and informant consensus factor value. Those selected traditional medicinal plants for the anti-microbial tests will serve as a baseline information for further pharmacological studies by interested researchers. Furthermore, the results of this study provide good feedback for various governmental, non-governmental organizations and private investors who need to contribute to conservation, management and sustainable utilization of natural resources. Particularly, the Ministry of Agriculture, Commission of Environment, Forest and Climate Change, Ministry of Culture and Tourism, Blue Nile (Abay) and Awash rivers watershed responsible stakeholders, Wild Life Protection Authority and Culture and Heritage Organizations in the use of the findings of the study as input in their strategic plan relating to the sustainable management of the area.

### **5.3. Recommendations**

Based on the research findings, the following recommendations were forwarded:

1. The result shows all the tree species recorded in the study area were found in the *Gajilo* forest whereas only 42% of the tree species were found in *Yegana* forest. Therefore, planting of trees which are found only in *Gajilo* forest (such as *Allophylus abyssinicus*, *Olea capensis* L. subsp. *macrocarpa*, *Podocarpus falcatus*, *Polyscias fulva*) at *Yegana* forest will be important to improve the tree diversity of *Yegana* forest since those forest patches are found in the same vegetation type of Ethiopia which is Dry Afromontane forest. Furthermore, establishment of separate grazing land or grassland for the community will be very important. To achieve this,

the involvement of many stakeholders including the local government authorities, the local communities and NGO's in establishing nursery sites to grow and plant indigenous tree species is very important and appropriate. Besides, the prevention of livestock grazing in the forest would promote the natural regeneration process of many species.

2. The structure shows *Erica arborea*, *Myrsine africana*, *Hypericum revolutum*, and *Dodonea angustifolia* are the relatively more abundant species, which cover half of the total density of the woody species, but the indigenous trees like *Podocarpus falcatus*, *Allophylus abyssinicus*, *Hagenia abyssinica*, *Juniperus procera*, *Olea europaea* subsp. *cuspidate*, etc. are less abundant. Therefore, such species need special attention by governmental and non-governmental offices for increasing their abundance at all growth stages to sustain the forests.
3. Disturbance level assessment of the three plant communities shows medium to high anthropogenic threats through stump counts of woody species. Therefore, such disturbance may be due to firewood collection for domestic use and cash generation, timber and agricultural utensils so it needs to use stoves from electricity and non-plant factory products, which replace timbers and agricultural materials by the collaboration of governmental and non-governmental bodies.
4. The zonal health and agriculture offices with Debre Berhan University and agriculture research center should establish research center which promotes and raises awareness on traditional medicinal plants conservation and sustainable use practices, in collaboration with local traditional health practitioners and community elders and
5. Further studies on isolation and characterization of chemicals from the plant species of *Inula confertiflora*, *Kalanchoe marmorata*, *Laggera tomentosa*, and *Satureja abyssinica* is needed identify the responsible factors for the observed high antimicrobial activity at lower MIC. Further research on isolation, characterization and formulation of the tested and other traditional medicinal plants for modern drug development in this study area is highly recommended. So higher learning institutions, research centers, Ethiopian Public Health Institute (EPHI) and other governmental and non-governmental organizations should take their share for the sustainable use of the traditional medicinal plants and associated indigenous knowledge.

## REFERENCES

- Abate Ayalew, Tamrat Bekele, and Sebsebe Demissew (2006). The Undifferentiated afro-montane forest of Denkoro in the central highland of Ethiopia: A floristic and Structural Analysis. *SINET: Ethiop. J. Sci.* **29**(1): 45-56.
- Abiyot Tilahun (2018). Vegetation Ecology and Carbon Stock of Wof-Washa Forest, North Shewa Zone, Amhara Region, Ethiopia. Ph.D. thesis, Addis Ababa University, Ethiopia.
- Abraha Teklay (2013). Traditional medicinal plants for ethnoveterinary medicine used in Kilte Awulaelo District, Tigray Region, Northern Ethiopia. *Advancement in Medicinal Plant Research* **3**(4): 137-150.
- Abiyot Berhanu, Sebsebe Demissew, Zerihun Woldu and Motuma Didita (2016). Woody species composition and structure of Kuandisha afro-montane forest fragment in northwestern Ethiopia. *Journal of Forestry Research*.
- Aerts, R., Overtveld, K.V., Mitiku Haile, Hermy, M., Deckers, J., Muys, B. (2006). Species composition and diversity of small Afro-montane forest fragments in northern Ethiopia. *Plant Ecology* **187**:127–142.
- Alemayehu Wassie (2007). Ethiopian church forests opportunities and challenges for restoration. Unpublished PhD thesis, Wageningen University, Wageningen, The Netherlands.
- Alemnew Alelign, Demel Teketay, Yonas Yemshaw and Edwards, S. (2007). Diversity and status of regeneration of woody plants on the peninsula of Zegie, northwestern Ethiopia. *Tropical Ecology* **48**(1): 37-49.
- Alexiades, M. (1996). Collecting ethnobotanical data. An introduction to basic concepts and techniques. In: (Alexiades, M. and Sheldon J.W. eds.). *Selected Guidelines for ethnobotanical research: A Field Manual*, Pp. 58-94. The New York. Botanic Garden, U.S.A.
- Amare Getahun (1976). *Some Common Medicinal and Poisonous Plants Used in Ethiopia Folk Medicine*. Addis Ababa University, Addis Ababa. pp. 3-63.
- Andrade-Cetto, A. and Heinrich, M. (2011). From field in to the lab: useful approaches to selecting species based on local knowledge. *Ethnopharmacology* **2**(20): 1-5.

- Aqeel, M., Adeel M. and Mamoon M. (2012). *In vitro* biological activities of most common medicinal plants of family Solanaceae. *World Applied Sciences Journal* **17**(8): 1026-1032.
- Ayensu, E.S. (1983). Endangered plants used in traditional medicine in Traditional Medicine and Healthcare Coverage, ed. Robert H. Bannerman, John Burton and Ch'en Wen-Chieh, pp. 175-183, *World Health Organization*, Geneva.
- Azam, M. Ajab, M. and Hussain, M. (2012). Ethno veterinary medicinal uses of plants of Poonch Valley Azad Kashmir, Pakistan. *Pakistan Journal of Weed Science Research* **18**(4): 495-507.
- Balick, M.J. (1996). Transforming ethnobotany for the new millennium. *Annals of the Missouri Botanical Garden* **83**: 58-66.
- Balick, M. J. and Cox, P. A. (1996). *Plants People and Culture*. The science of ethnobotany. Scientific American library, New York, USA. 288pp.
- Barkman, J.J. (1979). The investigation of vegetation structure and structure. **In:** *The study of vegetation*, pp. 123-160 (Werger, M.J.A. ed.) Junk, The Hague.
- Bartlett, J. E., Kotrlik, J. W., and Higgins, C., (2001). Organizational research: Determining appropriate sample size for survey research. *Journal of Information Technology, Learning, and Performance* **19**(1): 43-50.
- Berhan Mengiste, Yohannes Hagos, Fetene Moges, Habtamu Tassew, G/hiwot Tadesse, and Awet Teklu (2014). *In vitro* Antibacterial Screening of Extracts from Selected Ethiopian Medicinal Plants. *Momona Ethiopian Journal of Science*, **6**(1): 102-110.
- Berhan Mengiste, Yohannes Hagos, Masresha Fetene Moges, Habtamu Tassew, G/hiwot Tadesse, and Awet Teklu (2014). *In vitro* Antibacterial Screening of Extracts from Selected Ethiopian Medicinal Plants. *Momona Ethiopian Journal of Science (MEJS)*, **6**(1): 102-110.
- Biniyam Admassu and Zelalem Terefe, (2011). *Trek like the locals on the scenic Guassa Plateau Travel Guide book*. Frankfurt Zoological society, Ethiopia.
- Bussmann, R. and Sharon, D. (2006). Traditional medicinal plants use in Loja Province, Southern Ecuador. *Journal of Ethnobiology and Ethnomedicine* **2**: 35-44.

- Cain, S.A. and Castro, G.M.O. (1959). *Manual of Vegetation Analyses*. Harper and Brothers, New York.
- Chauhan, D.S., Dhanai, C.S., Singh, B., Chauhan, S., Todaria, N.P. and Khalid, M.A. (2008). Regeneration and tree diversity in natural and planted forests in a Terai - Bhabhar forest in Katarniaghat Wildlife Sanctuary, India. *Tropical Ecology* **49**(1): 53-67.
- Cheruiyot, K. R., Olila D. and Kateregga, J. (2009). In-vitro antibacterial activity of selected medicinal plants from Longisa region of Bomet district, Kenya. *African Health Sciences*, **9** *Special Issue 1*.
- Clark, J.S. (1991). Disturbance and population structure on the shifting mosaic landscape. *Ecology* **72**: 1119–1137.
- Cos, P., Vlietinck A.J., Vanden Berghe, D., Maes, L. (2006). Anti-infective potential of natural products: How to develop a stronger *in vitro* ‘proof- of- concept’. *Journal of Ethnopharmacology* **106**: 290-302.
- Cotler, H. and Ortega-Larrocea, M.P. (2006). Effects of land use on soil erosion in a tropical dry forest ecosystem, Chamela watershed, Mexico. *Catena* **65**: 107-117.
- Cotton, C. M. (1996). *Ethnobotany: Principles and Applications*. John Willey and Sons LTD. Chichester, UK, p. 424.
- Cunningham, A.B. (1993). African medicinal plants, Setting priorities at the interface between conservation and primary healthcare. People and plants working paper 1, Paris, France: UNESCO.
- Cunningham, A.B. (1993). People, Park and Plants use recommendations for multiple use zones and development alternatives around Bwindi: Impenetrable National Park, Uganda. In: *People and Plants, working paper 4*, Sample, A. (ed.), UNESCO, Paris pp.18-23.
- Davis, A. and Wagner, J.R. (2003). Who knows? On the importance of identifying “Experts” when researching local ecological knowledge. *Human Ecology* **31**: 463-489.
- Debela Hunde, Zemedede Asfaw and Ensermu Kelbessa (2006). Use of traditional medicinal plants by people of ‘Boosat’ sub district, Central Eastern Ethiopia. *Ethiopian Journal of Health Science* **16**:141-155.

- Demel Teketay (1996). Germination ecology of forest species from the highlands of Ethiopia. PhD thesis. Swedish University of Agricultural Sciences, Umea.
- Demel Teketay (1997). Seedling populations and regeneration of woody species in dry Afromontane forest of Ethiopia. *Forest Ecology and Management* **98**: 149–165.
- Demel Teketay (2005). Seed and regeneration ecology in Dry Afromontane forests of Ethiopia: I. Seed production - population structures. *Tropical Ecology* **46**(1): 29-44.
- Demel Teketay and Tamrat Bekele (1995). Floristic composition of Wof Washa natural forest, Central Ethiopia: implication for the conservation of biodiversity. *Feddes Repertorium* **106**(1-2): 127-147.
- Dhaulkhandi, M., Dobhal, A., Bhatt, S & Kumar, M. (2008). Community structure and regeneration potential of natural forest site in Gangotri, India. *Journal of Basic & Applied Sciences* **4**: 49-52.
- Dufrêne, M. and Legendre, P. (1997). Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecol. Mono.* **67**: 345-366.
- EFAP (1993). Ethiopian forestry action Programme. Volume II-the challenge for development. Ministry of National Resources Development and Environmental Protection. Addis Ababa, Ethiopia.
- EFAP (1994). Ethiopian Forestry Action Programme, Volume III. The Challenge for Development.
- Emery, A.R. (1996). The Participation of Indigenous Peoples and Their Knowledge in Environmental Assessment and Development Planning (draft). Centre for Traditional Knowledge. Ottawa, Canada.
- Engelbrecht, B., Comita, L., Condit, R., Kursar, T., Tyree, M., Turner, B. & Hubbell, S. (2007). Drought sensitivity shapes species distribution patterns in tropical forests. *Nature* **447**(3): 80–83.
- Ensermu Kelbessa and Sebsebe Demissew (2014). Diversity of Vascular Plant Taxa of Flora of Ethiopia and Eritrea. *Ethiop. J. Biol. Sci.* **13**: 37-45.

- Ensermu Kelbessa and Teshome Soromessa (2008). Interface of regeneration, structure, diversity and use of some plant species in Bonga Forest: a Reservoir for wild coffee gene pool. *SINET Ethiop. J. Sci.*, **31**(2): 121-134.
- Ensermu Kelbessa, Sebsebe Demissew, Zerihun Woldu and Edwards, S. (1992). Some threatened Endemic Plants of Ethiopia. In: *The status of some plants in parts of tropical Africa.*, Edwards, S. and Zemedede Asfaw (eds), NAPRECA, No. 2. Botany 2000, East and Central Africa, pp.35-55.
- Ermias Lulekal (2014). Plant diversity and ethnobotanical study of medicinal plants in Ankober district, North Shewa zone of Amhara region, Ethiopia. Ph.D. thesis, Addis Ababa University, Ethiopia.
- Ermias Lulekal, Zemedede Asfaw, Ensermu Kelbessa and Patrick Van Damme (2014). Ethnoveterinary plants of Ankober District, North Shewa Zone, Amhara Region, Ethiopia. *Ethnobiology and Ethnomedicine*, **10**:21.
- Ermias Lulekal, Ensermu Kelbessa, Tamrat Bekele, Haile Yineger (2008a). An ethnobotanical study of medicinal plants in Mana Angetu District, southeastern Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 2008, 4:10.
- Ermias Lulekal, Ensermu Kelbessa, Tamrat Bekele, Haile Yineger (2008b). Plant species composition and structure of the Mana Angetu moist montane forest, Southeastern Ethiopia. *Journal of East African Natural History* **97**(2): 165-185.
- Ermias Lulekal, J. Rondevaldova, E. Bernaskova, Cepkova J., Zemedede Asfaw, Ensermu Kelbessa, Kokoska L., and Van Damme P. (2013). Antimicrobial activity of traditional medicinal plants from Ankober District, North Shewa Zone, Amhara Region, Ethiopia. *Informa Healthcare USA*, 1-7.
- Ermias Lulekal, Zemedede Asfaw, Ensermu Kelbessa and Patrick V. D. (2013). Ethnomedicinal study of plants used for human ailments in Ankober District, North Shewa Zone, Amhara Region, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 9:63.
- Ermias Lulekal, Zemedede Asfaw, Ensermu Kelbessa and Patrick Van Damme. (2014). Ethnoveterinary plants of Ankober District, North Shewa Zone, Amhara Region, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 10:21.

- Eshetu Yirdaw (2002). Restoration of the native woody-species diversity, using plantation species as foster trees, in the degraded highlands of Ethiopia, PHD Thesis, University of Helsinki, Finland.
- EWNHS (2010). A Glimpse at Biodiversity Hotspots of Ethiopia: the essential directory for environment and development. Ethiopian Wildlife and Natural History Society & the Royal Netherlands Embassy, Addis Ababa. Pp. 94.
- FAO (Food and Agricultural Organization, 1996). Ethiopia: country report to the FAO international technical conference on plant genetic resources. Unpublished report. Leipzig, Germany.
- FAO (Food and Agricultural Organization, 2010). Global forest resources assessment. Rome. 340p.
- Fekadu Gurmessa, Teshome Soromessa and Ensermu Kelbessa (2013). Floristic composition and community analysis of Komto Afromontane moist forest, East Wollega Zone, West Ethiopia. *Science Technology and Arts Research Journal* 2(2):58-69.
- Fentahun M., Ayele Yilkal B., Amsalu N., Alemayehu A. and Amsalu G. (2017). Antibacterial Evaluation and Phytochemical Analysis of Selected Medicinal Plants against Some Pathogenic Enteric Bacteria in Gozamin District, Ethiopia. *J Pharmacovigil* 5: 244.
- Feyera Senbeta (2006). *Biodiversity and ecology of Afromontane rainforests with wild Coffea arabica L. populations in Ethiopia*. Ph.D. Thesis, Center for development research, University of Bonn, Germany.
- Feyera Senbeta and Demel Teketay (2001). Regeneration of indigenous woody species under the canopies of tree plantations in Central Ethiopia. *Tropical Ecology* 42(2): 175-185.
- Fisseha Mesfin, Sebsebe Demissew, Tilahun Tekelaymanot (2009). An Ethnobotanical study of medicinal plants in Wonago Woreda, SNNPR, Ethiopia. *Journal of Ethnobiology and Ethnomedicine*, 5:28.
- Frankel, O., Brown, H. and Burdon, J. J. (1995). *The Conservation of Plant Biodiversity*. Cambridge University Press, Britain.
- Friedman, J., Yaniv, Z., Dafni, A., and Palewitch, D. (1986). A preliminary classification on the healing potential of medicinal plants, based on rational analysis of and

ethnopharmacological field survey among Bedouins in the Negev Desert, Israel. *Journal of Ethnopharmacology* **16**: 275-287.

- Friis I. and Sebsebe Demissew (2001). Vegetation maps of Ethiopia and Eritrea. A review of existing maps and the need for a new map for the flora of Ethiopia and Eritrea. *In: Biodiversity Research in the Horn of Africa Region*, pp. 399-439 (Friis, I. and Ryding, O., eds). Proceedings of the 3rd International symposium on the Flora of Ethiopia and Eritrea at the Carlsberg Academy, Copenhagen.
- Friis, I. (1986). The forest vegetation of Ethiopia. *Symbolae Botanicae Upsaliensis* **26** (2): 31-47.
- Friis, I. (1992). Forest and Forest Trees of Northeast Tropical Africa: Their natural habitats and distribution pattern in Ethiopia, Djibouti and Somalia. *Kew. Bull. Add. Ser.* 15, 396 pp.
- Friis, I, Sebsebe Demissew and Breugel, P.V. (2010). Atlas of the Potential Vegetation of Ethiopia. Addis Ababa: The Royal Danish Academy of Sciences and Letters (Natural habitats). Pp. 307.
- Friis, I. and Mesfin Tadesse, (1990). The evergreen forests of tropical Northeast Africa. Dk-1123 Copenhagen K, Denmark. *Opera Botanica* **63**: 1-70.
- Gao Y., Van Belkum M. and Stiles M. (1999). The outer membrane of Gram-negative bacteria inhibits antibacterial activity of Brochocin C. *Applied Environ Microbiol* **65**: 4329-4333.
- Garwood, N. C. (1989). Tropical soil seed banks: a review. *In: Ecology of Soil Seed Banks*, M.A. Leck, V.T. Parker & R.L. Simpson (eds), Academic Press, San Diego & California, pp. 149-209.
- Gatzweiler, F.W. (2007). Deforestation of Ethiopia's Afromontane rainforests; Reasons for concern, ZEF Policy Brief No. 7.
- Gebremicael Fisaha, Kitessa Hundera and Gemedo Dalle (2013). Woody plants' diversity, structural analysis and regeneration status of Wof Washa natural forest, North-east Ethiopia. *John Wiley & Sons Ltd, Afr. J. Ecol.* **51**: 599–608.
- Gemedo Dalle and Masresha Fetene (2004). Gap-fillers in Munesa-Shashamane forest, Southern Ethiopia. *Ethiop. Biol. Sci.* **3** (1): 1-4.

- Gemedo Dalle, Maass, B. L. and Isselstein, J. (2005). Plant communities and their species diversity in the semi-arid rangelands of Borana lowland, Southern Oromia, Ethiopia. *Community ecology* **6**(2): 167-176.
- Gentry A. H. (1995). Patterns of diversity and floristic composition in neotropicalmontane forests. *In: Biodiversity and Conservation of Neotropical MontaneForests*, pp. 103–126, (Churchill S. P., Balslev H., Forero E. and Luteyn J. L., eds.). The New York Botanical Garden, Bronx, New York.
- Getachew Simeneh (2010). Habitat use and diet of golden jackal (*Canis aureus*) and Human carnivore conflict in Guassa community Conservation area, Menz. Unpublished MSc thesis, Addis Ababa University.
- Getachew Tesfaye, Demel Teketay, Masresha Fetene and Erwin, B. (2010). Regenerationof seven indigenous tree species in a Dry Afromontane forest, southern Ethiopia.*Flora* **205**(2): 135-143.
- Getaneh Belachew. (2006). Floristic composition and structure in Beschillo and Abay (Blue Nile) riverine vegetation. Unpublished M.Sc. thesis, Addis Ababa University.
- Getu Alemayehu, Zemedede Asfaw, Ensermu Kelbessa (2015). Ethnobotanical study of medicinal plants used by local communities of Minjar-Shenkora District, North Shewa Zone of Amhara Region, Ethiopia. *Journal of Medicinal Plants Studies* **3**(6): 01-11.
- Gidey Yirga, Mekonen Teferi, Gebrerufael Gidey, and Samuel Zerabruk (2012). An ethnoveterinary survey of medicinal plants used to treat livestock diseases in Seharti-Samre District, Northern Ethiopia. *African Journal of Plant Science* **6**(3): 113-119.
- Goldewijk, K.and Ramankutty, K. (2004). Land cover change over the last three centuries due to human activities: The availability of new global data sets. *Geojournal*. **61**: 335-344.
- Government of Ethiopia (GoE) (2006). Proclamation No. 482/2006, issue to providing for access to genetic resources, and community knowledge, and community right.
- Grubb, P.J., Lloyd, J.R., Pennington, J.D. and Whitmore, J.C. (1963). A comparison of montane and lowland rainforest in Ecuador. The forest structure, physiognomy, and floristics. *Ecology* **51**: 567-601.

- Habtamu Wodaj, Ensermu Kelbessa and Zerihun Woldu (2016). Floristic Composition and Herbaceous Aboveground Dry Weight Biomass of Afroalpine Vegetation in Guassa Community Conservation Area, North Shewa, Ethiopia. *Int. Res. J. Biological Sci.* **5**(1): 26-36.
- Haile Yineger, Ensermu Kelbessa, Tamrat Bekele and Ermias Lulekal (2008a). Floristic composition and structure of the Dry Afromontane forest at Bale mountains national park, Ethiopia. *SINET: Ethiop. J. Sci.* **31**(2):103-120.
- Haile Yineger, Ensermu Kelbessa, Tamrat Bekele and Ermias Lulekal (2008b). Plants used in traditional management of human ailments at Bale Mountains National Park, Southeastern Ethiopia. *Journal of Medicinal Plants Research* **2**(6):132-153.
- Haile Yineger, Ensermu Kelbessa, Tamrat Bekele and Ermias Lulekal (2007). Ethnoveterinary medicinal plants at Bale Mountains National Park, Ethiopia. *Journal of ethnopharmacology* **112**: 55-70.
- Haileab Zegeye, Demel Teketay and Ensermu Kelbessa (2011). Diversity and regeneration status of woody species in Tara Gedam and Abebaye forests, northwestern Ethiopia. *Journal of Forestry Research* **22**(3): 315–328.
- Hailu Beyene, (2010). Population Estimate and Structure of the Gelada Baboon, *Theropithecus Gelada*, In the Guassa Community Conservation Area, Central Ethiopia. (MSc Thesis). A.A.U.: Addis Ababa.
- Hamilton, A. C. (2003). Medicinal plants and Conservation: issues and approaches. International plants Conservation unit, WWF-UK. Panda House, Catte Shall Lane Gondalming, UK.
- Han, H., Jang, K, Song, J., Seol, A, Chung, W. Chung, J. (2011). The effects of site factors on herb species diversity in Kwangneung forest stands. *Forest Science and Technology* **7**(1) 1–7.
- Hedberg, I. and Edwards, S., eds. (1989): *Flora of Ethiopia and Eritrea. Pittosporaceae to Araliaceae Volume 3*. Department of Systematic Botany, Uppsala, Sweden: The National Herbarium, Addis Ababa, Ethiopia.

- Hedberg, I., Kelbessa, E., Edwards, S., Sebsebe Demissew and Persson, E., eds (2006). *Flora of Ethiopia and Eritrea. Gentianaceae to Cyclohellicaceae Volume 5*. Department of Systematic Botany, Uppsala, Sweden: The National Herbarium, Addis Ababa, Ethiopia.
- Hedberg, O. (1951). Vegetation belts of the East African mountains. *Svensk Botanisk Tidskrift Utgifven of Svenska Botaniska Foreningen* **45**: 140-202.
- Hedberg, O. (1978). Introduction in: *Systematic Botany, Plant utilization and Biosphere Conservation*, Hedberg, I. (ed), Almquist and Well International, Stockholm, Sweden.
- Heinrich, M., Ankli, A., Frei, B., Weimann, C. and Sticher, O. (1998). Medicinal plants in Mexico: Healers' consensus and cultural importance. *Social Science and Medicine* **47**:1859-1871.
- Hussain, S., Jamil, M., Ullah, F., Khan, A., Arfan, M., Ahmad, S. and Khatoon, L. (2010). Antimicrobial and antioxidant activities of the plant *Heliotropium strigosum*. *African Journal of Biotechnology* **9**: 7738-7743.
- Hussien Adal M. (2014). Plant Diversity and ethnobotany of Borena Sayint National Park, northern Ethiopia. Unpublished PhD dissertation, Addis Ababa University, Ethiopia.
- IBC (Institute of Biodiversity Conservation, 2009). Convention on Biological Diversity (CBD) Ethiopia's 4<sup>th</sup> Country Report. Unpublished report, Addis Ababa, Ethiopia.
- IUCN (International Union for Conservation of Nature, 1993). Guidelines on the Conservation of Medicinal Plants. Castle Cary Press, UK.
- Izzo, A. and Ernst, E. (2009). Interaction between herbal medicines and prescribed drugs. *Drugs*, **69**:1777–1798.
- Jansen, P. C. (1981). *Spices Condiments and Medicinal Plants in Ethiopia: Their Taxonomic and Agricultural Significance*. Center for Agricultural Publishing and Documentation. Wageningen, the Netherlands, pp. 327.
- Javid, T., Adnan, M., Tariq, A., Akhtar, B., Ullah, R. and AbdElsalam, M. (2015). Antimicrobial activity of three medicinal plants (*Artemisia indica*, *Medicago falcata* and *Tecoma stans*). *Afr J Tradit Complement Altern Med*. **12**(3):91-96.



- Kumelachew Yeshitila and Tamrat Bekele (2002). Plant Community Analysis and Ecology of Afromontane and Transitional Rainforest vegetation of South-Western Ethiopia. *SINET: Ethiop. J. of Sci.*, **25**(2): 155-175.
- Lamprecht, H. (1989). *Silviculture in Tropics. Tropical Forest Ecosystems and their Tree Species - Possibilities and Methods for their Long-term Utilization.* TZVerlagsgesellschaft GmbH, Rossdort, Germany
- Leul Kidane, Tamrat Bekele and Sileshi Nemomissa (2010). Vegetation Composition in Hugumbirda-Gratkhassu National Forest Priority Area, South Tigray. *MEJS* **2** (2): 27-48.
- Lyaruu, H.V.M., Eliapenda, S. & Backeus, I. (2000). Floristic, structural and seed bank diversity of a Dry Afromontane forest at Mafai central Tanzania. *Biodiversity Conservation* **9**: 241-263.
- MacDonald, I. (2009). Current trends in ethnobotany. *Trop. J. Pharm. Res.* **8**(4): 295-297.
- Macia, M.J., Garcia, E, and Vidaurre, P.J. (2005). An ethnobotanical survey of medicinal plants commercialized in the markets of La Paz and El Alto, Bolivia. *Journal of Ethnopharmacology*, **97**:337–350.
- Mahmood, A., Mahmood, A. and Mahmood, M. (2012). In vitro Biological Activities of Most Common Medicinal Plants of Family Solanaceae. *World Applied Sciences Journal* **17**(8): 1026-1032.
- Martin, G. J. (1995). *Ethnobotany: A Methods Manual.* Chapman and Hall, London, P. 267.
- Maydeu-Olivares, A & Bockenholt, U. (2005) Structural Equation Modeling of Paired Comparison and Ranking Data. *Psychological Methods*, **10**(3): 285–304.
- McCorkle, C.M. (1986). An Introduction to Ethnoveterinary Research and Development. *Journal of Ethnobiology* **6**(1): 129-149.
- McCune, B. and Grace J.B. (2002). *Analysis of Ecological Communities.* MjM Software Design. USA, 304 pp.
- Medhin Zewdu (2002). Sustainable Development in Ethiopia Report of Assessment of Activities Issues relevant to the review Process of the Earth Summit 2002 in Ethiopia for Heinrich

Boell Foundation; Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia.

- Mengesha Asefa, Min Cao, Yunyun He, Ewuketu Mekonnen, Xiaoyang Song, Yang Jie. (2020). Ethiopian vegetation types, climate and topography, Plant Diversity, <https://doi.org/10.1016/j.pld.2020.04.004>.
- Mersha Ashagre (2011). Ethnobotanical Study of Medicinal Plants used by Guji Agropastoralists in Bule Hora Wereda, Southern Oromia, Ethiopia. MSc Thesis, AAU, Ethiopia.
- Mesfin Tadesse (2004). *Flora of Ethiopia and Eritrea; Asteraceae (Compositae) Volume 4: Part 2*, Addis Ababa, Ethiopia: The National Herbarium, Addis Ababa University; 2004.
- (MEFCC) Ministry of Environment Forest and Climate Change (2015). Mid- Term Progress report from October 2012 to November 2015 of Ethiopia's R-PP Implementation. Submitted to the Forest Carbon Partnership Facility (FCPF), Addis Ababa, Ethiopia.
- Mirutse Giday, Zemedede Asfaw and Zerihun Woldu (2010). Ethnomedicinal study of plants used in Sheko ethnic group of Ethiopia. *Journal of Ethnopharmacology* **132**: 75-85.
- Mirutse Giday, Zemedede Asfaw, Thomas Elmqvist and Zerihun Woldu (2003). An ethnobotanical study of medicinal plants used by the Zay people in Ethiopia. *Journal of Ethnopharmacology* **85**: 43-52.
- Mirutse Giday, Zemedede Asfaw, Zerihun Woldu and Tilahun Teklehaymanot (2009). Medicinal plant knowledge of the Bench Ethnic group of Ethiopia: an ethnobotanical investigation. *Journal of Ethnobiology and Ethnomedicine*, **5**:34.
- Mligo, C. and Rocky, J. (2012). Regeneration pattern and size-class distribution of indigenous woody species in exotic plantation in Pugu Forest Reserve, Tanzania. *International Journal of Biodiversity and Conservation* **4**(1): 1-14.
- MOA and EPA (2013). Terms of Reference for Developing Capacities for a national Measuring, Monitoring, Reporting and Verification System to support REDD+ participation of Ethiopia. Background, Capacity Assessment and Roadmap, 37p.
- Moa Megersa, Zemedede Asfaw, Ensermu Kelbessa, Abebe Beyene and Bizuneh Woldeab (2013). An ethnobotanical study of medicinal plants in Wayu Tuka District, East Welega Zone

- of Oromia Regional State, West Ethiopia, *Journal of Ethnobiology and Ethnomedicine* **9**(68): 1-18.
- Moravec, I., Fernandez, E., Vlkova, M. and Milella, L. (2014). Ethnobotany of Medicinal Plants of Northern Ethiopia. *Boletín Latinoamericano Y Del Caribe De Plantas Medicinales Y Aromáticas* **13**(2): 126-134.
- Mueller-Dombois, D. and Ellenberg, H. (1974). *Aims and Methods of Vegetation Ecology*. Wiley and Sons, New York.
- Magurran, A.E. (2004). *Measuring Biological Diversity*. Blackwell Publishing, Oxford, UK. 256pp.
- Ngarivhume, T., vant Klooster, C. de Jong, J. and der Westhuizen, J. (2015). Medicinal plants used by traditional healers for the treatment of malaria in the Chipinge district in Zimbabwe. *Journal of Ethnopharmacology* **159**: 224–237.
- Nyssen, J., Frankl, A., Haile, M., Hurni, H., Descheemaeker, K., Crummey, D., Ritler, A., Portner, B., Nievergelt, B., Moeyersons, J., Munro, N., Deckers, J., Billi, P., Poesen, J. (2014). Environmental conditions and human drivers for changes to north Ethiopian mountain landscapes over 145 years. *Sci. Total Environ.* 485e486, 164e179.
- Peters, C. M. (1996). *The Ecology and Management of Non-Timber Forest Recourses*. World Bank Technical Paper 322, ISBN 0-8213-3619-3, Washington.
- Pichi-Seremolli, R.E.G. (1957). Una carta geobotanica dell Africa orientale (Eritrea, Ethiopia, Somalia) *Webbia* **12**:15-132.
- Poorter, L., Bongers, F., van Rompaey, R.S.A.R and de Klerk, M. (1996). Regeneration of canopy tree species at five sites in West African forest. *Forest Ecology and Management* **84**(1): 61-69.
- Popma, J., Bongers, F. and Meave del Castillo, J. (1988). Patterns in the vertical structure of the lowland rainforest of Los Tuxtlas, Mexico. *Vegetatio* **74**: 81-91.
- R Development Core Team (2009). *A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. ISBN 3-900051-07-0, URL <http://www.r-project.org>.

- Rey, P.J., Julio, M. and Alcantara, M. (2000). Recruitment dynamics of a fleshy-fruited plant (*Olea europaea*): Connecting patterns of seed dispersal to seedling establishment. *Journal of Ecology* **88**(4):622-633.
- Sayer, A.J., Harcourt, S.C. and Collins, M.N. (1992). The conservation atlas of tropical forests of Africa. IUCN, Cambridge. 288pp.
- Sapkota, I.P., Tigabu, M. and Oden, P.C. (2010). Changes in tree species diversity and dominance across a disturbance gradient in Nepalese Sal (*Shorea robusta* Gaertn. f.) forests. *Journal of Forestry Research* **21**(1): 25-32.
- Schippmann, U., Leaman, D.J. and Cunningham, A.B. (2002). Impact of Cultivation and Gathering of Medicinal Plants on Biodiversity: Global Trends and issues. Inter Department Working Group on Biology Diversity for Food and Agriculture, Food and Agricultural Organization of the United Nations, Rome.
- Shankar, U. (2001). A case of high tree diversity in a Sal (*Shorea robusta*) dominated lowland forest of Eastern Himalaya: Floristic composition, regeneration and conservation. *Curr. Sci.* **81**: 776–786.
- Sharma, R., Amin, H. Galib R, and Prajapati, P. (2013). Seasonal variations in physicochemical profiles of *Guduchi Satva* (starchy substance from *Tinospora cordifolia* [Willd.] Miers). *Journal of Ayurveda and Integrative Medicine* **4**(4):193–197.
- Shmida, A. and Wilson, M.V. (1985). Biological determinants of species diversity. *Journal of Biogeography* **12**: 1-20.
- Silvertown, J. (1982). *Introduction to Plant Population Ecology*. Longman, New York.
- Silvertown JW, Doust JL. (1993). *Introduction to Plant Population Biology*. Oxford, UK: Blackwell.
- Simon Shibru and Girma Balcha (2004). Composition, Structure and regeneration status of woody species in Dindin Natural Forest, Southeast Ethiopia: An implication for conservation. *Ethiop. J. of Biol. Sci.***3**(1):15-35.
- Singariya, P., Mourya, K. and Kumar, P. (2012). Antimicrobial Activity of the Crude Extracts of *Withania somnifera* and *Cenchrus setigerus* In-vitro. *Pharmacognosy Journal*, **4**(27).

- Singh, A., (2008). A Note on Variation of Active Principles in Indian Medicinal Plants and TIM Formulations. *Ethnobotanical Leaflets* **12**: 603-606. <http://www.ethnoleaflets.com/leaflets/tim>.
- Slik, J.W.F. (2004). El Nino droughts and their effects on tree species composition and diversity in tropical rain forests. *Oecologia* **141**: 114–120.
- Sofowora, A. (1982). Medicinal Plants and Traditional Medicine in Africa. *John Wiley and Sons, Ltd.* New York. 256pp.
- Sofowora, A. (1996). Research on medicinal plants and traditional medicines in Africa. *The Journal of Alternative and Complementary Medicine*. **2**(3): 365-372.
- Solomon Ayele and Demel Teketay, (2017). Contribution of the Guassa Community Eco-Lodge to the Conservation of Wild Mammals, Birds and Woody Plants in Menz-Gera Midir District, North Shewa Administrative Zone, Ethiopia. *International Journal of Avian & Wildlife Biology*, **2** (4).
- Tadesse Woldemariam (2003). Vegetation of the Yayu forest in Southwest Ethiopia: Impacts of human use and Implications for *In-situ* conservation of Wild *Coffea arabica* L. populations. Ecology and Development Series No. 10.Center for Development Research, University of Bonn, Germany.
- Tadesse Woldemariam, Borsch, T.; Denich, M. and Demel Teketay (2008). Floristic composition and environmental factors characterizing coffee forests in southwest Ethiopia. *Forest Ecology and Management* **255**: 2138-2150.
- Tadesse Woldemariam, Demel Teketay, Edwards, S. and Olsson, M. (2000). Woody plant and avian species diversity in a Dry Afromontane forest on the central plateau of Ethiopia: Biological indicators for conservation. *Ethiopian Journal of Natural Resources* **2**: 255-293.
- Tafesse Mesfine and Mekonen Lemma (2001). The role of traditional veterinary herbal medicine and its constraints in Animal healthcare system in Ethiopia. *In: Proceeding of the National Work shop on Biodiversity Conservation and Sustainable use of Medicinal Plants in Ethiopia*. IBC, Ethiopia.

- Mesfin Tadesse, Debela Hunde and Yehenew Getachew (2005). Survey of medicinal plants used to treat human diseases in Seka Cherkosa, Jimma Zone, Ethiopia. *Ethiopian Journal of Health Sciences* **15**: 89-106.
- Tamrat Bekele (1993). Vegetation Ecology of Remnant Afromontane Forests on the Central Plateau of Shewa, Ethiopia, PhD Dissertation, Uppsala University, Uppsala, Sweden.
- Tamrat Bekele (1994). Phytosociology and ecology of a humid Afromontane forest on the Central Plateau of Ethiopia. *Journal of Vegetation Science* **5**: 87-98.
- Tantiado, R.G. (2012). Survey on ethnopharmacology of medicinal plants in Iloilo. *Philippines International Journal of Bioscience and Biotechnology* **4**(4):11-26.
- Tekwu, E.M., Pieme, A.C. and Beng, V.P. (2012). Investigations of antimicrobial activity of some Cameroonian medicinal plant extracts against bacteria and yeast with gastrointestinal relevance. *Journal of Ethnopharmacology* **142**: 265-73.
- Teshale Sori, Merga Bekana, Girma Adugna and Ensermu Kelbessa (2004). Medicinal Plants in the Ethnoveterinary Practices of Borana Pastoralists, Southern Ethiopia. *Intern. J. Appl. Re. Vet. Med.* **2**(3): 220-225.
- Teshome Soromessa, Demel Teketay and Sebsebe Demissew (2004). Ecological study of the vegetation in Gamo Gofa zone, southern Ethiopia. *Tropical Ecology* **45**(2): 209-221.
- Tewodros Atlabachew, Getachew Taye and Bahru Alemu (2003). Summary of the Feasibility Study for Ecotourism Development in Semen Shewa. Unpublished article, Addis Ababa, Ethiopia.
- Thomas, E., Semob, L., Morales, M., Noza, Z., Nuñez, H., Cayuba, A., Noza, M., Humaday, N., Vaya, J. and Van Damme, P. (2010) Ethnomedicinal practices and medicinal plant knowledge of the yuracarés and trinitarios from indigenous territory and national park Isiboro-sécure, Bolivian Amazon.
- Toledo, B. A., Galetto, L. and Colantonio, S. (2009). Ethnobotanical knowledge in rural communities of Cordoba (Argentina): the importance of cultural and biogeographical factors. *J. Ethnobiol Ethnomed.* **5**:40.

- Trotter, R.T. and Logan, M.H. (1998). Informant Consensus: a new approach for identifying potentially effective medicinal plants. **In:** *Plants in Indigenous Medicinal and Diet*. pp. 91-112 (Etkin, N.L. ed.). Redgrave publishing company, Bedford Hill, NY.
- Tsekpo, W.M.K. (1997). Application of ethnobotany. In: *Conservation and Utilization of Indigenous Medicinal plants and Wild Relatives of food crops*, UNESCO, Nairobi, Kenya. Pp.57-64.
- UNEP (United Nation Environmental Programme, 1995). Global Biodiversity assessment. Published for the United Nations Environmental Programme. Pp.552-574.
- UNEP (United Nation Environmental Programme, 2007). Global Environment Outlook 4: Environment for Development. United Nations Environment Programme. Progress Press, Valletta.
- UNDP (United Nations Development Programme, 2012). Guassa-Menz Community Conservation Area, Ethiopia. Equator Initiative Case Study Series. New York, NY.
- Van der Maarel, E. (Ed.). (2005). *Vegetation Ecology*. Blackwell Science Ltd. Victoria, Australia.
- Van der Maarel, E.; Espejel, I. and Moreno-Casasola, P. (1987). Two-step vegetation analysis based on very large datasets. *Vegetatio*. **68**: 139- 143.
- Voeks, R.A. (2007). Are women reservoirs of traditional plant knowledge? Gender, ethnobotany and globalization in northeast Brazil. *Singapore Journal of Tropical Geography* **28**:7-20.
- Von Breitenbach, F. (1962). National Forestry Development Planning: A Feasibility and Priority Study on the examples of Ethiopia. *Ethiop. For. Rev.*, **3**(4): 41-68.
- Warburton, H. and Martin, A. (1999). Local People's Knowledge: It's Contribution to Natural Resource Research and Development. In: *Decision Tools for Sustainable Development*, (Grant, I. and Sear, C., Eds). NRI, Chatham.
- Warren, D. M. (1991). Using Indigenous Knowledge in Agricultural Development. World Bank Discussion Paper No. 127. Washington, D. C., World Bank.
- White, F. (1983). The Vegetation of Africa. A descriptive memoir to accompany the UNESCO/AETFAT/UNSO. UNESCO, 356p.

- White, F. (1978). The Afromontane Region. In: *Biogeography and ecology of Africa*, Werger, M.J.A. (ed), Junk: *The Hague*. 463-513.
- Whittaker, R.H. (1972). Evolution and measurement of species diversity. *Taxon* **21**: 213-251.
- Whittaker, R.J., Willis, K.J. and Field, R. (2003). Climatic–energetic explanations of diversity: a macroscopic perspective. In *Macroecology: concepts and consequences*, Blackburn, T.M. and Gaston, K.J. (Eds), Cambridge University Press; Cambridge, 2003, pp. 107-129.
- WHO (2008). Traditional medicine fact sheet World Health Organization. № 34.
- Wright, C. W. (2005). Plant derived antimalarial agents: new leads and challenges. *Phytochemistry*, **4**: 55-61.
- Yadav, U., Ram C. P., Hugo A., and Emmanuel B. (2011). Plant biodiversity and ethnobotany inside the projected impact area of the Upper Seti Hydropower Project, Western Nepal. *Environ Dev Sustain* **13**: 463 - 492.
- Yared Yigezu, Demissew Berihun and Wubeante Yenet (2014). Ethnoveterinary medicines in four districts of Jimma zone, Ethiopia: cross sectional survey for plant species and mode of use. *BMC Veterinary Research* **10**(76): 1-12
- Zelalem Tefera, (2001). Common Property Resource Management of Afroalpine Habitat: Supporting a Population of a Critically Endangered Ethiopian Wolf (*Cannis simensis*), PhD. Thesis, Durrel, Institute of Conservation and Ecology, University of Kent, Canterberg.
- Zelalem Tefera, Coulson, T. and Beslsham, C. (2000). *Guassa biodiversity project*. Darwin's initiative for survival of species, London. Pp. 27.
- Zelalem Tefera, Nigel Leader-Williams and Tim Coulson. (2012). Consequences of Human Land Use for an Afroalpine Ecological Community in Ethiopia. *Conservation and Society* **10**(3): 209-16.
- Zemedede Asfaw (1997). Survey of Indigenous Food Plants, their preparations and HomeGardens in Ethiopia. *Indigenous Food Crops and Useful Plants*. Edited by Bede N.Okigbo, UNU/INRA Assessment Series No.: B6.

- Zemedede Asfaw (2001). The role of home gardens in production and conservation of medicinal plants. *Institute of Biodiversity Conservation and Research*, Addis Ababa.
- Zemedede Asfaw (2006). Towards a dynamic indigenous knowledge practice: Optimization of the uses and management of plant resources in the Drylands of Ethiopia. **In:** Nikundiwe, M, A. and Kabigumila, D.L.J (Eds). *Dryland ecosystem: challenges and opportunities for sustainable Natural Resources Management*. Proceedings of the Regional Workshop held at Arusha, Tanzania. pp. 64-67.
- Zemedede Asfaw and Tigst Wondimu (2007). Introduction to Ethnobiology: People and Biota. Addis Ababa University Press, Addis Ababa, Ethiopia.
- Zerihun Woldu (1985). Variation in Grassland Vegetation on the Central Plateau of Shewa, Ethiopia, in relation to edaphic factors and grazing conditions. Doctoral thesis, Uppsala University Dissertations Botanicae, 84, J. Cramer, Vaduz.
- Zerihun Woldu (1999). Forest in the vegetation types of Ethiopia and their status in the geographical context. *In:* Forest genetic resource conservation: Principles, strategies and actions. (Edwards, Taye Bekele and Haase, G.Eds). Workshop proceeding. Institute of Biodiversity Conservation and Research, and GTZ, Addis Ababa.
- Zerihun Woldu (2008). The Population, Health and Environment Nexus, The need for integration and networking. A background paper for the establishment and launching of PHE. Addis Ababa University. Pp. 34.
- Zerihun Woldu, Feoli, E. and Nigatu, L. (1989). Partitioning an elevational gradient of vegetation from southeastern Ethiopia by probabilistic methods. *Vegetation* **81**: 189-198.
- Zewdie Kassa, Zemedede Asfaw and Sebsebe Demissew (2016). Plant diversity and community analysis of the vegetation around Tulu Korma project centre, Ethiopia. *Tropica lplant research* **3**(2): 292–319.

## APPENDICES

### Appendix 1: Semi-structured interview questions employed in the ethnobotanical data collection, *Menz Gera* District

#### I. General information on respondents:

- Date \_\_\_\_\_ Kebele \_\_\_\_\_ name of interviewer Gebremicael Fisaha
- Name of the respondent \_\_\_\_\_ Gender: M\_\_ F\_\_ Age: \_\_\_\_\_
- Marital status: Married\_\_\_\_ widowed\_\_\_\_ divorced\_\_\_\_ single\_\_\_\_
- Religion: Orthodox\_\_ Muslim\_\_ Protestant\_\_ Other\_\_\_\_\_
- Educational status: Read and write? (Yes\_\_ grade\_\_ ; No\_\_); Experience year: \_\_\_\_\_

#### II. Ethnobotanical data

1. What are the main human health problems/diseases at your locality?
2. What are the main livestock health problems/diseases at your locality?
3. How do you diagnose each disease/health problem?
4. Symptom(s) of the disease/health problem
5. How do you control/prevent health problems/diseases?
6. Plants used to treat human health problems/diseases?

Local name of plants	Disease treated	Parts used	Habit	Habitat	Preparation	Application	Dosage (age, sex, pregnant)	Side effects	Antidotes	Code no.

#### 7. Plants used to treat livestock health problems/diseases?

Local name of plants	Disease treated	Parts used	Habit	Habitat	Preparation	Application	Dosage (age, sex, pregnant)	Side effects	Antidotes	Code no.

#### 8. Plants used to treat both human and livestock health problems/diseases?

Local name of plants	Disease treated	Parts used	Habit	Habitat	Preparation	Application	Dosage (age, sex, pregnant)	Side effects	Antidotes	Code no.

Habit: Tree (T) /shrub (Sh) /herb (H) /liana (L) /epiphyte (Ep)/semi-parasite (S-p)/ parasite (P)/aquatic (Aq)

Habitat: Wild or cultivated

9. Botanical name(s) to be filled in by the researcher:\_\_\_\_\_
10. Family name(s) to be completed by the researcher:\_\_\_\_\_
11. Brief description of the plant (by investigator/enumerator), including height, flower color, mature fruit color, mature seed color and other unique features
12. How widespread is/are the medicinal plant (s)? Easily obtained from home garden\_\_\_ /surrounding areas\_\_\_ /faraway places\_\_\_ (how far?\_\_\_) / purchased\_\_\_ [if purchased from individual at household\_\_\_ /market\_\_\_ (indicate name of market place\_\_\_\_\_)]
13. Plant part used in medicine: Root\_\_\_/stem\_\_\_/root bark\_\_\_/stem bark\_\_\_/leaves\_\_\_/small twigs with leaves\_\_\_/flowers\_\_\_/fruit\_\_\_/seed\_\_\_/whole\_\_\_ Others\_\_\_\_\_.
14. Used alone\_\_\_, mixed with water\_\_\_ /concoction\_\_\_ /decoction\_\_\_ other materials\_\_\_\_\_ Other\_\_\_\_\_
15. How plant parts are used: Fresh only\_\_\_ /dried only\_\_\_ /fresh\_\_\_ /dried\_\_\_ Other\_\_\_\_\_
16. Preparation for medicinal use: Crushed\_\_\_ /crushed and powdered\_\_\_ /extracted with cold water\_\_\_ /boiled (juice/latex)\_\_\_ Other\_\_\_\_\_
17. Dose/amount: \_\_\_\_\_
18. Any restriction or taboo in collecting and utilizing medicinal plants
19. How do you preserve traditional medicine?
20. For what other purposes do you use traditional medicinal plants? Food\_\_\_ /firewood\_\_\_ /charcoal\_\_\_ /fence\_\_\_ /house construction\_\_\_ furniture\_\_\_ /forage\_\_\_ /other \_\_\_\_\_
21. Are medicinal plants marketed/ marketable?
22. Which season of preferred for collection of medicinal plants in your area? Wet season, \_\_\_ Dry season\_\_\_, All the year round\_\_\_\_\_
23. Are there any threats to the medicinal plants? List out the main threats, starting with the most serious threat
24. From where do the medicinal plants collect? Home gardens \_\_\_\_, Followed land\_\_\_\_, Arable land\_\_\_\_, Forest\_\_\_\_\_
25. Which medicinal plants species are commonly threaten in the locality
26. How do you conserve traditional medicinal plants?
27. How is the knowledge on traditional medicine passed to a family member/younger generation?
28. From whom did you acquire the knowledge? How
29. To whom do you want to share your knowledge? If yes how
30. Availability of medicinal plants as compared to the past: More\_\_\_ same\_\_\_ less\_\_\_
31. How does modernization interfere with traditional medicinal knowledge?

## Appendix 2: Checklist of semi-structured interview question for key informants

1. Which of the following medicinal plants are most preferred in your area?

No	Plant species	Respondents						Total	Rank
		R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	R <sub>4</sub>	R <sub>5</sub>	...		
1									
2									
3									
4									
5									
6									
7									
8									

2. Which of the following medicinal plants have multiple uses?

No	Plant species	Uses						Total	Rank
		U <sub>1</sub>	U <sub>2</sub>	U <sub>3</sub>	U <sub>4</sub>	U <sub>5</sub>	...		
1									
2									
3									
4									
5									
6									
7									
8									

### Appendix 3: Checklist of semi-structured interview questions for ethnobotanical data collection from market places

#### *I. General information on Vendor:*

- Date \_\_\_\_\_ Location of market/Kebele \_\_\_\_\_ name of interviewer: Gebremicael Fisaha
- Name of the respondent \_\_\_\_\_ Gender: M \_\_\_ F \_\_\_ Age: \_\_\_\_\_
- Marital status: Married \_\_\_ widowed \_\_\_ divorced \_\_\_ single \_\_\_
- Religion: Orthodox \_\_\_ Muslim \_\_\_ Protestant \_\_\_ Other \_\_\_\_\_
- Type of vendor: Permanent \_\_\_ Temporal \_\_\_\_\_
- How often do they sell here? \_\_\_\_\_
- Educational status: Read and write? (Yes \_\_\_ grade \_\_\_; No \_\_\_); Service year: \_\_\_\_\_

#### *II. Ethnobotanical data*

1. Which medicinal plant species is commonly used to treat for both human and animal diseases in the study area?
2. Local name of medicinal plants \_\_\_\_\_
3. To be filled by the researcher: Botanical name \_\_\_\_\_ and Family name \_\_\_\_\_
4. Where do plants grow? In the wild \_\_\_\_\_ in home gardens \_\_\_\_\_ other \_\_\_\_\_
5. Plant parts used \_\_\_\_\_
6. Medicinal plant use condition: single \_\_\_\_\_ mixture \_\_\_\_\_ (list \_\_\_\_\_ )
7. Condition of medicinal plants: In Fresh \_\_\_\_\_, Dried \_\_\_\_\_, powdered \_\_\_\_\_
8. Estimated quantity: per single vendor \_\_\_\_\_ per whole market \_\_\_\_\_
9. Availability of medicinal plant species: in Sep \_\_\_\_\_, Oct \_\_\_\_\_, Nov \_\_\_\_\_, Dec \_\_\_\_\_, Jan \_\_\_\_\_, Feb \_\_\_\_\_, Mar \_\_\_\_\_, Apr \_\_\_\_\_, May \_\_\_\_\_, Jun \_\_\_\_\_, Jul \_\_\_\_\_, Aug \_\_\_\_\_
10. What is your measurement to sell? \_\_\_\_\_, How much you sell? \_\_\_\_\_
11. How much sold now \_\_\_\_\_ compare to past: More \_\_\_\_\_, Same \_\_\_\_\_, Less \_\_\_\_\_

#### Appendix 4: List of equipments and chemicals during research data collection

Name of equipment	Function
<i>Field materials</i>	
Diameter tape	Diameter at Breast Height (DBH)
Garmin GPS 60	Navigation and orientation of geographical position
Compass	Direction measurement
Suunto Clinometer	Tree height and slope measurement
Digital camera	Collection of photos
Rope	Tie specimen
Press set	Specimen press
Meter 50 meter size	Quadrat and tree height measurement
Plastic bag, aerated non plastic container, hard paper bag	Specimen collection and plant powder container
Note book, pencil, pen	For data record
First aid kit	For sudden injury treatment
Plant specimen and sample	For identification at herbarium and laboratory extraction
Ampicillin and Chloramphenicol	Positive control for plant extract test
DEMSO	Dilute extracts and use as negative control
Ethanol 80%	Solvent of specimen
Questionnaire	For ethnomedicinal plant respondents data collection
Labeling tag	Specimen labeling for identification
Nylon rope	For making quadrat
<i>Laboratory materials and chemicals</i>	
Metal Universal Miller	For grinding the sample
Pressure vacuum pump	For filtration macerated specimen
Incubator _ model: TBS3 ALC	For growing the microorganisms
Refrigerator _ model: RC-76Ws4sA	For preserving the microorganisms and the extract sample
laminar flow cabinet _ model: BS-H1300-D	clean air bench used to work in aseptic condition, reduce contamination
Autoclave _ model: YM-50A	For sterilization of the materials, and the media
Oven _ model: DHG-9203A	For drying the extract
Electronic balance _ model: ESJ 200-4	For weighing the sample, powder
Advanced microprocessor Uv-vis single beam spectrometer _ model: LI-295	For OD reading
Distiller _ model: BASIC /PH4	For collecting distilled water
Petridish	For culturing microorganisms in solid media
Conical flask	For boiling the media, for macerating the plant sample
Test tube	For culturing microorganisms in liquid media

<b>Name of equipment</b>	<b>Function</b>
Test tube rack	For holding the test tube
Vortex	For shaking well the microorganisms in the test tube during plating the organisms on the petridish
Hot plate	For source of heat during boiling the media
Measuring cylinder	For measuring distill water for hydration of solvents
Aluminum Foil	For covering the mouth of the flask, and covering forceps during sterilization
Micropipette	For dispensing accurate amount of sample
Forceps	For Applying the paper disk on the agar
Spatula	For holding, powder during weighing
Paper disk	For holding the plant extract during Applying on the agar
Bunsen burner	For source of heat during direct heat sterilization of forceps and spreader
Spreader	For spreading the organisms on the gar
Cuvette	For reading OD under spectrophotometer
Metal mortar and pistil	For crushing samples for extraction

**Appendix 5: Plant species collected from Menz Gera District**

R.No	Scientific Name	Family	Local Name(Amharic)	Habit	Found	Voucher №
1	<i>Abutilon longicuspe</i> Hochst. ex A. Rich.	Malvaceae	Nechlo	H	Y	GF11
2	<i>Achyranthes aspera</i> L.	Amaranthaceae	Demesech/ Telenj	H	G	GF112
3	<i>Adiantum capillus-veneris</i> L.	Adiantaceae	Yedngay lbs	H	B	GF44
4	<i>Adiantum poiretii</i> Wikstr.	Adiantaceae	Enchet lbs	H	Y	GF108
5	<i>Aeonium leucoblepharum</i> A. Rich	Crassulaceae	Yefyel dabe	H	Y	GF40
6	<i>Ageratum conyzoides</i> L.	Asteraceae		H	Y	GF83
7	<i>Alchemilla abyssinica</i> Fresen.	Rosaceae	Yemdr koso	H	B	GF25
8	<i>Allium sativum</i> L.	Alliaceae	Nech shnkurt	H	O	GF63
9	<i>Allophylus abyssinicus</i> (Hochst.) Radlk.	Sapindaceae	Embs	T	G	GF110
10	<i>Aloe debrana</i> Christian	Aloaceae	Wende Ret	S	B	GF10
11	<i>Aloe pulcherrima</i> Gilbert & Sebsebe	Aloaceae	Sete ret	S	B	GF126
12	<i>Anchusa affinis</i> R.Br. ex DC.**	Boraginaceae	Yewsha mlas	H	Y	GF32
13	<i>Andropogon abyssinicus</i> Fresen.	Poaceae	Gersa sar	H	B	GF201
14	<i>Andropogon amethystinus</i> Steud.	Poaceae	Dmalo	H	Y	GF12
15	<i>Anthemis tigreensis</i> J. Gay ex A. Rich.	Asteraceae	Chkugn	H	G	GF212
16	<i>Anthospermum herbaceum</i> L.f.	Rubiaceae		H	G	GF186
17	<i>Argemone mexicana</i> L.	Papaveraceae	Nech lebash	H	O	GF264
18	<i>Argyrolobium schimperianum</i> Hochst. ex A. Rich. **	Fabaceae		H	G	GF216
19	<i>Artemisia abyssinica</i> Sch. Bip. ex A. Rich.	Asteraceae	Chkugn	H	Y	GF60
20	<i>Asparagus africanus</i> Lam.	Asparagaceae	Kestencha/ Set kest	Li	B	GF16
21	<i>Asplenium aethiopicum</i> (Burm.f.) Bech. subsp. <i>aethiopicum</i>	Aspleniaceae	Enseferi	H	B	GF30
22	<i>Asplenium monanthes</i> L.	Aspleniaceae	Enseferi	H	B	GF119
23	<i>Asplenium protensum</i> Schrad.	Aspleniaceae	Enseferi	H	G	GF166
24	<i>Bartsia decurva</i> Hochst. ex Benth	Scrophulariaceae	Znjero tfr	S	Y	GF53
25	<i>Becium grandiflorum</i> (Lam.) Pic.Serm.	Lamiaceae	Muatsh	H	G	GF226
26	<i>Berberis holstii</i> Engl.	Berberidaceae	Znkila	S	B	GF05
27	<i>Bersama abyssinica</i> Fresen.	Meliantaceae	Azamr	T	B	GF148
28	<i>Bidens macroptera</i> (Sch. Bip. ex Chiov.) Mesfin **	Asteraceae	Adey abeba	H	B	GF68
29	<i>Bidens pilosa</i> L.	Asteraceae	Yeseytan wesfe	H	B	GF102
30	<i>Bidens prestinaria</i> (Sch.Bip.) Cufod.	Asteraceae	Adey abeba	H	B	GF122
31	<i>Bidens rueppellii</i> (Sch. Bip. ex Walp.) Sherff	Asteraceae	Adey Abeba	H	G	GF221
32	<i>Boswellia papyrifera</i> (Del.) Hochst	Burseraceae	Etan	T	O	GF248

33	<i>Brassica nigra</i> (L.) Koch	Brassicaceae	Senafich	H	O	GF245
34	<i>Brassica oleracea</i> L.	Brassicaceae	Tkl gomen	H	O	GF181
35	<i>Buddleja polystachya</i> Fresen.	Loganiaceae	Anfar	T	B	GF105
36	<i>Caesalpinia decapetala</i> (Roth) Alston	Fabaceae	Kentefa	S	G	GF237
37	<i>Calotropis procera</i> (Ait.) Ait. f.	Asclepiadaceae	Knbo/ Topia	S	O	GF263
38	<i>Calpurnia aurea</i> (Ait.) Benth.	Fabaceae	Dgta	S	G	GF131
39	<i>Canthium lactescens</i> Hiern	Rubiaceae	Seged	T	G	GF147
40	<i>Capparis tomentosa</i> Lam.	Capparidaceae	Gumaro	S	B	GF234
41	<i>Capsicum annuum</i> L.	Solanaceae	Kundo Berbere	H	O	GF279
42	<i>Capsicum frutescens</i> L.	Solanaceae	Mitmita	H	O	GF253
43	<i>Carduus schimperi</i> Sch. Bip. ex. A. Rich. subsp. <i>schimperi</i>	Asteraceae	Shekole	H	O	GF81
44	<i>Carissa spinarum</i> L.	Apocynaceae	Agam	S	G	GF146
45	<i>Carthamus tinctorius</i> L.	Asteraceae	Yeahya suf	H	O	GF182
46	<i>Catha edulis</i> (Vahl) Forssk. ex Endl.	Celastraceae	Chat	S	O	GF262
47	<i>Celtis africana</i> Burm.	Ulmaceae	Lanquata	T	G	GF180
48	<i>Cerastium octandrum</i> A. Rich.	Caryophyllaceae		H	G	GF199
49	<i>Ceropegia sobolifera</i> N.E. Br. **	Asclepiadaceae	Langochit hareg	H	Y	GF109
50	<i>Chenopodium ambrosioides</i> L.	Chenopodiaceae	Amedmado	H	O	GF267
51	<i>Cirsium dender</i> Friis **	Asteraceae	Tlku koshele	H	Y	GF97
52	<i>Cirsium schimperi</i> (Vatke) C. Jeffrey ex Cufod. **	Asteraceae	Yendr koshele	S	G	GF236
53	<i>Citrus aurantiifolia</i> (Christm.) Swingle	Rutaceae	Lomi	S	O	GF37
54	<i>Clausena anisata</i> (Willd.) Benth.	Rutaceae	Limich	S	O	GF140
55	<i>Clematis hirsuta</i> Perr. & Guill.**	Ranunculaceae	Azo Hareg	Li	Y	GF22
56	<i>Clematis simensis</i> Fresen.	Ranunculaceae	Azo hareg	Li	G	GF206
57	<i>Clerodendrum myricoides</i> (Hochst.) Vatke	Lamiaceae	Msrch	S	G	GF143
58	<i>Clutia abyssinica</i> Jaub.& Spach.	Euphorbiaceae	Fyele fej	S	B	GF95
59	<i>Coffea arabica</i> L.	Rubiaceae	Buna	S	O	GF282
60	<i>Colutia abyssinica</i> Kunth & Bouche	Fabaceae	Tuatuat	H	G	GF213
61	<i>Combretum molle</i> R. Br. ex G. Don	Combretaceae	Weyba	T	O	GF254
62	<i>Commelina africana</i> L.	Commelinaceae	Wefankur	H	B	GF13
63	<i>Convolvulus sagittatus</i> Thunb.	Convolvulaceae	Etse felatsut	H	O	GF265
64	<i>Conyza abyssinica</i> Sch. Bip. ex A. Rich. **	Asteraceae	Kuncha fej	H	G	GF158
65	<i>Conyza steudelii</i> Sch. Bip. ex A. Rich.	Asteraceae		H	G	GF193
66	<i>Conyza tigrensis</i> Oliv. & Hiern	Asteraceae		H	Y	GF88
67	<i>Crassula alba</i> Forssk.	Crassulaceae	Enzerezeyt	H	O	GF61
68	<i>Crassula vaginata</i> Eckl and Zeyh.	Crassulaceae	Kbe golgul	H	O	GF261
69	<i>Craterostigma pumilum</i> Hochst.	Scrophulariaceae	Sre bzu	H	G	GF188
70	<i>Crinum abyssinicum</i> Hochst. ex A.Rich.	Amaryllidaceae	Yejb shnkurt	H	B	GF240

71	<i>Croton macrostachyus</i> Del.	Euphorbiaceae	Bsana	T	G	GF161
72	<i>Cucumis ficifolius</i> A. Rich.	Cucurbitaceae	Yemdr embuay	H	O	GF260
73	<i>Cucurbita pepo</i> L.	Cucurbitaceae	Duba	H	O	GF233
74	<i>Cymbopogon martini</i> (Roxb.) Wats.	Poaceae	Tej sar	H	O	GF269
75	<i>Cynoglossum amplifolium</i> Hochst ex A.DC	Boraginaceae	Chegotot/ Ashkt	H	Y	GF31
76	<i>Cynoglossum coeruleum</i> Hochst. ex A.DC.	Boraginaceae	Chegotot	H	O	GF58
77	<i>Cynoglossum densefoliatum</i> Chiov.	Boraginaceae	Godelo	H	Y	GF76
78	<i>Cynoglossum lanceolatum</i> Forssk.	Boraginaceae	Chegotot	H	O	GF268
79	<i>Cyperus chlorotropis</i> (Steud.) Mattf. & Kuk.	Cyperaceae	Fila sar	H	Y	GF33
80	<i>Cyperus fischerianus</i> A.Rich.	Cyperaceae	Gcha	H	B	GF99
81	<i>Cyperus longus</i> L.	Cyperaceae	Gcha	H	B	GF200
82	<i>Cyphostemma adenocaula</i> (Steud. ex A. Rich.) Descoings ex Wild & Drummond	Vitaceae	Aserkush tebetebkush	H	G	GF196
83	<i>Cyphostemma junceum</i> (Webb) Descoings ex Wild & Drummond	Vitaceae	Etse zwe	H	O	GF247
84	<i>Datura stramonium</i> L.	Solanaceae	Etse faris/ astenagr	H	O	GF47
85	<i>Daucus carota</i> L.	Apiaceae	Carot	H	O	GF270
86	<i>Debregeasia saeneb</i> (Forssk.) Hepper & Wood	Urticaceae	Ashesho	S	G	GF154
87	<i>Delphinium wellbyi</i> Hemsl.	Ranunculaceae		H	B	GF222
88	<i>Desmodium repandum</i> (Vahl) DC.	Fabaceae	Hareg	H	G	GF120
89	<i>Discopodium penninervium</i> Hochst.	Solanaceae	Ameraro	S	B	GF19
90	<i>Dodonea angustifolia</i> L.F.	Sapindaceae	Ktkta	S	B	GF92
91	<i>Dombeya torrida</i> (J.F. Gmel.) P. Bamps	Sterculiaceae	Wlkfa	S	G	GF177
92	<i>Dovyalis abyssinica</i> (A. Rich.) Warb.	Flacourtiaceae	Koshm	S	G	GF162
93	<i>Dovyalis verrucosa</i> (Hochst.) Warb.	Flacourtiaceae	Mnytm	S	G	GF141
94	<i>Dryopteris rodolfii</i> J.P.Roux	Dryopteridaceae	Etseanbesa	H	O	GF219
95	<i>Duranta erecta</i> L.	Verbenaceae	Muatsh	S	O	GF150
96	<i>Echinops kebericho</i> Mesfin **	Asteraceae	Kebercho	H	Y	GF210
97	<i>Echinops longisetus</i> A. Rich. **	Asteraceae	Koshele	S	O	GF271
98	<i>Echinops macrochaentus</i> Fresen	Asteraceae	Koshele	H	Y	GF241
99	<i>Echinops pappii</i> Chiov.	Asteraceae	Koshele	H	B	GF49
100	<i>Ekebergia capensis</i> Sparm.	Meliaceae	Lol	T	B	GF01
101	<i>Eleusine floccifolia</i> (Forssk.) Spreng.	Poaceae	Akrma	H	G	GF191
102	<i>Epilobium hirsutum</i> L.	Onagraceae	Unknown	H	Y	GF55
103	<i>Eragrostis schweinfurthii</i> Chiov.	Poaceae	Sar	H	G	GF14
104	<i>Erica arborea</i> L.	Ericaceae	Asta	S	B	GF07
105	<i>Erucastrum abyssinicum</i> (A. Rich) R. E. Fries	Brassicaceae	Yewefe	H	G	GF195
106	<i>Erucastrum arabicum</i> Fisch. & Mey.	Brassicaceae	Wef ankur	H	G	GF66
107	<i>Erythrina brucei</i> Schweinf. **	Fabaceae	Korch	T	G	GF156

108	<i>Eucalyptus globulus</i> Labill.	Myrtaceae	Nech bahrzaf	T	O	GF280
109	<i>Euclea racemosa</i> Murr. subsp. <i>schimperi</i> (A. DC.) White	Ebenaceae	Dedeho	S	O	GF246
110	<i>Euphorbia abyssinica</i> Gmel.	Euphorbiaceae	Kulqual	T	G	GF197
111	<i>Euphorbia ampliphylla</i> Pax	Euphorbiaceae	Qulqual	T	G	GF155
112	<i>Euphorbia petitiana</i> A. Rich.	Euphorbiaceae	Meret aly yemitegna	H	O	GF54
113	<i>Euphorbia platyphyllos</i> L.	Euphorbiaceae	Anterfa	H	G	GF79
114	<i>Euryops antinorii</i> (Avetta) S. Moore **	Asteraceae	Chare	H	Y	GF77
115	<i>Euryops pinifolius</i> A. Rich. **	Asteraceae	Chranfe	S	Y	GF73
116	<i>Ferula communis</i> L.	Apiaceae	Dog	H	Y	GF84
117	<i>Festuca macrophylla</i> Hochst.ex A. Rich.	Poaceae	Guasa	H	Y	GF75
118	<i>Festuca richardii</i> Alexeev.	Poaceae	Chebere/ gausa	H	Y	GF57
119	<i>Ficus carica</i> L.	Moraceae	Beles zaf	S	O	GF257
120	<i>Ficus sur</i> Forsk.	Moraceae	Shola	T	G	GF151
121	<i>Foeniculum vulgare</i> Mill.	Apiaceae	Enslal	H	O	GF274
122	<i>Galiniera saxifraga</i> (Hochst.) Bridson	Rubiaceae	Tota kula	T	B	GF98
123	<i>Galium simense</i> Fresen.	Rubiaceae	Ashkt	H	Y	GF27
124	<i>Geigeria alata</i> (DC.) Benth. & Hook. f. ex Oliv. & Hiern	Asteraceae	Yekola mdr koso	H	G	GF121
125	<i>Geranium aculeolatum</i> Olive.	Geraniaceae	Wef ankur	H	G	GF238
126	<i>Geranium arabicum</i> Forssk.	Geraniaceae	Wef ankur	H	G	GF130
127	<i>Geranium ocellatum</i> Cambess.	Geraniaceae	Yekura wesfe	H	G	GF209
128	<i>Gladiolus abyssinicus</i> (Brongn. ex Lemaire) Goldblatt & de Vos	Iridaceae	Metete	H	Y	GF96
129	<i>Gomphocarpus fruticosus</i> (L.) Ait. f. subsp. <i>flavidus</i> (N.E. Br.) Goyder	Asclepiadaceae	Yetnchel wetet	H	G	GF157
130	<i>Guizotia scabra</i> (Vis.) Chiov.	Asteraceae	Mech	H	G	GF214
131	<i>Guizotia schimperi</i> Sch. Bip. ex Walp.	Asteraceae	Mech	H	G	GF160
132	<i>Hagenia abyssinica</i> (Bruce) J.F.Gmel.	Rosaceae	Koso	T	B	GF18
133	<i>Helichrysum forsskahlii</i> (J.F. Gmel.) Hilliard & Burt	Asteraceae	Chare	H	B	GF70
134	<i>Helichrysum splendidum</i> (Thunb.) Less.	Asteraceae	Nechlo	H	B	GF80
135	<i>Helichrysum stenopterum</i> DC.	Asteraceae	Nechlo	H	Y	GF218
136	<i>Heteromorpha arborescens</i> (Spreng.) Cham. & Schldl.	Apiaceae	Yejb mrkuz	S	B	GF135
137	<i>Hordeum vulgare</i> L.	Poaceae	Gebbs	H	O	GF278
138	<i>Hyparrhenia anthistirioides</i> (Hochst. ex A. Rich.)	Poaceae	Senbelet	H	B	GF132
139	<i>Hyparrhenia hirta</i> (L.) Stapf	Poaceae	Fura sembelet	H	G	GF184
140	<i>Hypericum quartinianum</i> A. Rich.	Hypericaceae	Ameja	S	O	GF118
141	<i>Hypericum revolutum</i> Vahl	Hypericaceae	Ameja	S	Y	GF20

142	<i>Hypoestes forskalii</i> (Vahl) R. Br.	Acanthaceae	Yeznjero berbere	H	G	GF133
143	<i>Impatiens rothii</i> Hook. f.	Balsaminaceae	Gshrt/Enso sula	H	B	GF15
144	<i>Inula confertiflora</i> A. Rich. **	Asteraceae	Eja/ Weynagft	H	B	GF207
145	<i>Ipomoea tenuirostris</i> Choisy	Convolvulaceae	Yeayt hareg	H	B	GF45
146	<i>Jasminum abyssinicum</i> Hochets. Ex DC.	Oleaceae	Tembelelel	Li	G	GF124
147	<i>Jasminum stans</i> Pax **	Oleaceae	Tegeg	S	G	GF185
148	<i>Juniperus procera</i> Hochst. ex Endl.	Cuperssaceae	Tsd	T	B	GF50
149	<i>Justicia schimperiana</i> (Hochst. ex Nees) T. Anders.	Acanthaceae	Sensel (Semiza)	S	O	GF244
150	<i>Kalanchoe citrina</i> Schweinfurth.	Crassulaceae	Boter	H	G	GF172
151	<i>Kalanchoe marmorata</i> Bak.	Crassulaceae	Endahula/ nech	H	G	GF115
152	<i>Kalanchoe petitiiana</i> A. Rich.	Crassulaceae	Boter	H	G	GF138
153	<i>Kniphofia foliosa</i> Hochst.**	Asphodelaceae	Zblble	H	Y	GF74
154	<i>Kniphofia isoetifolia</i> Steud.ex Hochst **	Asphodelaceae	Abelbila tnshu	H	G	GF204
155	<i>Lactuca glandulifera</i> Hook.f.	Asteraceae		H	G	GF159
156	<i>Lactuca inermis</i> Forssk.	Asteraceae		H	Y	GF86
157	<i>Lagenaria siceraria</i> (Molina) Standl.	Cucurbitaceae	Kil	H	O	GF258
158	<i>Laggera tomentosa</i> (Sch. Bip. ex A. Rich.) Olivo & Hiern	Asteraceae	Keskeso	S	G	GF153
159	<i>Lens culinaris</i> Medik.	Fabaceae	Msr	H	O	GF113
160	<i>Lens ervoides</i> (Brign.) Grande	Fabaceae	Yeayt msr	H	G	GF215
161	<i>Leonotis ocyimifolia</i> (Burm. f.) Iwarsson	Lamiaceae	Ras kmr	S	B	GF100
162	<i>Lepidium sativum</i> L.	Brassicaceae	Feto	H	O	GF256
163	<i>Lepisorus excavatus</i> (Willd.) Ching	Polypodiaceae	Yeenchet lbs	H	Y	GF104
164	<i>Linum usitatissimum</i> L.	Linaceae	Telba	H	O	GF127
165	<i>Lippia adoensis</i> Hochst. ex Walp.	Verbenaceae	Kese	S	G	GF114
166	<i>Lobelia rynchopetalum</i> Hemsl.	Lobeliaceae	Jbra	S	B	GF71
167	<i>Lotus schoelleri</i> Schweinf.	Fabaceae	Yeayt msr	H	B	GF67
168	<i>Lycopersicon esculentum</i> Mill.	Solanaceae	Timatim	H	O	GF249
169	<i>Maesa lanceolata</i> Forssk.	Myrsinaceae	Kelewa	S	G	GF149
170	<i>Malva verticillata</i> L.	Malvaceae	Lut	H	G	GF223
171	<i>Maytenus arbutifolia</i> (A.Rich.) Wilczek	Celastraceae	Atat tnshu	S	B	GF24
172	<i>Maytenus gracilipes</i> (Welw. ex Oliv.) Exell subsp. <i>arguta</i> (Loes.) Sebsebe	Celastraceae	Damza	S	G	GF144
173	<i>Maytenus obscura</i> (A. Rich.) Cuf.	Celastraceae	Atat tlku	S	G	GF64
174	<i>Medicago polymorpha</i> L.	Fabaceae	Maget	H	G	GF208
175	<i>Millettia ferruginea</i> (Hochst.) Bak. subsp. <i>ferruginea</i> **	Fabaceae	Brbra	T	O	GF220
176	<i>Minuartia filifolia</i> (Forssk.) Mattf.	Caryophyllaceae	Chfrg	H	B	GF163
177	<i>Momordica foetida</i> Schumach.	Cucurbitaceae	Kura hareg	H	O	GF255

178	<i>Myrica salicifolia</i> A.Rich.	Myricaceae	Shnet	T	B	GF93
179	<i>Myrsine africana</i> L.	Myrsinaceae	Kecho	S	B	GF06
180	<i>Nicotiana tabacum</i> L.	Solanaceae	Tinbaho	S	O	GF273
181	<i>Nigella sativa</i> L.	Ranunculaceae	Tkur kmem	H	O	GF78
182	<i>Nuxia congesta</i> R. Br. ex Fresen.	Loganiaceae	Atkuar	T	B	GF123
183	<i>Ocimum lamiifolium</i> Hochst. ex Benth.	Lamiaceae	Demekase	H	O	GF277
184	<i>Oenanthe palustris</i> (Chiov.) Norman	Apiaceae	Gudgn/Etse siol	H	O	GF235
185	<i>Olea capensis</i> L. subsp. <i>macrocarpa</i> (C.A. Wright.) Verdc.	Oleaceae	Damot weyra	T	G	GF164
186	<i>Olea europaea</i> L. subsp. <i>cuspidata</i> (Wall. ex G. Don.) cif.	Oleaceae	Weyra	T	B	GF03
187	<i>Olinia rochetiana</i> A. Juss.	Oliniaceae	Tfe	T	B	GF89
188	<i>Oplismenus hirtellus</i> (L.) P. Beauv.	Poaceae	Sar	H	B	GF116
189	<i>Oplismenus undulatifolius</i> (Ard.) Roem. & Schult.	Poaceae	Sar	H	G	GF211
190	<i>Opuntia ficus-indica</i> (L.) Miller	Cactaceae	Beles	S	O	GF41
191	<i>Oreoschimperella verrucosa</i> (A. Rich.) Rauschert	Apiaceae	Sar	H	B	GF203
192	<i>Osteospermum vaillantii</i> (Decne) T. Norl.	Asteraceae		Li	B	GF205
193	<i>Osyris quadripartita</i> Decn.	Santalaceae	Keret	S	B	GF04
194	<i>Otostegia integrifolia</i> Benth.	Lamiaceae	Tnjut	S	B	GF165
195	<i>Pennisetum sphacelatum</i> (Nees) Th. Dur. & Schinz	Poaceae	Sendedo	H	G	GF192
196	<i>Pennisetum purpureum</i> Schumach.	Poaceae	Elefant gras	H	G	GF187
197	<i>Pennisetum thunbergii</i> Kunth	Poaceae	Sndedo/ Gta	H	B	GF87
198	<i>Pennisetum villosum</i> Fresen.	Poaceae	Engcha	H	B	GF94
199	<i>Pentarrhinum insipidum</i> E. Mey.	Asclepiadaceae	Tekula wetet	H	O	GF275
200	<i>Periploca linearifolia</i> Quart.-Dill. & A. Rich.	Asclepiadaceae	Moyder hareg	Li	G	GF183
201	<i>Peucedanum winkleri</i> H. Wolff	Apiaceae	Kereshashm bo	H	B	GF28
202	<i>Phagnalon quartinianum</i> A. Rich. **	Asteraceae	Nbasl	S	Y	GF43
203	<i>Physalis peruviana</i> L.	Solanaceae	Grfat	H	G	GF225
204	<i>Phytolacca dodecandra</i> L'Herit.	Phytolaccaceae	Endod	Li	G	GF175
205	<i>Piper nigrum</i> L.	Piperaceae	Kundo Berbere	H	O	GF198
206	<i>Pittosporum viridiflorum</i> Sims.	Pittosporaceae	Weyl	S	G	GF229
207	<i>Plantago lanceolata</i> L.	Plantaginaceae	Gorteb	H	O	GF252
208	<i>Plectrocephalus varians</i> (A. Rich.) C. Jeffrey ex Cufod. **	Asteraceae		H	B	GF90
209	<i>Plectranthus cylindraceus</i> Hochst. ex Benth.	Lamiaceae	Tibtibo	H	O	GF243
210	<i>Plectranthus longipes</i> Baker	Lamiaceae	Yemch/ Ayderke	H	Y	GF82

211	<i>Plectranthus ornatus</i> Codd	Lamiaceae	Yekola ayderke	H	G	GF179
212	<i>Poa simensis</i> Hochst. ex A. Rich. **	Poaceae	Yekok sar	H	B	GF26
213	<i>Podocarpus falcatus</i> (Thunb.) R. B ex Mirb.	Podocarpaceae	Zgba	T	G	GF129
214	<i>Polygala rupicola</i> A.Rich. **	Polygalaceae	Etse lbona	H	G	GF194
215	<i>Polygala steudneri</i> Chod.	Polygalaceae		H	G	GF128
216	<i>Polygonum aviculare</i> L.	Polygonaceae	Yetja sga	H	Y	GF103
217	<i>Polyscias fulva</i> (Hiern) Harms	Araliaceae	Znjero wenber	T	G	GF171
218	<i>Prunus africana</i> (Hook. f.) Kalkm.	Rosaceae	Tkur enchet	T	B	GF56
219	<i>Pteris cretica</i> L.	Pteridaceae	Enseferi	H	B	GF173
220	<i>Punica granatum</i> L.	Punicaceae	Roman	T	O	GF101
221	<i>Rhamnus prinoides</i> L 'Herit.	Rhamnaceae	Gesho	S	G	GF136
222	<i>Rhus glutinosa</i> A.Rich. Subsp <i>neoglutinosa</i> (M. Gilbert) M.Gilbert **	Anacardiaceae	Tlem	T	G	GF111
223	<i>Rhus natalensis</i> Krauss	Anacardiaceae	Busi	T	G	GF169
224	<i>Rhus quartiniana</i> A.Rich.	Anacardiaceae	Takma	T	G	GF230
225	<i>Rhus vulgaris</i> Meikle	Anacardiaceae		S	G	GF125
226	<i>Rhynchosia elegans</i> A. Rich.	Fabaceae	Yeayt hareg	H	G	GF142
227	<i>Rosa abyssinica</i> Lindley	Rosaceae	Kega	S	B	GF02
228	<i>Rubus apetalus</i> Poir.	Rosaceae	Enjori	Li	Y	GF35
229	<i>Rubus steudneri</i> Schweinf.	Rosaceae	Yekola enjori	Li	G	GF168
230	<i>Rumex abyssinicus</i> Jacq.	Polygonaceae	Mekmeko	H	Y	GF39
231	<i>Rumex nepalensis</i> Spreng.	Polygonaceae	Tult	H	Y	GF46
232	<i>Rumex nervosus</i> Vahl	Polygonaceae	Embacho	S	B	GF62
233	<i>Ruta chalepensis</i> L.	Rutaceae	Tena adam	H	O	GF65
234	<i>Salix subserrata</i> Willd.	Salicaceae	Akeya	H	B	GF239
235	<i>Salvia merjamie</i> Forssk.	Lamiaceae	Hulegeb	H	B	GF34
236	<i>Salvia nilotica</i> Jacq.	Lamiaceae	Hule geb	H	Y	GF21
237	<i>Salvia schimperi</i> Benth.	Lamiaceae		H	Y	GF224
238	<i>Sansevieria ehrenbergii</i> Schweinf. ex Baker	Dracaenaceae	Wende kacha	H	O	GF36
239	<i>Satureja abyssinica</i> (Benth.) Briq.	Lamiaceae	Yelomi eshet	H	B	GF85
240	<i>Satureja punctata</i> (Benth.) Briq. subsp. <i>punctata</i>	Lamiaceae		H	Y	GF52
241	<i>Scabiosa columbaria</i> L.	Dipsacaceae	Yetja zago	H	G	GF190
242	<i>Schefflera abyssinica</i> (Hochst. ex A. Rich.) Harms	Araliaceae	Ntem	T	O	GF259
243	<i>Schinus molle</i> L.	Anacardiaceae	Kundo Berbere zaf	T	O	GF266
244	<i>Schoenoplectus corymbosus</i> (Roem. & Schult.) Rayn.	Cyperaceae	Ketema sar	H	Y	GF69
245	<i>Securidaca longepedunculata</i> Fresen.	Polygalaceae	Etse menahe	S	O	GF272

246	<i>Senna didymobotrya</i> (Fresen.) Irwin & Barneby	Fabaceae	Yeferenj dgta	S	G	GF152
247	<i>Sesamum orientale</i> L.	Pedaliaceae	Selit	H	O	GF250
248	<i>Sideroxylon oxyacanthum</i> Baill.	Sapotaceae	Damza	S	G	GF231
249	<i>Silene macrosolen</i> A. Rich	Caryophyllaceae	Wegert	H	G	GF232
250	<i>Smilax aspera</i> L.	Smilacaceae	Ashkla	Li	B	GF137
251	<i>Solanecio gigas</i> (Vatke) C. Jeffrey **	Asteraceae	Yeshkoko gomen	H	Y	GF48
252	<i>Solanum benderianum</i> Schimper ex Dammer	Solanaceae	Babute	Li	B	GF23
253	<i>Solanum incanum</i> L.	Solanaceae	Zert embuay	S	G	GF178
254	<i>Solanum marginatum</i> L.f.	Solanaceae	Embuay tlku	S	G	GF170
255	<i>Sonchus melanolepis</i> Fresen.	Asteraceae		H	G	GF134
256	<i>Sphenoslylis stenocarpa</i> (Hochst. ex A. Rich.)	Fabaceae	Yeayt hareg	H	O	GF117
257	<i>Sporobolus africanus</i> (Poir) Robyns & Tournay	Poaceae	Sar	H	G	GF217
258	<i>Stachys alpigena</i> T.C.E. Fr. subsp. <i>longipetala</i> Sebsebe.	Lamiaceae		H	Y	GF29
259	<i>Stephania abyssinica</i> (Dillon & A. Rich.) Walp.	Menispermaceae	Engochit hareg	H	O	GF17
260	<i>Tagetes minuta</i> L.	Asteraceae	Gme	H	B	GF176
261	<i>Tephrosia interrupta</i> Hochst. & Steud ex Engl.	Fabaceae	Gerengere	H	G	GF107
262	<i>Thymus schimperi</i> Ronniger subsp. <i>schimperi</i>	Lamiaceae	Tosign	H	B	GF08
263	<i>Toddalia asiatica</i> (L.) Lam.	Rutaceae	Gumaro	Li	G	GF145
264	<i>Trachyspermum ammi</i> (L.) Sprague ex Turrill	Apiaceae	Nech kmem	H	O	GF228
265	<i>Tragia brevipes</i> Pax	Euphorbiaceae	Ablalit	H	B	GF139
266	<i>Trifolium semipilosum</i> Fresen.	Fabaceae	Yegrsha	H	O	GF281
267	<i>Trifolium simense</i> Fresen.	Fabaceae	Maget	H	B	GF59
268	<i>Trigonella foenum-graecum</i> L.	Fabaceae	Absh	H	O	GF38
269	<i>Triticum aestivum</i> L.	Poaceae	Snde	H	O	GF51
270	<i>Triticum aethiopicum</i> Jakubz. **	Poaceae	Snde	H	O	GF283
271	<i>Urera hypselodendron</i> (A.Rich.) Weed.	Urticaceae	Lankuso	Li	G	GF174
272	<i>Urtica simensis</i> Steudel	Urticaceae	Sama	H	B	GF106
273	<i>Verbascum sinaiticum</i> Benth.	Scrophulariaceae	Yeahya jero/Ketetna	H	Y	GF72
274	<i>Verbena officinalis</i> L.	Verbenaceae	Atuch	H	O	GF251
275	<i>Vernonia amygdalina</i> Del.	Asteraceae	Grawa	S	G	GF202
276	<i>Vernonia hochstetteri</i> Sch. Bip. ex Walp.	Asteraceae	Wzgn	S	G	GF189
277	<i>Vernonia leopoldi</i> (Sch. Bip. ex Walp.) Vatke **	Asteraceae	Demesech/c hibo	T	G	GF227
278	<i>Vernonia urticifolia</i> A.Rich	Asteraceae		S	G	GF167
279	<i>Vicia faba</i> L.	Fabaceae	Bakela	H	O	GF276
280	<i>Vitis vinifera</i> L.	Vitaceae	Weyn	Li	O	GF09

281	<i>Withania somnifera</i> (L.) Dun.	Solanaceae	Gzewa	S	G	GF242
282	<i>Xanthium spinosum</i> L.	Asteraceae	Yeset mlas	H	Y	GF91
283	<i>Zehneria scabra</i> (L.f.) Sond	Cucurbitaceae	Buhe hareg	H	B	GF42
284	<i>Zingiber officinale</i> Roscoe	Zingiberaceae	Znjbl	H	O	GF284

**Key:** B: Species found at both forests; G: Species found at *Gajilo*; O: Species collected for

Medicinal purpose out of the natural forests Y: Species found at *Yegana*

H: Herb; S: Shrub; Li: Lianas; T: Tree; \*\*: Endemic species to Ethiopia

**Appendix 6: Plant species collected from Yegana and Gajilo natural forest patches**

R.No	Scientific Name	Family	Local Name (Amharic)	Habit
1	<i>Abutilon longicuspe</i>	Malvaceae	Nechlo	H
2	<i>Achyranthes aspera</i>	Amaranthaceae	Demesech/ Telenj	H
3	<i>Adiantum capillus-veneris</i>	Adiantaceae	Yedngay lbs	H
4	<i>Adiantum poiretii</i>	Adiantaceae	Enchet lbs	H
5	<i>Aeonium leucoblepharum</i>	Crassulaceae	Yefyel dabe	H
6	<i>Ageratum conyzoides</i>	Asteraceae	Unknown	H
7	<i>Alchemilla abyssinica</i>	Rosaceae	Yemdr koso	H
8	<i>Allophylus abyssinicus</i>	Sapindaceae	Embs	T
9	<i>Aloe debrana</i> **	Aloaceae	Wende Ret	H
10	<i>Aloe pulcherrima</i> **	Aloaceae	Sete ret	H
11	<i>Anchusa affinis</i> **	Boraginaceae	Grfat	H
12	<i>Andropogon abyssinicus</i>	Poaceae	Gersa sar	H
13	<i>Andropogon amethystinus</i>	Poaceae	Dmalo	H
14	<i>Anthemis tigreensis</i>	Asteraceae	Chkugn	H
15	<i>Anthospermum herbaceum</i>	Rubiaceae	Unknown	H
16	<i>Argyrolobium schimperianum</i> **	Fabaceae	Unknown	S
17	<i>Artemisia abyssinica</i>	Asteraceae	Chkugn	H
18	<i>Asparagus africanus</i>	Asparagaceae	Kestencha/ Set kest	Li
19	<i>Asplenium aethiopicum</i> subsp. <i>aethiopicum</i>	Aspleniaceae	Enseferi	H
20	<i>Asplenium monanthes</i>	Aspleniaceae	Enseferi	H
21	<i>Asplenium protensum</i>	Aspleniaceae	Enseferi	H
22	<i>Bartsia decurva</i>	Scrophulariaceae	Znjero tfr	S
23	<i>Becium grandiflorum</i>	Lamiaceae	Muatsh	H
24	<i>Berberis holstii</i>	Berberidaceae	Znkila	S
25	<i>Bersama abyssinica</i>	Meliantaceae	Azamr	T
26	<i>Bidens macroptera</i> **	Asteraceae	Adey abeba	H
27	<i>Bidens pilosa</i>	Asteraceae	Yeseytan wesfe	H
28	<i>Bidens prestinaria</i>	Asteraceae	Adey abeba	H
29	<i>Bidens rueppellii</i>	Asteraceae	Adey Abeba	H
30	<i>Buddleja polystachya</i>	Loganiaceae	Anfar	T
31	<i>Caesalpinia decapetala</i>	Fabaceae	Kentefa	S
32	<i>Calpurnia aurea</i>	Fabaceae	Dgta	S
33	<i>Canthium lactescens</i>	Rubiaceae	Seged	T
34	<i>Capparis tomentosa</i>	Capparidaceae	Gumaro	S
35	<i>Carissa spinarum</i>	Apocynaceae	Agam	S
36	<i>Celtis africana</i>	Ulmaceae	Lanquata	T
37	<i>Cerastium octandrum</i>	Caryophyllaceae	Unknown	H
38	<i>Ceropegia sobolifera</i> **	Asclepiadaceae	Langochit hareg	H
39	<i>Cirsium dender</i> **	Asteraceae	Tlku koshele	H

40	<i>Cirsium schimperi</i> **	Asteraceae	Yemdr koshele	H
41	<i>Clematis hirsuta</i> **	Ranunculaceae	Azo Hareg	Li
42	<i>Clematis simensis</i>	Ranunculaceae	Azo hareg	Li
43	<i>Clerodendrum myricoides</i>	Lamiaceae	Msrch	S
44	<i>Clutia abyssinica</i>	Euphorbiaceae	Fyele fej	S
45	<i>Colutea abyssinica</i>	Fabaceae	Tuatuete	S
46	<i>Commelina africana</i>	Commelinaceae	Wefankur	H
47	<i>Conyza abyssinica</i> **	Asteraceae	Kuncha fej	H
48	<i>Conyza steudelii</i>	Asteraceae	Unknown	H
49	<i>Conyza tigrensis</i>	Asteraceae	Unknown	H
50	<i>Craterostigma pumilum</i>	Scrophulariaceae	Sre bzu	H
51	<i>Crinum abyssinicum</i>	Amaryllidaceae	Yejb shnkurt	H
52	<i>Croton macrostachyus</i>	Euphorbiaceae	Bsana	T
53	<i>Cynoglossum amplifolium</i>	Boraginaceae	Chegot/ Ashkt	H
54	<i>Cynoglossum densefoliatum</i>	Boraginaceae	Godelo	H
55	<i>Cyperus chlorotropis</i>	Cyperaceae	Fila sar	H
56	<i>Cyperus fischerianus</i>	Cyperaceae	Gcha	H
57	<i>Cyperus longus</i>	Cyperaceae	Gcha	H
58	<i>Cyphostemma adenocaulis</i>	Vitaceae	Aserkush tebetbkush	H
59	<i>Debregeasia saeneb</i>	Urticaceae	Ashesho	S
60	<i>Delphinium wellbyi</i>	Ranunculaceae	Unknown	H
61	<i>Desmodium repandum</i>	Fabaceae	Hareg	H
62	<i>Discopodium penninervium</i>	Solanaceae	Ameraro	S
63	<i>Dodonea angustifolia</i>	Sapindaceae	Ktkta	S
64	<i>Dombeya torrida</i>	Sterculiaceae	Wlkfa	S
65	<i>Dovyalis abyssinica</i>	Flacourtiaceae	Koshm	S
66	<i>Dovyalis verrucosa</i>	Flacourtiaceae	Mnytm	S
67	<i>Echinops kebericho</i> **	Asteraceae	Kebercho	H
68	<i>Echinops macrochaentus</i>	Asteraceae	Koshele Meka	H
69	<i>Echinops pappii</i>	Asteraceae	Koshele mekakelegna	H
70	<i>Ekebergia capensis</i>	Meliaceae	Lol	T
71	<i>Eleusine floccifolia</i>	Poaceae	Akrma	H
72	<i>Epilobium hirsutum</i>	Onagraceae	Unknown	H
73	<i>Eragrostis schweinfurthii</i>	Poaceae	Sar	H
74	<i>Erica arborea</i>	Ericaceae	Asta	S
75	<i>Erucastrum abyssinicum</i>	Brassicaceae	Yewefe	H
76	<i>Erucastrum arabicum</i>	Brassicaceae	Wef ankur	H
77	<i>Erythrina brucei</i> **	Fabaceae	Korch	T
78	<i>Euphorbia abyssinica</i>	Euphorbiaceae	Kulqual	T
79	<i>Euphorbia ampliphylla</i>	Euphorbiaceae	Qulqual	T
80	<i>Euphorbia platyphyllos</i>	Euphorbiaceae	Anterfa	H
81	<i>Euryops antinorii</i> **	Asteraceae	Chare	H
82	<i>Euryops pinifolius</i> **	Asteraceae	Chranfe	S

83	<i>Ferula communis</i>	Apiaceae	Dog	H
84	<i>Festuca macrophylla</i>	Poaceae	Guasa	H
85	<i>Festuca richardii</i>	Poaceae	Chebere/ gausa	H
86	<i>Ficus sur</i>	Moraceae	Shola	T
87	<i>Galiniera saxifraga</i>	Rubiaceae	Tota kula	T
88	<i>Galium simense</i>	Rubiaceae	Ashkt	H
89	<i>Geigeria alata</i>	Asteraceae	Yekola mdr koso	H
90	<i>Geranium aculeolatum</i>	Geraniaceae	Wef ankur	H
91	<i>Geranium arabicum</i>	Geraniaceae	Wef ankur	H
92	<i>Geranium ocellatum</i>	Geraniaceae	Yekura wesfe	H
93	<i>Gladiolus abyssinicus</i>	Iridaceae	Metete	H
94	<i>Gomphocarpus fruticosus</i> subsp. <i>flavidus</i>	Asclepiadaceae	Yetnchel wetet	H
95	<i>Guizotia scabra</i>	Asteraceae	Mech	H
96	<i>Guizotia schimperi</i>	Asteraceae	Mech	H
97	<i>Hagenia abyssinica</i>	Rosaceae	Koso	T
98	<i>Helichrysum forsskahlii</i>	Asteraceae	Chare	H
99	<i>Helichrysum splendidum</i>	Asteraceae	Nechlo	H
100	<i>Helichrysum stenopterum</i>	Asteraceae	Nechlo	H
101	<i>Heteromorpha arborescens</i>	Apiaceae	Yejb mrkuz	S
102	<i>Hyparrhenia anthistirioides</i>	Poaceae	Senbelet	H
103	<i>Hyparrhenia hirta</i>	Poaceae	Fura sembelet	H
104	<i>Hypericum revolutum</i>	Hypericaceae	Ameja	S
105	<i>Hypoestes forskaolii</i>	Acanthaceae	Yeznjero berbere	H
106	<i>Impatiens rothii</i>	Balsaminaceae	Gshrt/Ensoola	H
107	<i>Inula confertiflora</i> **	Asteraceae	Eja/ Weynagft	H
108	<i>Ipomoea tenuirostris</i>	Convolvulaceae	Yeayt hareg	H
109	<i>Jasminum abyssinicum</i>	Oleaceae	Tembelet	Li
110	<i>Jasminum stans</i> **	Oleaceae	Tegeg	S
111	<i>Juniperus procera</i>	Cuperssaceae	Tsd	T
112	<i>Kalanchoe citrina</i>	Crassulaceae	Boter	H
113	<i>Kalanchoe marmorata</i>	Crassulaceae	Endahula/ nech	H
114	<i>Kalanchoe petitiata</i>	Crassulaceae	Boter	H
115	<i>Kniphofia foliosa</i> **	Asphodelaceae	Zblble	H
116	<i>Kniphofia isoetifolia</i> **	Asphodelaceae	Abelbila tnshu	H
117	<i>Lactuca glandulifera</i>	Asteraceae	Unknown	H
118	<i>Lactuca inermis</i>	Asteraceae	Unknown	H
119	<i>Laggera tomentosa</i>	Asteraceae	Keskeso	S
120	<i>Lens ervoides</i>	Fabaceae	Yeayt msr	H
121	<i>Leonotis ocyimifolia</i>	Lamiaceae	Ras kmr	S
122	<i>Lepisorus excavatus</i>	Polypodiaceae	Yeenchet lbs	H
123	<i>Lippia adoensis</i>	Verbenaceae	Kese	S
124	<i>Lobelia rhynchopetalum</i>	Lobeliaceae	Jbra	S
125	<i>Lotus schoelleri</i>	Fabaceae	Yeayt msr	H
126	<i>Maesa lanceolata</i>	Myrsinaceae	Kelewa	S

127	<i>Malva verticillata</i>	Malvaceae	Lut	H
128	<i>Maytenus arbutifolia</i>	Celastraceae	Atat tnsu	S
129	<i>Maytenus gracilipes</i> subsp. <i>arguta</i>	Celastraceae	Damza	S
130	<i>Maytenus obscura</i>	Celastraceae	Atat tlku	S
131	<i>Medicago polymorpha</i>	Fabaceae	Maget	H
132	<i>Minuartia filifolia</i>	Caryophyllaceae	Chfrg	H
133	<i>Myrica salicifolia</i>	Myricaceae	Shnet	T
134	<i>Myrsine africana</i>	Myrsinaceae	Kecho	S
135	<i>Nuxia congesta</i>	Loganiaceae	Atkuar	T
136	<i>Olea capensis</i> subsp. <i>macrocarpa</i>	Oleaceae	Damot weyra	T
137	<i>Olea europaea</i> subsp. <i>cuspidata</i>	Oleaceae	Weyra	T
138	<i>Olinia rochetiana</i>	Oliniaceae	Tfe	T
139	<i>Oplismenus hirtellus</i>	Poaceae	Sar	H
140	<i>Oplismenus undulatifolius</i>	Poaceae	Sar	H
141	<i>Oreoschimperella verrucosa</i>	Apiaceae	Sar	H
142	<i>Osteospermum vaillantii</i>	Asteraceae	Unknown	Li
143	<i>Osyris quadripartita</i>	Santalaceae	Keret	S
144	<i>Otostegia integrifolia</i>	Lamiaceae	Tnjut	S
145	<i>Pennisetum sphacelatum</i>	Poaceae	Sendedo	H
146	<i>Pennisetum purpureum</i>	Poaceae	Elefant gras	H
147	<i>Pennisetum thunbergii</i>	Poaceae	Sndedo/ Gta	H
148	<i>Pennisetum villosum</i>	Poaceae	Engcha	H
149	<i>Periploca linearifolia</i>	Asclepiadaceae	Moyder hareg	Li
150	<i>Peucedanum winkleri</i>	Apiaceae	Kereshashmbo	H
151	<i>Phagnalon quartinianum</i> **	Asteraceae	Nbasl	S
152	<i>Physalis peruviana</i>	Solanaceae	Grfat	H
153	<i>Phytolacca dodecandra</i>	Phytolaccaceae	Endod	Li
154	<i>Pittosporum viridiflorum</i>	Pittosporaceae	Weyl	T
155	<i>Plectocephalus varians</i> **	Asteraceae	Unknown	H
156	<i>Plectranthus longipes</i>	Lamiaceae	Yemch/ Ayderke	H
157	<i>Plectranthus ornatus</i>	Lamiaceae	Yekola ayderke	H
158	<i>Poa simensis</i> **	Poaceae	Yekok sar	H
159	<i>Podocarpus falcatus</i>	Podocarpaceae	Zgba	T
160	<i>Polygala rupicola</i> **	Polygalaceae	Etse lbona	H
161	<i>Polygala steudneri</i>	Polygalaceae	Unknown	H
162	<i>Polygonum aviculare</i>	Polygonaceae	Yetja sga	H
163	<i>Polyscias fulva</i>	Araliaceae	Znjero wenber	T
164	<i>Prunus africana</i>	Rosaceae	Tkur enchet	T
165	<i>Pteris cretica</i>	Pteridaceae	Enseferi	H
166	<i>Rhamnus prinoides</i>	Rhamnaceae	Gesho	S
167	<i>Rhus glutinosa</i> Subsp <i>neoglutinosa</i> **	Anacardiaceae	Tlem	T
168	<i>Rhus natalensis</i>	Anacardiaceae	Busi	T
169	<i>Rhus quartiniana</i>	Anacardiaceae	Takma	T
170	<i>Rhus vulgaris</i>	Anacardiaceae	Unknown	S

171	<i>Rhynchosia elegans</i>	Fabaceae	Yeayt hareg	H
172	<i>Rosa abyssinica</i>	Rosaceae	Kega	S
173	<i>Rubus apetalus</i>	Rosaceae	Enjori	Li
174	<i>Rubus steudneri</i>	Rosaceae	Yekola enjori	Li
175	<i>Rumex abyssinicus</i>	Polygonaceae	Mekmeko	H
176	<i>Rumex nepalensis</i>	Polygonaceae	Tult	H
177	<i>Rumex nervosus</i>	Polygonaceae	Embacho	S
178	<i>Salix subserrata</i>	Salicaceae	Akeya	S
179	<i>Salvia merjamie</i>	Lamiaceae	Hulegeb	H
180	<i>Salvia nilotica</i>	Lamiaceae	Hule geb	H
181	<i>Salvia schimperi</i>	Lamiaceae	Unknown	H
182	<i>Satureja abyssinica</i>	Lamiaceae	Yelomi eshet	H
183	<i>Satureja punctata</i> subsp. <i>punctata</i>	Lamiaceae	Tosign mesay	H
184	<i>Scabiosa columbaria</i>	Dipsacaceae	Yetja zago	H
185	<i>Schoenoplectus corymbosus</i>	Cyperaceae	Ketema sar	H
186	<i>Senna didymobotrya</i>	Fabaceae	Yeferenj dgta	S
187	<i>Sideroxylon oxyacanthum</i>	Sapotaceae	Damza	S
188	<i>Silene macrosolen</i>	Caryophyllaceae	Wegert	H
189	<i>Smilax aspera</i>	Smilacaceae	Ashkla	Li
190	<i>Solanecio gigas</i> **	Asteraceae	Yeshkoko gomen	H
191	<i>Solanum benderianum</i>	Solanaceae	Babute	Li
192	<i>Solanum incanum</i>	Solanaceae	Zert embuay	S
193	<i>Solanum marginatum</i>	Solanaceae	Embuay tlku	S
194	<i>Sonchus melanolepis</i>	Asteraceae	Unknown	H
195	<i>Sporobolus africanus</i>	Poaceae	Sar	H
196	<i>Stachys alpigena</i> subsp. <i>longipetala</i>	Lamiaceae	Unknown	H
197	<i>Tagetes minuta</i>	Asteraceae	Gme	H
198	<i>Tephrosia interrupta</i>	Fabaceae	Gerengere	H
199	<i>Thymus schimperi</i> subsp. <i>schimperi</i>	Lamiaceae	Tosign	H
200	<i>Toddalia asiatica</i>	Rutaceae	Gumaro	Li
201	<i>Tragia brevipes</i>	Euphorbiaceae	Ablalit	H
202	<i>Trifolium simense</i>	Fabaceae	Maget	H
203	<i>Urera hypselodendron</i>	Urticaceae	Lankuso	Li
204	<i>Urtica simensis</i>	Urticaceae	Sama	H
205	<i>Verbascum sinaiticum</i>	Scrophulariaceae	Yeahya jero/Ketetna	H
206	<i>Vernonia amygdalina</i>	Asteraceae	Grawa	S
207	<i>Vernonia hochstetteri</i>	Asteraceae	Wzgn	S
208	<i>Vernonia leopoldi</i> **	Asteraceae	Demesech/chibo	H
209	<i>Vernonia urticifolia</i>	Asteraceae	Unknown	S
210	<i>Withania somnifera</i>	Solanaceae	Gzewa	S
211	<i>Xanthium spinosum</i>	Asteraceae	Yeset mlas	H
212	<i>Zehneria scabra</i>	Cucurbitaceae	Buhe hareg	H

Key: H: Herb; S: Shrub; Li: Lianas; T: Tree; \*\*: Endemic species to Ethiopia

**Appendix 7: Transect and quadrats geographical location and environmental data**

<b>Transect</b>	<b>Quadrats</b>	<b>Altitude</b>	<b>Latitude -N</b>	<b>Longitude -E</b>	<b>Slope</b>	<b>Aspect</b>	<b>Disturbance</b>	<b>Forest</b>
1	1	3256	10°26'9.91"	39°47'13.16"	13	2	3	Y
	2	3206	10°26'7.88"	39°47'13.93"	13	2	3	Y
	3	3156	10°26'5.72"	39°47'14.33"	13	2	3	Y
	4	3126	10°26'3.51"	39°47'14.88"	43	2	2	Y
2	5	3252	10°26'8.28"	39°46'57.76"	44	2	3	Y
	6	3202	10°26'7.23"	39°46'58.22"	44	2	2	Y
	7	3152	10°26'5.97"	39°46'59.08"	44	2	1	Y
	8	3102	10°26'3.83"	39°46'59.81"	44	2	1	Y
	9	3089	10°26'1.11"	39°47'0.68"	44	2	1	Y
3	10	3250	10°26'9.25"	39°46'32.69"	35	4	3	Y
	11	3200	10°26'7.77"	39°46'32.99"	38	4	3	Y
	12	3163	10°26'5.51"	39°46'33.79"	38	4	1	Y
	13	3098	10°26'1.42"	39°46'34.87"	38	4	1	Y
	14	3033	10°25'57.29"	39°46'34.44"	38	4	1	Y
4	15	3232	10°26'0.65"	39°46'8.57"	44	8	3	Y
	16	3162	10°25'58.76"	39°46'9.75"	44	8	2	Y
	17	3110	10°25'56.61"	39°46'9.87"	44	8	1	Y
	18	3060	10°25'54.14"	39°46'9.95"	44	8	1	Y
	19	3012	10°25'51.94"	39°46'10.15"	44	8	0	Y
	20	2940	10°25'48.70"	39°46'10.05"	44	8	1	Y
5	21	3150	10°25'50.56"	39°45'56.80"	42	2	3	Y
	22	3100	10°25'49.04"	39°45'57.46"	31	2	2	Y
	23	3050	10°25'47.21"	39°45'57.66"	31	2	1	Y
	24	3001	10°25'45.35"	39°45'58.18"	31	2	1	Y
	25	2890	10°25'41.15"	39°46'0.08"	31	2	1	Y
6	26	3180	10°25'33.08"	39°46'17.80"	28	1	2	Y
	27	3130	10°25'34.80"	39°46'16.73"	28	1	1	Y
	28	3080	10°25'36.67"	39°46'15.09"	28	1	1	Y
	29	3011	10°25'39.12"	39°46'13.01"	28	1	0	Y
	30	2930	10°25'41.77"	39°46'10.40"	28	1	1	Y
7	31	3260	10°25'54.33"	39°47'14.78"	16	1	2	Y
	32	3210	10°25'55.59"	39°47'13.39"	16	1	1	Y
	33	3160	10°25'57.45"	39°47'11.67"	16	1	1	Y
	34	3115	10°25'59.99"	39°47'8.97"	16	1	1	Y
	35	2735	10°32'24.37"	39°46'31.51"	27.7	4	3	G
	36	2685	10°32'23.63"	39°46'28.93"	55.4	4	3	G

8	37	2635	10°32'23.07"	39°46'26.49"	51.3	4	1	G
	38	2590	10°32'22.55"	39°46'24.09"	50.7	4	1	G
	39	2530	10°32'21.69"	39°46'21.19"	53.3	4	2	G
9	40	2677	10°32'30.12"	39°46'36.29"	44.9	1	3	G
	41	2627	10°32'32.63"	39°46'36.48"	45.1	1	1	G
	42	2577	10°32'35.39"	39°46'37.20"	45.5	1	2	G
	43	2522	10°32'38.77"	39°46'37.89"	37	1	2	G
	44	2401	10°32'44.44"	39°46'39.41"	49.7	1	0	G
10	45	2701	10°32'27.44"	39°46'51.99"	49.5	6	3	G
	46	2626	10°32'30.81"	39°46'50.85"	57.4	6	2	G
	47	2575	10°32'32.82"	39°46'50.14"	52.8	6	0	G
	48	2523	10°32'34.95"	39°46'50.00"	56.4	6	0	G
	49	2453	10°32'37.95"	39°46'50.30"	66.8	6	0	G
	50	2403	10°32'39.83"	39°46'51.17"	66.6	6	1	G
	51	2340	10°32'42.19"	39°46'52.84"	55.2	6	1	G
11	52	2661	10°32'18.24"	39°47'7.45"	47.1	1	3	G
	53	2610	10°32'22.19"	39°47'8.86"	55.6	1	3	G
	54	2560	10°32'25.37"	39°47'9.59"	63.5	1	2	G
	55	2510	10°32'27.95"	39°47'9.98"	47.2	1	1	G
	56	2420	10°32'31.90"	39°47'10.43"	45.8	1	1	G
12	57	2676	10°32'4.81"	39°47'14.78"	46.2	5	3	G
	58	2626	10°32'7.89"	39°47'15.86"	67	5	3	G
	59	2576	10°32'10.44"	39°47'16.70"	62.9	5	2	G
	60	2526	10°32'13.11"	39°47'17.60"	65.7	5	1	G
	61	2475	10°32'14.22"	39°47'19.50"	46.6	5	1	G
	62	2445	10°32'14.88"	39°47'21.05"	40.1	5	2	G
13	63	2685	10°31'54.79"	39°47'17.91"	59.6	3	3	G
	64	2635	10°31'54.24"	39°47'20.07"	74.3	3	2	G
	65	2585	10°31'53.96"	39°47'22.26"	71.6	3	1	G
	66	2535	10°31'54.21"	39°47'24.71"	52.1	3	1	G
	67	2485	10°31'54.95"	39°47'27.74"	54	3	2	G
14	68	2810	10°31'3.64"	39°47'22.98"	66.1	4	3	G
	69	2760	10°31'4.67"	39°47'20.06"	80	4	3	G
	70	2710	10°31'4.76"	39°47'17.62"	55.1	4	2	G
	71	2660	10°31'6.16"	39°47'14.75"	55.6	4	1	G
	72	2635	10°31'8.32"	39°47'13.79"	48.5	4	2	G

**Key:** - Aspect: 1: North, 2: South, 3: East, 4: West, 5: Northeast, 6: Northwest, 7: Southeast and 8: Southwest;

Disturbance: - 1: Rare (rare trampling or 1 stump in the quadrat),  
2: Low (low trampling or 2 stumps in the quadrats),  
3: Medium (medium trampling or 3-4 stumps in the quadrat) &  
4: High (high trampling or > 4 stumps in the quadrat);

Forest: Y: Quadrats from *Yegana* Natural Forest Patch and G: Quadrats from *Gajilo* Natural Forest Patch

**Appendix 8: Frequency and density of woody species in *Menz Gera* District natural forest patches**

Scientific Name	Family	Habit	Freq.	R. Freq.	% Freq.	Dens./ Quadra	Dens./ ha	R. Dens/ ha
<i>Erica arborea</i>	Ericaceae	S	40	54.05	6.11	408	453.33	19.98
<i>Myrsine africana</i>	Myrsinaceae	S	40	54.05	6.11	386	428.89	18.90
<i>Hypericum revolutum</i>	Hypericaceae	S	17	22.97	2.60	121	134.44	5.92
<i>Osyris quadripartita</i>	Santalaceae	S	27	36.49	4.12	72	80.00	3.53
<i>Dodonea angustifolia</i>	Sapindaceae	S	13	17.57	1.98	70	77.78	3.43
<i>Ekebergia capensis</i>	Meliaceae	T	36	48.65	5.50	187	64.93	2.86
<i>Juniperus procera</i>	Cuperssaceae	T	33	44.59	5.04	182	63.19	2.78
<i>Hagenia abyssinica</i>	Rosaceae	T	23	31.08	3.51	151	52.43	2.31
<i>Rosa abyssinica</i>	Rosaceae	S	15	20.27	2.29	43	47.78	2.11
<i>Discopodium penninervium</i>	Solanaceae	S	17	22.97	2.60	42	46.67	2.06
<i>Debregeasia saeneb</i>	Urticaceae	S	8	10.81	1.22	41	45.56	2.01
<i>Berberis holstii</i>	Berberidaceae	S	8	10.81	1.22	40	44.44	1.96
<i>Podocarpus falcatus</i>	Podocarpaceae	T	25	33.78	3.82	122	42.36	1.87
<i>Maytenus gracilipes</i> subsp. <i>arguta</i>	Celastraceae	S	9	12.16	1.37	38	42.22	1.86
<i>Clutia abyssinica</i>	Euphorbiaceae	S	14	18.92	2.14	34	37.78	1.66
<i>Maytenus arbutifolia</i>	Celastraceae	S	14	18.92	2.14	33	36.67	1.62
<i>Olinia rochetiana</i>	Oliniaceae	T	23	31.08	3.51	102	35.42	1.56
<i>Maytenus obscura</i>	Celastraceae	S	11	14.86	1.68	27	30.00	1.32
<i>Olea europaea</i> subsp. <i>cuspidata</i>	Oleaceae	T	29	39.19	4.43	79	27.43	1.21
<i>Dombeya torrida</i>	Sterculiaceae	S	10	13.51	1.53	24	26.67	1.18
<i>Galiniera saxifraga</i>	Rubiaceae	T	18	24.32	2.75	77	26.74	1.18
<i>Lobelia rynchopetalum</i>	Lobeliaceae	S	4	5.41	0.61	24	26.67	1.18
<i>Bersama abyssinica</i>	Meliantaceae	T	14	18.92	2.14	67	23.26	1.03
<i>Phagnalon quartinianum</i>	Asteraceae	S	4	5.41	0.61	21	23.33	1.03
<i>Rumex nervosus</i>	Polygonaceae	S	9	12.16	1.37	19	21.11	0.93
<i>Prunus africana</i>	Rosaceae	T	18	24.32	2.75	60	20.83	0.92
<i>Calpurnia aurea</i>	Fabaceae	S	7	9.46	1.07	17	18.89	0.83
<i>Nuxia congesta</i>	Loganiaceae	T	13	17.57	1.98	49	17.01	0.75
<i>Maesa lanceolata</i>	Myrsinaceae	S	6	8.11	0.92	15	16.67	0.73
<i>Otostegia integrifolia</i>	Lamiaceae	S	5	6.76	0.76	15	16.67	0.73
<i>Lippia adoensis</i>	Verbenaceae	S	3	4.05	0.46	12	13.33	0.59
<i>Solanum incanum</i>	Solanaceae	S	4	5.41	0.61	12	13.33	0.59
<i>Allophylus abyssinicus</i>	Sapindaceae	T	13	17.57	1.98	38	13.19	0.58
<i>Laggera tomentosa</i>	Asteraceae	S	5	6.76	0.76	11	12.22	0.54

<i>Croton macrostachyus</i>	Euphorbiaceae	T	8	10.81	1.22		32	11.11	0.49
<i>Canthium lactescens</i>	Rubiaceae	T	11	14.86	1.68		29	10.07	0.44
<i>Carissa spinarum</i>	Apocynaceae	S	5	6.76	0.76		9	10.00	0.44
<i>Leonotis ocyimifolia</i>	Lamiaceae	S	3	4.05	0.46		9	10.00	0.44
<i>Myrica salicifolia</i>	Myricaceae	T	8	10.81	1.22		29	10.07	0.44
<i>Olea capensis</i> subsp. <i>macrocarpa</i>	Oleaceae	T	8	10.81	1.22		28	9.72	0.43
<i>Capparis tomentosa</i>	Capparidaceae	S	4	5.41	0.61		7	7.78	0.34
<i>Euryops pinifolius</i>	Asteraceae	S	2	2.70	0.31		7	7.78	0.34
<i>Sideroxylon oxyacanthum</i>	Sapotaceae	S	2	2.70	0.31		7	7.78	0.34
<i>Colutea abyssinica</i>	Fabaceae	S	2	2.70	0.31		6	6.67	0.29
<i>Dovyalis abyssinica</i>	Flacourtiaceae	S	3	4.05	0.46		6	6.67	0.29
<i>Rhus vulgaris</i>	Anacardiaceae	S	3	4.05	0.46		6	6.67	0.29
<i>Polyscias fulva</i>	Araliaceae	T	7	9.46	1.07		18	6.25	0.28
<i>Buddleja polystachya</i>	Loganiaceae	T	6	8.11	0.92		17	5.90	0.26
<i>Ficus sur</i>	Moraceae	T	5	6.76	0.76		17	5.90	0.26
<i>Caesalpinia decapetala</i>	Fabaceae	S	2	2.70	0.31		5	5.56	0.24
<i>Solanum marginatum</i>	Solanaceae	S	2	2.70	0.31		5	5.56	0.24
<i>Vernonia amygdalina</i>	Asteraceae	S	2	2.70	0.31		5	5.56	0.24
<i>Argyrobium schimperianum</i>	Fabaceae	S	4	5.41	0.61		4	4.44	0.20
<i>Bartsia decurva</i>	Scrophulariaceae	S	2	2.70	0.31		4	4.44	0.20
<i>Jasminum stans</i>	Oleaceae	S	2	2.70	0.31		4	4.44	0.20
<i>Vernonia hochstetteri</i>	Asteraceae	S	2	2.70	0.31		4	4.44	0.20
<i>Pittosporum viridiflorum</i>	Pittosporaceae	T	4	5.41	0.61		10	3.47	0.15
<i>Senna didymobotrya</i>	Fabaceae	S	1	1.35	0.15		3	3.33	0.15
<i>Salix subserrata</i>	Salicaceae	S	3	4.05	0.46		3	3.33	0.15
<i>Withania somnifera</i>	Solanaceae	S	1	1.35	0.15		3	3.33	0.15
<i>Euphorbia abyssinica</i>	Euphorbiaceae	T	2	2.70	0.31		8	2.78	0.12
<i>Clerodendrum myricoides</i>	Lamiaceae	S	1	1.35	0.15		2	2.22	0.10
<i>Dovyalis verrucosa</i>	Flacourtiaceae	S	1	1.35	0.15		2	2.22	0.10
<i>Rhamnus prinoides</i>	Rhamnaceae	S	1	1.35	0.15		2	2.22	0.10
<i>Erythrina brucei</i>	Fabaceae	T	3	4.05	0.46		6	2.08	0.09
<i>Heteromorpha arborescens</i>	Apiaceae	S	1	1.35	0.15		1	1.11	0.05
<i>Rhus natalensis</i>	Anacardiaceae	T	2	2.70	0.31		3	1.04	0.05
<i>Rhus quartiniana</i>	Anacardiaceae	T	1	1.35	0.15		3	1.04	0.05
<i>Vernonia urticifolia</i>	Asteraceae	S	1	1.35	0.15		1	1.11	0.05
<i>Celtis africana</i>	Ulmaceae	T	2	2.70	0.31		2	0.69	0.03
<i>Euphorbia ampliphylla</i>	Euphorbiaceae	T	1	1.35	0.15		2	0.69	0.03
<i>Rhus glutinosa</i> Subsp <i>neoglutinosa</i>	Anacardiaceae	T	2	2.70	0.31		2	0.69	0.03
Total			<b>655</b>		<b>100.00</b>		<b>2950</b>	<b>2269.44</b>	<b>100.00</b>

Key: H: Herb, S: Shrub, T: Tree; Den: Density, ha: Hectare; Freq: Frequency, R: Relative; Bold: 1<sup>st</sup> rank, Bold and Italic: 2<sup>nd</sup> rank, Italic: 3<sup>rd</sup> rank.

**Appendix 9: Basal area (m<sup>2</sup>/h<sup>-1</sup>) of woody plants and their percentage contribution in the Menz Gera District natural forest patches**

Scientific Name	Family	Habit	BA (m <sup>2</sup> h <sup>-1</sup> )	%
<i>Hagenia abyssinica</i>	Rosaceae	T	11.8	20.50
<i>Juniperus procera</i>	Cuperssaceae	T	7.56	13.13
<i>Podocarpus falcatus</i>	Podocarpaceae	T	4.5	7.82
<i>Galiniera saxifraga</i>	Rubiaceae	T	4	6.95
<i>Olea europaea</i> subsp. <i>cuspidata</i>	Oleaceae	T	3.95	6.86
<i>Ekebergia capensis</i>	Meliaceae	T	2.5	4.34
<i>Erica arborea</i>	Ericaceae	S	2.5	4.34
<i>Nuxia congesta</i>	Loganiaceae	T	1.8	3.13
<i>Olinia rochetiana</i>	Oliniaceae	T	1.61	2.80
<i>Myrica salicifolia</i>	Myricaceae	T	1.58	2.74
<i>Allophylus abyssinicus</i>	Sapindaceae	T	1.5	2.61
<i>Ficus sur</i>	Moraceae	T	1.5	2.61
<i>Olea capensis</i> subsp. <i>macrocarpa</i>	Oleaceae	T	1.5	2.61
<i>Prunus africana</i>	Rosaceae	T	1.5	2.61
<i>Bersama abyssinica</i>	Melanthaceae	T	1.05	1.82
<i>Hypericum revolutum</i>	Hypericaceae	S	0.98	1.70
<i>Canthium lactescens</i>	Rubiaceae	T	0.8	1.39
<i>Maytenus gracilipes</i> subsp. <i>arguta</i>	Celastraceae	S	0.75	1.30
<i>Myrsine africana</i>	Myrsinaceae	S	0.68	1.18
<i>Osyris quadripartita</i>	Santalaceae	S	0.68	1.18
<i>Rosa abyssinica</i>	Rosaceae	S	0.56	0.97
<i>Croton macrostachyus</i>	Euphorbiaceae	T	0.55	0.96
<i>Polyscias fulva</i>	Araliaceae	T	0.5	0.87
<i>Maytenus obscura</i>	Celastraceae	S	0.46	0.80
<i>Pittosporum viridiflorum</i>	Pittosporaceae	T	0.3	0.52
<i>Berberis holstii</i>	Berberidaceae	S	0.23	0.40
<i>Discopodium penninervium</i>	Solanaceae	S	0.23	0.40
<i>Maytenus arbutifolia</i>	Celastraceae	S	0.21	0.36
<i>Debregeasia saeneb</i>	Urticaceae	S	0.18	0.31
<i>Dodonea angustifolia</i>	Sapindaceae	S	0.17	0.30
<i>Celtis africana</i>	Ulmaceae	T	0.15	0.26
<i>Calpurnia aurea</i>	Fabaceae	S	0.15	0.26
<i>Carissa spinarum</i>	Apocynaceae	S	0.14	0.24
<i>Lobelia rhynchopetalum</i>	Lobeliaceae	S	0.14	0.24
<i>Clusia abyssinica</i>	Euphorbiaceae	S	0.13	0.23
<i>Dombeya torrida</i>	Sterculiaceae	S	0.13	0.23
<i>Dovyalis abyssinica</i>	Flacourtiaceae	S	0.11	0.19
<i>Maesa lanceolata</i>	Myrsinaceae	S	0.09	0.16
<i>Bartsia decurva</i>	Scrophulariaceae	S	0.08	0.14
<i>Buddleja polystachya</i>	Loganiaceae	T	0.06	0.10
<i>Argyrolobium schimperianum</i>	Fabaceae	S	0.05	0.09

<i>Rhus vulgaris</i>	Anacardiaceae	S	0.03	0.05
<i>Sideroxylon oxyacanthum</i>	Sapotaceae	S	0.03	0.05
<i>Rhus quartiniana quartiniana</i>	Anacardiaceae	T	0.02	0.03
<i>Clerodendrum myricoides</i>	Lamiaceae	S	0.02	0.03
<i>Jasminum stans</i>	Oleaceae	S	0.02	0.03
<i>Salix subserrata</i>	Salicaceae	S	0.02	0.03
<i>Rhus glutinosa</i> Subsp <i>neoglutinosa</i>	Anacardiaceae	T	0.01	0.02
<i>Caesalpinia decapetala</i>	Fabaceae	S	0.01	0.02
<i>Capparis tomentosa</i>	Capparidaceae	S	0.01	0.02
<i>Colutea abyssinica</i>	Fabaceae	S	0.01	0.02
<i>Senna didymobotrya</i>	Fabaceae	S	0.01	0.02
<i>Vernonia hochstetteri</i>	Asteraceae	S	0.01	0.02
Total			57.56	100.00

Key: S: Shrub, T: Tree; BA: Basal Area

**Appendix 10: Frequency of woody species with DBH > 2 cm in Yegana and Gajilo forests**

Scientific Name	Family	Habit	Quadrat Frequency	% Frequency	Relative Frequency
<i>Erica arborea</i>	Ericaceae	S	40	55.56	6.11
<i>Myrsine africana</i>	Myrsinaceae	S	40	55.56	6.11
<i>Ekebergia capensis</i>	Meliaceae	T	36	50.00	5.50
<i>Juniperus procera</i>	Cuperssaceae	T	33	45.83	5.04
<i>Olea europaea</i> subsp. <i>cuspidata</i>	Oleaceae	T	29	40.28	4.43
<i>Osyris quadripartita</i>	Santalaceae	S	27	37.50	4.12
<i>Podocarpus falcatus</i>	Podocarpaceae	T	25	34.72	3.82
<i>Hagenia abyssinica</i>	Rosaceae	T	23	31.94	3.51
<i>Olinia rochetiana</i>	Oliniaceae	T	23	31.94	3.51
<i>Galiniera saxifraga</i>	Rubiaceae	T	18	25.00	2.75
<i>Prunus africana</i>	Rosaceae	T	18	25.00	2.75
<i>Discopodium penninervium</i>	Solanaceae	S	17	23.61	2.60
<i>Hypericum revolutum</i>	Hypericaceae	S	17	23.61	2.60
<i>Rosa abyssinica</i>	Rosaceae	S	15	20.83	2.29
<i>Bersama abyssinica</i>	Melanthaceae	T	14	19.44	2.14
<i>Clutia abyssinica</i>	Euphorbiaceae	S	14	19.44	2.14
<i>Maytenus arbutifolia</i>	Celastraceae	S	14	19.44	2.14
<i>Allophylus abyssinicus</i>	Sapindaceae	T	13	18.06	1.98
<i>Dodonea angustifolia</i>	Sapindaceae	S	13	18.06	1.98
<i>Nuxia congesta</i>	Loganiaceae	T	13	18.06	1.98
<i>Canthium lactescens</i>	Rubiaceae	T	11	15.28	1.68
<i>Maytenus obscura</i>	Celastraceae	S	11	15.28	1.68
<i>Dombeya torrida</i>	Sterculiaceae	S	10	13.89	1.53
<i>Maytenus gracilipes</i> subsp. <i>arguta</i>	Celastraceae	S	9	12.50	1.37
<i>Rumex nervosus</i>	Polygonaceae	S	9	12.50	1.37
<i>Berberis holstii</i>	Berberidaceae	S	8	11.11	1.22
<i>Croton macrostachyus</i>	Euphorbiaceae	T	8	11.11	1.22
<i>Debregeasia saeneb</i>	Urticaceae	S	8	11.11	1.22
<i>Myrica salicifolia</i>	Myricaceae	T	8	11.11	1.22
<i>Olea capensis</i> subsp. <i>macrocarpa</i>	Oleaceae	T	8	11.11	1.22
<i>Calpurnia aurea</i>	Fabaceae	S	7	9.72	1.07
<i>Polyscias fulva</i>	Araliaceae	T	7	9.72	1.07
<i>Buddleja polystachya</i>	Loganiaceae	T	6	8.33	0.92
<i>Maesa lanceolata</i>	Myrsinaceae	S	6	8.33	0.92
<i>Carissa spinarum</i>	Apocynaceae	S	5	6.94	0.76
<i>Ficus sur</i>	Moraceae	T	5	6.94	0.76
<i>Laggera tomentosa</i>	Asteraceae	S	5	6.94	0.76
<i>Otostegia integrifolia</i>	Lamiaceae	S	5	6.94	0.76

<i>Argyrolobium schimperianum</i>	Fabaceae	S	4	5.56	0.61
<i>Capparis tomentosa</i>	Capparidaceae	S	4	5.56	0.61
<i>Lobelia rynchopetalum</i>	Lobeliaceae	S	4	5.56	0.61
<i>Phagnalon quartinianum</i>	Asteraceae	S	4	5.56	0.61
<i>Pittosporum viridiflorum</i>	Pittosporaceae	T	4	5.56	0.61
<i>Solanum incanum</i>	Solanaceae	S	4	5.56	0.61
<i>Dovyalis abyssinica</i>	Flacourtiaceae	S	3	4.17	0.46
<i>Erythrina brucei</i>	Fabaceae	T	3	4.17	0.46
<i>Leonotis ocymifolia</i>	Lamiaceae	S	3	4.17	0.46
<i>Lippia adoensis</i>	Verbenaceae	S	3	4.17	0.46
<i>Rhus vulgaris</i>	Anacardiaceae	S	3	4.17	0.46
<i>Salix subserrata</i>	Salicaceae	S	3	4.17	0.46
<i>Bartsia decurva</i>	Scrophulariaceae	S	2	2.78	0.31
<i>Caesalpinia decapetala</i>	Fabaceae	S	2	2.78	0.31
<i>Celtis africana</i>	Ulmaceae	T	2	2.78	0.31
<i>Colutea abyssinica</i>	Fabaceae	S	2	2.78	0.31
<i>Euphorbia abyssinica</i>	Euphorbiaceae	T	2	2.78	0.31
<i>Euryops pinifolius</i>	Asteraceae	S	2	2.78	0.31
<i>Jasminum stans</i>	Oleaceae	S	2	2.78	0.31
<i>Rhus glutinosa</i> . Subsp <i>neoglutinosa</i>	Anacardiaceae	T	2	2.78	0.31
<i>Rhus natalensis</i>	Anacardiaceae	T	2	2.78	0.31
<i>Sideroxylon oxyacanthum</i>	Sapotaceae	S	2	2.78	0.31
<i>Solanum marginatum</i>	Solanaceae	S	2	2.78	0.31
<i>Vernonia amygdalina</i>	Asteraceae	S	2	2.78	0.31
<i>Vernonia hochstetteri</i>	Asteraceae	S	2	2.78	0.31
<i>Clerodendrum myricoides</i>	Lamiaceae	S	1	1.39	0.15
<i>Dovyalis verrucosa</i>	Flacourtiaceae	S	1	1.39	0.15
<i>Euphorbia ampliphylla</i>	Euphorbiaceae	T	1	1.39	0.15
<i>Heteromorpha arborescens</i>	Apiaceae	S	1	1.39	0.15
<i>Rhamnus prinoides</i>	Rhamnaceae	S	1	1.39	0.15
<i>Rhus quartiniana quartiniana</i>	Anacardiaceae	T	1	1.39	0.15
<i>Senna didymobotrya</i>	Fabaceae	S	1	1.39	0.15
<i>Vernonia urticifolia</i>	Asteraceae	S	1	1.39	0.15
<i>Withania somnifera</i>	Solanaceae	S	1	1.39	0.15
Total			<b>655</b>		<b>100.00</b>

Key: S: Shrub, T: Tree

### Appendix 11: List of medicinal plants used for human ailments

Methods of preparation and application (MPA):-1. Boil and drink the decoction; 2. Grind and paint the powder or crushed part ; 3. Grind and tie the crushed part; 4. Extract the juice/oil/latex and drink \_1, paint it \_2 or pour/drop\_3; 5. Crush, homogenize with cold water and drink; 6. Hold with teeth and inhale its liquid 7. Crush, heat/ burn or boil the part and inhale its smoke or steam; 8. Crush and sniff\_1/smell\_2 the fresh part; 9. Crush and eat the part; 10. Boil and do steam bath; 11. Drink the concoction directly or after Fermentation; 12. Boil the part and paint the decoction; 13. Crush, heat burn and paint the powder on the affected part; 14. Dry Crush, heat burn homogenize with cold water and drink; 15. Clean directly the affected part; 16. Paint the latex; 17. Crush, mix/alone and Tying/put externally; 18. Boil/Crush with water and wash on the body; 19. Add the concoction to the affected part; 20. Paint the latex, milk, oil.

Route of Administration (RA): Oral, O; Dermal, De; Nasal, Na; Optical, Op; Auricular, Au; Anal, An.; External Tying, Et;

Part used (PU):- Leaf, L; Root, R; Stem wood, Sw; Fruit, Fr; Bark, B; Root bark, RB; Stem bark, SB; Flower, Fl; Bulb, Bu; Rhizome, Rh; Seed, S; Latex, Lx; Whole, Wh; Shoot, Sh; Tuber, Tu; Oil, O; Resin, Re;

Growth form or Habit:- Tree (T); Shrub (S); Liana (Li) Herb (H); Climber (C): Conditions of Part Used (CPU):- Dry, D; Fresh, F

R.No	Local Name (Am)	Scientific Name	Family	Habit	PU	Human Disease treated	MPA	CPU	RA
1	Bihe hareg/ Hareg resa/ Etse menehe	<i>Zehneria scabra</i>	Cucurbitaceae	H	L	Toothache	6	F	O
						Lashing / Fibril	7	F	Na
						Uvula	11	F/D	O
						Trachoma	15	F	Op
						Kid Crying	4	F	De
						RH factor related disease	17	F	Et
						Getting love	17	F/D	Et
						Hemorrhoid	20	F	De
						Headache	4_3	F	Na
2	Embacho	<i>Rumex nervosus</i>	Polygonaceae	S	L	Uvula	11	F/D	O

3	Anfar	<i>Buddleja polystachya</i>	Loganiaceae	S	L	Uvula	11	F/D	O
					L	Infinitely/manic	5	F	O
4	Tife	<i>Olinia rochetiana</i>	Oliniaceae	T	L	Eczema	13	D	De
5	Muatsh	<i>Duranta erecta</i>	Verbenaceae	S	L	Eczema	13	D	De
					Fl	Blood disease (AFI)	5	D	O
					Fl	Varicella-Zoster	13	D	De
6	Dingay lbs	<i>Adiantum capillus-veneris</i>	Adiantaceae	H	Wh	Eczema	13	D	De
						Eye disease	13	D	Op
7	Weyra	<i>Olea europaea</i> subsp. <i>cuspidata</i>	Oleaceae	T	Sw	Eczema	13	D	De
					Sw	Morbidity	7	D	De
					R	Dermatophytosis	3	D	De
					R	Eczema	3	D	De
					Sh	Eye disease	4_3	F	Op
					Sh	Ear pus	19	F	Au
8	Sete ret	<i>Aloe pulcherrima</i>	Aloaceae	S	R	Eczema	13	D	De
					L	Gastritis	5	D	O
9	Kebricho	<i>Echinops kebericho</i> Mesfin **	Asteraceae	H	R	Blood disease (AFI)	5	D	O
					R	Evil Protection	7	D	Na
10	Senafich	<i>Brassica nigra</i>	Brassicaceae	H	Fr	Blood disease (AFI)	5	D	O
11	Ktkta	<i>Dodonea angustifolia</i>	Sapindaceae	S	L	Blood disease (AFI)	5	D	O
12	Koshm	<i>Dovyalis abyssinica</i>	Flacourtiaceae	S	L	Blood disease (AFI)	5	D	O
					L	Fibril illness	18	D	De
13	Feto	<i>Lepidium sativum</i>	Brassicaceae	H	S	Trypanosomiasis	14	D	O
						Tuberculosis	13	D	De
						Breast swelling	13	D	De
						Placenta	14	D	O
						Diarrhea	9	D	O

						Morbidity	7	D	Na
						Ear worm	19	D	Au
						Relapse	2	D	De
						Blood disease	5	F	O
						Teeth pain/Disease	6	F	O
14	Gzewa	<i>Withania somnifera</i>	Solanaceae	S	R	Trypanosomiasis	14	D	O
						Tuberculosis	13	D	De
						Breast swelling	13	D	De
						Placenta	14	D	O
						Dog rabies vaccination	9	D	O
15	Yemdr embuay	<i>Cucumis ficifolius</i>	Cucurbitaceae	H	Fr	Trypanosomiasis	14	D	O
					Fr	Tuberculosis	1	D	O
					Fr	Snake bite	14	D	O
					Fr	Eczema	3	D	De
					R/L	Sudden Abdominal cramp	6	F	O
					Fr	Evil eye	7	D	Na
					Fr	Breast swelling	2	D	De
					Fr	Dog rabies vaccination	9	D	O
					R	Gonorrhea	9	D	O
					R	Placenta	5	F	O
					R	Blood disease	5	F	O
16	Znkila	<i>Berberis holstii</i>	Berberidaceae	T	R	Trachoma	2	D	Op
17	Sama	<i>Urtica simensis</i>	Urticaceae	H	R	Delivery Blood clotting	6	F	O
					L	Gastritis	9	F	O
					R	Heart failer	9	F	O
					R	Eczema	3	F	De
					L	Pit like scare	4_1	F	De

18	Zert embuay	<i>Solanum incanum</i>	Solanaceae	S	R	Delivery Blood clotting	6	F	O
					R	Syphilis	9	F	O
					R	Sudden abdominal cramp	6	F	O
					R	Node pain	11	F	O
					R	Evil	7	D	Na
19	Yeahya jero/Ketetna	<i>Verbascum sinaiticum</i>	Scrophulariaceae	H	R	Vaccinate for Snake bite	9	D	O
					R	Tuberculosis	9	F	O
					R	Snake bite	6	F	O
					Lx	Eye disease	20	F	Op
					L	RH factor related disease	17	D	Et
					R	Evil eye	7	D	Et
					R	Morbidity	6	F	O
20	Gumaro	<i>Toddalia asiatica</i>	Rutaceae	Li	R	Vaccinate for Snake bite	9	D	O
					Lx	Eye disease	16	F	Op
					R	Epilepsy	17	D	De
					R	Erectile dysfunction	10	D	De
21	Kega	<i>Rossa abyssinica</i>	Rosaceae	S	R	Stop Menstrual cycle	17	D	Et
					Fr	Ascarids	9	F	O
					R	Infinitely/manic	5	D	O
22	Tinbaho	<i>Nicotiana tabacum</i>	Solanaceae	S	R	Stop Menstrual cycle	17	D	Et
					R	Infinitely/manic	5	D	O
23	Enslal	<i>Foeniculum vulgare</i>	Apiaceae	H	L	Dysuria	1	F	O
					L	Common cold	1	D	O
					L	Gonorrhea	5	D	O
24	Tekula wetet	<i>Pentarrhinum insipidum</i>	Asclepiadaceae	Cl	R	RH factor related disease	17	D	Et
25	Bakela	<i>Vicia faba</i>	Fabaceae	H	S	Mumps	17	D	Et
					S	Abscess	3	D	De

26	Grawa	<i>Vernonia amygdalina</i>	Asteraceae	S	L/R	Lashing	7	F	Na
					L	Acute sickness and abdominal pain	4_1	F	O
27	Yetnchel Wetet/ Tifrina	<i>Gomphocarpus fruticosus</i> subsp. <i>flavidus</i>	Asclepiadaceae	S	R	Measeles like disease	17	D	Et
					R	RH factor related disease	17	D	Et
					Lx	Eye granule	20	F	De
					Lx	Tinea capitaites	20	F	De
					Lx	Hemorrhoid	20	F	De
28	Chfrg	<i>Minuartia filifolia</i>	Caryophyllaceae	H	R	RH factor related disease	17	D	Et
					R	Syphilis	9	F	O
					R	Erectile dysfunction	11	D	O
					R	Evil	7	D	Na
					R	Tooth Cleaner	15	D	De
29	Etse Ibona	<i>Polygala abyssinica</i>	Polygalaceae	H	R/L	Epilepsy	17	D	De
					R	Snake bite	6	F	O
					R/L	Kid Abdominal pain/disease	4_1	F	De
30	Agam	<i>Carissa spinarum</i>	Apocynaceae	S	R	Tuberculosis	11	D	De
					R	Snake bite	14	D	O
31	Endahula zngurgur	<i>Kalanchoe marmorata</i>	Crassulaceae	H	R	Tuberculosis	11	D	De
					R	Snake bite	14	D	O
					R	Wound	3	D	De
					R	Uvula	5	D	O
					R	Dermatophytosis	3	D	De
32	Tibtibo	<i>Plectranthus cylindraceus</i>	Lamiaceae	H	R	Tuberculosis	11	D	De
					R	Snake bite	14	D	O
					R	Uvula	5	D	O
33	Tult	<i>Rumex nepalensis</i>	Polygonaceae	H	R	Sudden abdominal cramp)	5	F/D	O

					R	Hair detergent	20	F	De
					R	Node pain	11	F	O
					R	Placenta	1	F	O
34	Lol/Etseramnon	<i>Ekebergia capensis</i>	Meliaceae	T	L	Pneumonia	1	D	O
35	Beles	<i>Opuntia ficus-indica</i>	Cactaceae	S	R	Pneumonia	1	D	O
36	Embuay tlku/ engule (Tg)	<i>Solanum marginatum</i>	Solanaceae	S	Fr	Pneumonia	1	D	O
					Fr	Teeth pain/Disease	7, 6	D	O
					L	Sudden abdominal cramp	11	D	O
					L	Aback/Amazement	3, 9	D, O	De, O
37	Chkugn	<i>Artemisia abyssinica</i>	Asteraceae	H	R	Evil eye	7	D	Na
					R	Morbidity	7	D	Na
					R	Teeth pain/Disease	6	F	O
					R	Common cold	7	D	Na
					R	Abdominal pain	5	D	O
38	Ras kmr	<i>Leonotis ocymifolia</i>	Lamiaceae	S	L	Lashing	4_1/ 8	F	O/Na
					L	Headache	4_1/ 8	F	O/Na
					L	Delivery blood clotting	7	D	Na
					L	Morbidity	7	D	Na
					L	Kid wound	15	F	De
					L	Sudden abdominal cramp	5	F/D	O
					L/R	Evil	7	D	Na
39	Etse faris/ astenagr	<i>Datura stramonium</i>	Solanaceae	H	S	Dermatophytosis	13	D	De
					S	Teeth pain/Disease	7	D	O
					S	Getting love	17	D	Et
					L	Ear pus	19	F	Au
40	Demekase	<i>Ocimum lamiifolium</i>	Lamiaceae	H	L	Lashing	7	D	Na
41	Endod	<i>Phytolacca dodecandra</i>	Phytolaccaceae	Li	L	Rabies	9	D	O
					L	Gonorrhea	11	F	O

					L	Ascarids	11	F	O
					Fr	Scabies	3	D	De
					R	Ear pus	4_3	F	Au
42	Kulqual	<i>Euphorbia abyssinica</i>	Euphorbiaceae	T	Lx	Rabies	9	F	O
					Lx	Gonorrhea	9	F	O
					Fl	Leprosy	2	D	De
					Lx	Ascarids	9	F	O
43	Snde	<i>Triticum aestivum</i>	Poaceae	H	S	Rabies	9	D	O
44	Gebs	<i>Hordeum vulgare</i>	Poaceae	H	S	Rabies	9	D	O
					S	Morbidity	18	D	Et
						Fire Burn	3	D	De
45	Meret aly yemitegna	<i>Euphorbia petitiiana</i>	Euphorbiaceae	H	Lx	Morbidity	20	F	De
					Lx	Fungal skin problem	20	F	De
46	Sndedo	<i>Pennisetum thunbergii</i>	Poaceae	H	R	RH factor related disease	17	D	Et
47	Koshele	<i>Echinops pappii</i>	Asteraceae	S	R	RH factor related disease	17	D	Et
					R	Eczema	3	F	De
48	Chegot	<i>Cynoglossum coeruleum</i>	Boraginaceae	H	L	Lashing	4	F	Au
49	Enzerezeyt	<i>Crassula alba</i>	Crassulaceae	H	R	Milk spoilage	17	F	Et
50	Nech shnkurt	<i>Allium sativum</i>	Alliaceae	H	Bu	Eczema	3	F	De
					Bu	Morbidity	18	F	De
					Bu	Teeth pain/Disease	6	F	O
					Bu	Gastritis	8	F	Na
					Bu	Ear worm	19	D	Au
					Bu	Lashing	10	F	Na
					Bu	Sudden Abdominal cramp	11	F	O
					S	Headache	8_1	D	Na
					Bu	Abdominal pain	5	D	O
					Bu	Cough	1	F	O

					Bu	Blood disease	5	F	O
51	Eja/ Weynagft	<i>Inula confertiflora</i> **	Boraginaceae	S	L	Lashing	11	F	O
					L	Teeth pain/Disease	6	F	O
					L	Uvula	5	D	O
					L	Rabies	9	F	O
					L	Pit like scare	2	D	De
					L	Ear pus	19	F	Au
52	Tena adam	<i>Ruta chalepensis</i>	Rutaceae	H	L/S	Blood pressure	1	F/D	O
					L/S	Epistaxis	8_1	D	Na
					L	Common cold	1	D	O
					L	Blood disease	5	F	O
53	Tnjut	<i>Otostegia integrifolia</i>	Lamiaceae	S	Fl	Varicella-Zoster	13	D	De
					R	Sudden Abdominal cramp	11	D	O
54	Guasa	<i>Festuca macrophylla</i>	Poaceae	H	R	Varicella-Zoster	13	D	De
					L	Eczema	13	D	De
55	Nech bahrzaf	<i>Eucalyptus globulus</i>	Myrtaceae	T	L	Morbidity	18	F	De
					L	Common cold	7	F	Na
					L	Teeth pain/Disease	6	D	O
56	Hulegeb	<i>Salvia nilotica</i>	Lamiaceae	H	L	Lashing	11	F	O
					L/Fr	Relapse	2	D	De
57	Yegrsha/Yewlaj	<i>Trifolium semipilosum</i>	Fabaceae	H	L	Lashing	11	F	O
					L	Diarrhea	11	F	O
					L	Morbidity	8_1	F	Na
58	Bifejgn lemne	<i>Cheilanthes farinosa</i>	Sinopteridaceae	H	L	Fire Burn	3	D/F	De
59	Buna	<i>Coffea arabica</i>	Rubiaceae	S	S	Fire Burn	3	D/F	De
					L	Asthma	1	F	Na; O
60	Snde	<i>Triticum aethiopicum</i> **	Poaceae	H	S	Tinea capitaites	17	D	De
61	Znjbl	<i>Zingiber officinale</i>	Zingiberaceae	H	R	Teeth pain/Disease	6	F/D	O

					R	Gastritis	1	D	O
					R	Abdominal pain	1	F/D	O
					R	Breast swelling	2	D	De
62	Tkur kmem	<i>Nigella sativa</i>	Ranunculaceae	H	S	Teeth pain/Disease	6	D	O
					S	Abdominal pain	1	D	O
63	Nech kmem	<i>Trachyspermum ammi</i>	Apiaceae	H	S	Teeth pain/Disease	6	D	O
					S	Abdominal pain	1	D	O
64	Shekole	<i>Carduus schimperi</i> subsp. <i>schimperi</i>	Asteraceae	H	R	Morbidity	1	F	O
65	Grfat	<i>Anchusa affinis</i> **	Boraginaceae	H	L	Lashing	2, 1, 4_3	F	De, O, Au
					L	Lashing	5	F	O
66	Azo hareg tseguramu	<i>Clematis hirsuta</i>	Ranunculaceae	Li	L	Tinea capitaites	2	F	De
67	Yejb shnkurt	<i>Crinum abyssinicum</i>	Amaryllidaceae	H	Bu	RH factor related disease	17	D	Et
68	Gudgn	<i>Oenanthe palustris</i>	Apiaceae	H	L	Eczema	3	F	De
					L	Fire Burn	3	F	De
69	Azo hareg	<i>Clematis simensis</i>	Ranunculaceae	Li	L	Eczema	3	F	De
					L	Tinea capitaites	2	F	De
					R	Teeth pain/Disease	6	F	O
					L	Ear pus	19	F	Au
70	Dbrk	<i>Salvia merjamie</i>	Lamiaceae	H	L/S	Diarrhea	11	F	O
71	Wende kacha	<i>Sansevieria ehrenbergii</i>	Dracaenaceae	H	R	Erectile dysfunction	11	D	O
					R	Ear pus	4_3	F	Au
72	Aserkush tebetebkush	<i>Cyphostemma adenocaula</i>	Vitaceae	Cl	R	Writing	9	F/D	O
					R	Gonorrhea	9	D	O
73	Lomi	<i>Citrus aurantiifolia</i>	Rutaceae	S	L/Fr	Uvula	3	F	De
74	Wende ret	<i>Aloe debrana</i>	Aloaceae	S	Bu	Milk spoilage	17	F	Et

					O	Dysuria	9	D	O
					O	Erectile dysfunction	4_2	D	De
					Lx	Wound	4_2	F	De
75	Absh	<i>Trigonella foenum-graecum</i>	Fabaceae	H	S	Evil eye	7	D	Na
					S	Abscess	3	D	De
					S	Blood pressure	5	D	O
76	Kundo Berbere	<i>Piper nigrum</i>	Piperaceae	H	S	Evil eye	7	D	Na
					S	Abdominal pain	5	D	O
77	Msr	<i>Lens culinaris</i>	Fabaceae	H	S	Evil eye	7	D	Na
78	Keskeso	<i>Laggera tomentosa</i> **	Asteraceae	S	R	Digestant	1	F	O
					R	Teeth pain/ Toothache	6	F	O
					R	Oxytocic	4_1	F	O
					L/R	Common cold	8_1	D	Na
					L	Rabies	17	D/F	Et
79	Enjori yedega	<i>Rubus volkensii</i>	Rosaceae	Li	L	Anemia	1	F	O
80	Duba	<i>Cucurbita pepo</i>	Cucurbitaceae	Cl	S	False pregnancy	5	D	O
					S	Headache	17	D	Et
81	Koseret/ Yemdr kese	<i>Lippia adoensis</i>	Verbenaceae	H	R	Lashing	7	F	Na
					L	Uvula	5	D	O
82	Gme	<i>Tagetes minuta</i>	Asteraceae	H	L	Tonsillitis	4_1	F	O
					L	Ear pus	4_3	F	Au
83	Shnet	<i>Myrica salicifolia</i>	Myricaceae	T	B	Ear worm	19	D	Au
84	Engochit hareg/ Etse eyesus	<i>Stephania abyssinica</i>	Menispermaceae	Cl	Fr	Ear worm	19	D	Au
84	Roman	<i>Punica granatum</i>	Punicaceae	T	Sh	Ear worm	19	D	Au
					L	Breast swelling	13	D	De
					Sh	Ear pus	19	F	Au

86	Tembelel	<i>Jasminum abyssinicum</i>	Oleaceae	Li	Sh	Ear worm	19	D	Au
					S	Women Sterility	9	D	O
					Sh	Eye disease	4_3	F	Op
					L	Sudden abdominal cramp	6	F	O
					Sh	Ear pus	19	F	Au
87	Brbra	<i>Millettia ferruginea</i> **	Fabaceae	T	Fr	Ear worm	19	D	Au
					Fr	Head injury	3	D	De
88	Weyn	<i>Vitis vinifera</i>	Vitaceae	Li	L	Ear worm	19	D	Au
89	Nechlo	<i>Helichrysum splendidum</i>	Asteraceae	H	L	Ear tuberous	19	D	Au
91	Sensel (Semiza)	<i>Justicia schimperiana</i>	Acanthaceae	S	L	Ear pus	19	F	Au
					L	Evil eye	7	D	Na
92	Wzgn	<i>Vernonia hochstetteri</i>	Asteraceae	S	Sh	Uvula	3	F	O
					Sh	Teeth pain/ Toothache	6	F	O
93	Dedeho	<i>Euclea racemosa</i> subsp. <i>schimperii</i>	Ebenaceae	S	R	Out-warded anus	3	D	De
					R	Head injury	3	D	De
					R	Dermatophytosis	2	D	De
					R	Eczema	2	D	De
94	Mekmeko	<i>Rumex abyssinicus</i>	Polygonaceae	H	R	Gonorrhea	1	F	O
					L	Dermatophytosis	3	F	De
95	Etse zwe	<i>Cyphostemma junceum</i>	Vitaceae	H	R	Getting love	17	F/D	Et
					R	Snake bite	14	D	O
96	Etan	<i>Boswellia papyrifera</i>	Burseraceae	T	Re	Dysuria	9	D	O
						Typhoid/typhus	5	D	O
97	Ameja	<i>Hypericum quartinianum</i>	Hypericaceae	S	S	Continuous bleeding	11	D	O
98	Yeayt hareg	<i>Sphenoslylis stenocarpa</i>	Fabaceae	H	S	Continuous bleeding	11	D	O
99	Bsana	<i>Croton macrostachyus</i>	Euphorbiaceae	T	B	Typhoid/typhus	5	D	O

					B	Gonorrhea	11	F	O
					B	Ascarids	11	F	O
					L	Hepatitis	5	F	O
					B	Abdominal pain	11	F	O
100	Akeya/ Ahaya	<i>Salix subserrata</i>	Salicaceae	T	L/S	Rabies	9	Rabies	O
101	Timatim	<i>Lycopersicon esculentum</i>	Solanaceae	H	L	Dysuria	1	F	O
102	Selit	<i>Sesamum orientale</i>	Pedaliaceae	H	S	Deaf	4_3	D	Au
103	Atuch	<i>Verbena officinalis</i>	Verbenaceae	H	L	Deaf	4_3	F	Au
					L	Tongue Disease	2	F	O
104	Moyder	<i>Periploca linearifolia</i>	Asclepiadaceae	Li	L	Hemorrhoid	20	F	De
105	Telba	<i>Linum usitatissimum</i>	Linaceae	H	S	Abscess	3	D	De
106	Gorteb	<i>Plantago lanceolata</i>	Plantaginaceae	H	L	Leprosy	9	D	O
					L	Genital Ulcer	3	D	De
					L	Snake bite	3	F/D	De
					L	Conjunctivitis	4_3	F	Op
					L	Prevention injury scar	3	F	De
107	Mitmita	<i>Capsicum frutescens</i>	Solanaceae	H		Genital Ulcer	2	D	De
108	Weyba	<i>Combretum molle</i>	Combretaceae	T	Fr	Eczema	3	D	De
						Diarrhea			
						Skin disease			
						Leprosy	3	D	De
109	Msrch	<i>Clerodendrum myricoides</i>	Lamiaceae	S	R	Sudden Abdominal cramp	5	D	O
110	Koso	<i>Hagenia abyssinica</i>	Rosaceae	T	Fl	Amoeba (tapeworm)	5	D	O
					Fl	Wound	3	D	De
111	Kura hareg	<i>Momordica foetida</i>	Cucurbitaceae	Cl	R	Evil eye	7	D	Na
112	Lmch	<i>Clausena anisata</i> Benth.	Rutaceae	S	R	Evil eye	8	D	Na
113	Beles zaf	<i>Ficus carica</i>	Moraceae	S	L	Tuberculosis	13	D	De
					L	Ear pus	4_3	F	Au

114	Kil	<i>Lagenaria siceraria</i>	Cucurbitaceae	Cl	L	Tuberculosis	13	D	De
					L	Ear pus	4_3	F	Au
115	Ntem	<i>Schefflera abyssinica</i>	Araliaceae	T	B	Head injury	3	D	De
116	Gesho	<i>Rhamnus prinoides</i>	Rhamnaceae	S	L	Uvula	4_1	F	O
					Fr	Scabies	3	D	De
					L	Dermatophytosis	2	D	De
					L	Eczema	2	D	De
117	Lut Yedega	<i>Malva verticillata</i>	Malvaceae	H	R	Fire Burn	3	D	De
					R	Abdominal pain	6	F	O
					L	Aback/Amazement	3, 9	D, O	De, O
118	Keret	<i>Osyris quadripartita</i>	Santalaceae	T	L	Teeth pain/Disease	6	F	O
					L	Abscess	3	F	De
					Fr	Hemorrhoid	2	D	O
					L	Wound	3	D	De
					L	Tooth bleeding	6	F	O
119	Dabo ktel/ Endahula	<i>Kalanchoe petitiiana</i> **	Crassulaceae	H	Fr	Morbidity	7	D	Na
					S	Wound	13	D	De
					R	Dysuria	4_3	F	De
120	Lomi eshet/ Etse meaza	<i>Satureja abyssinica</i>	Lamiaceae	H	L/R	Snake bite	3	F/D	De
					L/R	Consciousness	1	D/F	O
					L	Fibril illness	1	D	O
					L	Common cold	1	D	O
					L	Stimulant	1	D	O
121	Demesech	<i>Vernonia leopoldi</i>	Asteraceae	H	L	Lashing	5	F	O
					L	Stop bleeding	2	F	De
					L	Lashing	5	F	O
122	Mech	<i>Guizotia scabra</i>	Asteraceae	H	L	Conjunctivitis	4_3	F	Op

123	Anterfa	<i>Euphorbia platyphyllos</i>	Euphorbiaceae	H	Lx	Hemorrhoid	20	F	De
124	Mech	<i>Guizotia schimperii</i>	Asteraceae	H	L	Relapse	4_1,5	F	O; De
125	Akoma/ Tkur enchet	<i>Prunus africana</i>	Rosaceae	T	R	Hemorrhoid	3	D	De
126	Kbe gulgul	<i>Crassula vaginata</i>	<i>Crassulaceae</i>	H	R	Abdominal pain	6	F	O
127	Fyel dabe	<i>Aeonium leucoblepharum</i>	Crassulaceae	H	R	Placenta	11	D	O
128	Chat	<i>Catha edulis</i>	Celastraceae	S	L	Asthma	1	F	Na; O
129	Knbo/ Topia	<i>Calotropis procera</i>	Asclepiadaceae	S	Lx	Wound	16	F	De
					R	Hemorrhoids	16	F	De
130	Dgta	<i>Calpurnia aurea</i>	Fabaceae	S	L	Prevention injury scar	3	F	De
131	Nech lebash	<i>Argemone mexicana</i>	Papaveraceae	H	L	Liver	1	F/D	O
					L	Pancreas	1	F/D	O
					L	Kidney	1	F/D	O
					L	Gastritis	1	F/D	O
					Lx	Eye disease	20	F	Op
132	Etse felatsut	<i>Convolvulus sagittatus</i>	Convolvulaceae	H	L/R	Getting love	17	D	Et
133	Dog	<i>Ferula communis</i>	Apiaceae	H	R	Erectile dysfunction	11	D	O
134	Aleblabit	<i>Tragia brevipes</i>	Euphorbiaceae	Cl	R/L	Erectile dysfunction	11	D	O
					R	Sudden abdominal cramp	6	F	O
135	Kestencha/ Yeset kest	<i>Asparagus africanus</i>	Asparagaceae	S	R	Erectile dysfunction	11	D	O
					Sw	Milk spoilage	17	F	Et
136	Nbasl	<i>Phagnalon abyssinicum</i>	Asteraceae	H	L	Good smell	7	D	Na
137	Yemdr koso	<i>Alchemila abyssinica</i>	Rosaceae	H	L	Stop bleeding	3	F	De
138	Kershashmbo	<i>Peusedanum winkleri</i>	Apiaceae	H	L	Softening human skin	4_2	F	De
139	Kundo Berbere zaf	<i>Schinus molle</i>	Anacardiaceae	T	Fr	Abdominal pain	9	D	O
					L	Tonsillitis	5	F	Et
140	Tosign	<i>Thymus schimperii</i> subsp. <i>schimperii</i> **	Lamiaceae	H	L	Common cold	1	D	O
						Lung tuberculosis	1	D	O

						Anti-vomiting	1	D	O
141	Tkl gomen	<i>Brassica oleracea</i>	Brassicaceae	H	L	Gastritis	2	D	O
142	Yeahya suf	<i>Carthamus tinctorius</i>	Asteraceae	H	S	Cough	1	F	O
143	Amedmado	<i>Chenopodium ambrosioides</i>	Chenopodiaceae	H	Fr	Wound	3	D	De
144	Chegot	<i>Cynoglossum lanceolatum</i>	Boraginaceae	H	L	Fibril illness	4_1	F	O
145	Tej sar	<i>Cymbopogon martini</i>	Poaceae	H	L/R	Evil eye	7	D	Na
146	Carot	<i>Daucus carota</i>	Apiaceae	H	R	Kidney problem	9	F	O
147	Koshelie	<i>Echinops longisetus</i> **	Asteraceae	S	L	Wound	3	D	De
148	Atat	<i>Maytenus arbutifolia</i>	Celastraceae	S	R	Kidney problem	5	D	O
149	Kechemo	<i>Myrsine africana</i>	Myrsinaceae	S	Fr	Tapeworm	4_1	F	O
150	Fyele fej	<i>Clutia abyssinica</i>	Euphorbiaceae	S	L	Evil eye	7	D	Na
151	Kelewa	<i>Maesa lanceolata</i>	Myrsinaceae	S	R	Evil eye	7	D	Na
152	Embs	<i>Allophylus abyssinicus</i>	Sapindaceae	T	R	Evil eye	7	D	Na
153	Kentefa	<i>Acacia brevispica</i>	Fabaceae	S	R	Evil eye	7	D	Na
154	Etse menahe	<i>Securidaca longepedunculata</i>	Polygalaceae	S	R	Evil eye	7	D	Na

\*\* Endemic Species

## Appendix 12: List of medicinal plants used for livestock ailments

Methods of preparation and application (MPA):- 2. Grind and paint the powder or crushed part; 3. Grind and Tying the crushed part; 5. Crush, homogenize with cold water and drink; 7. Crush, heat/ burn or boil the part and inhale its smoke or steam; 9. Crush and eat the part; 11. Drink the concoction directly or after Fermentation; 13. Crush, heat burn and paint the powder on the affected part; 17. Crush, mix/alone and Tying/put externally.

Route of Administration (RA): Oral, O; Dermal, De; Nasal, Na; Optical, Op; Auricular, Au; External Tying, Et;

Part used (PU):- Leaf, L; Root, R; Stem wood, Sw; Fruit, Fr; Bark, B; Root bark, RB; Stem bark, SB; Flower, Fl; Bulb, Bu; Rhizome, Rh; Seed, S; Latex, Lx; Whole, Wh; Shoot, Sh; Tuber, Tu; Oil, O; Resin, Re;

Growth form or Habit:- Tree (T); Shrub (S); Herb (H):

Conditions of Part Used (CPU):- Dry, D; Fresh, F

RN <sub>2</sub>	L.Name (Am)	Scientific Name	Family	Habit	PU	Animal Disease treated	MPA	CPU	RA
1	Bihe hareg/ Hareg resa/ Etse menehe	<i>Zehneria scabra</i>	Cucurbitaceae	H	R	Lashing	11	F	O
2	Anfar	<i>Buddleja polystachya</i>	Loganiaceae	S	L	Infintely/manic	5	F	O
3	Yedngay libs	<i>Adiantum capillus-veneris</i>	Adiantaceae	H	Wh	Sudden wound	13	D	De
4	Weyra	<i>Olea europaea</i> subsp. <i>cuspidata</i>	Oleaceae	T	Sw	Eczema	13	D	De
5	Gzewa	<i>Withania somnifera</i>	Solanaceae	H	R	Dog rabies vaccination	11	D	O
					Sw	Evil eye	7	D	Na
					R	Fungal skin disease	5	D	O, Na, Au

6	Yemdr embuay	<i>Cucumis ficifolius</i>	Cucurbitaceae	H	R	Dog rabies vaccination	11	D	O
					R	Fungal skin disease	5	D	O, Na, Au
7	Zert embuay	<i>Solanum incanum</i>	Solanaceae	S	R	Sudden abdominal cramp	5	F	O
					R	Node pain	11	F	O
8	Yeahya jero/Ketetna	<i>Verbascum sinaiticum</i>	Scrophulariaceae	H	L	Diarrhea	9	D	O
					L	RH factor related disease	5	D	Et
9	Tinbaho	<i>Nicotiana tabacum</i>	Solanaceae	S	L	Diarrhea	11	D	O
10	Grawa	<i>Vernonia amygdalina</i>	Asteraceae	S	L/R	Lashing	7	F	Na
11	Yetnchel Wetet/ Tifrina	<i>Gomphocarpus fruticosus</i> subsp. <i>flavidus</i>	Asclepiadaceae	S	R	Measles like disease	17	D	Et
					R	RH factor related disease	17	D	Et
12	Chfrg	<i>Minuartia filifolia</i>	Caryophyllaceae	H	R	RH factor related disease	17	D	Et
13	Tibtibo	<i>Plectranthus cylindraceus</i>	Lamiaceae	H	L	Diarrhea	11	D	O
14	Tult	<i>Rumex nepalensis</i>	Polygonaceae	H	R	Node pain	11	F	O
					R	Sudden abdominal cramp	5	F	O
15	Ras kmr	<i>Leonotis ocymifolia</i>	Lamiaceae	S	L	Sudden abdominal cramp	5	F/D	O
					L	Morbidity	7	D	Na
					L	Neck abscess	3	D	De
16	Sndedo	<i>Pennisetum thunbergii</i>	Poaceae	H	R	RH factor related disease	17	D	Et
17	Koshele	<i>Echinops pappii</i>	Asteraceae	S	R	RH factor related disease	17	D	Et
18	Nech shnkurt	<i>Allium sativum</i>	Alliaceae	H	Bu	Diarrhea	11	D	O
					L	Abscess	3	F	De
19	Eja/ Weynagft	<i>Inula confertiflora</i> **	Boraginaceae	S	L	Rabies	9	F	O


20	Kundo Berbere	<i>Capsicum annum</i>	Solanaceae	H	Fr	Abdominal disease	5	D	O
21	Tena adam	<i>Ruta chalepensis</i>	Rutaceae	H	L/S	Abdominal disease	5	D	O
					R	Fungal skin disease	5	D	O, Na, Au
22	Tnjut	<i>Otostegia integrifolia</i>	Lamiaceae	S	R	Fungal skin disease	5	D	O, Na, Au
23	Buna	<i>Coffea arabica</i>	Rubiaceae	S	S	Wound	2	D	O/De
24	Jbra	<i>Lobelia rynchopetalum</i>	Lobeliaceae	S	L	Diarrhea	5	D/F	O
25	Yeshkoko gomen	<i>Solanecio gigas</i> **	Asteraceae	H	L	Diarrhea	5	D/F	O
26	Yejb shnkurt	<i>Crinum abyssinicum</i>	Amaryllidaceae	H	Tu	RH factor related disease	17	D	Et
27	Dbrk/ Hulegeb	<i>Salvia merjamie</i>	Lamiaceae	H	L/S	Diarrhea	11	D	O
28	Etseanbesa	<i>Dryopteris rodolfii</i>	Dryopteridaceae	H	R	Cattle death	17	D	Et
29	Keskeso	<i>Laggera tomentosa</i> **	Asteraceae	S	R	Cattle death	17	D	Et
30	Koseret/ Yemdr kese	<i>Lippia adoensis</i>	Verbenaceae	H	R	RH factor related disease	17	D	Et
31	Gme	<i>Tagetes minuta</i>	Asteraceae	H	R	RH factor related disease	17	D	Et
32	Bsana	<i>Croton macrostachyus</i>	Euphorbiaceae	T	R	Fungal skin disease	5	D	O, Na, Au
33	Msrch	<i>Clerodendrum myricoides</i>	Lamiaceae	S	R	RH factor related disease	17	D	Et
34	Kundo Berbere	<i>Piper nigrum</i>	Piperaceae	H	S	Abdominal pain	5	D	O

\*\* Endemic Species

## DECLARATION

I, the undersigned, declare that this dissertation is my original work. It has never been presented for a degree in any other university in any form, and that all sources of material used for the thesis have been duly acknowledged.

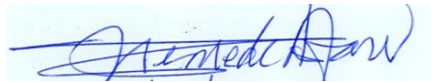
Name: Gebremicael Fisaha

Signature: \_\_\_\_\_  \_\_\_\_\_

Date: 14 August 2020

Supervisors:

Zemedet Asfaw (Prof.)



Signature: \_\_\_\_\_

Date: November, 2020

Sebsebe Demissew (Prof.)

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Ermias Lulekal (Ph.D)

Signature: \_\_\_\_\_

Date: \_\_\_\_\_