Diversity of farmers' varieties (landraces) of Cowpea (*Vigna unguiculata* (L.) Walp., Fabaceae) in Wag-himra and North Wollo zones of Amhara Region, Ethiopia

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This is to certify that the Thesis prepared by Meresa Gufuy Hadis, entitled: *"Diversity of farmers' varieties (landraces) of Cowpea (Vigna unguiculata (L.) Walp., Fabaceae) in Wag-himra and North Wollo zones of Amhara Region, Ethiopia"* and Submitted in partial fulfillment of the requirements for the Degree of Master of Science (Plant Biology and Biodiversity Management) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

Diversity of farmers'varieties (landraces) of Cowpea (*Vigna unguiculata* (L.) Walp., Fabaceae) in Wag-himra and North Wollo zones, Amhara Region, Ethiopia

Meresa Gufuy Hadis, MSc Thesis

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This study was conducted on cowpea (*Vigna unguiculata* (L.) Walp., Fabaceae) varieties identified by farmers of Wag-himra and North Wollo zones in Amhara Region of Ethiopia. The main objective of the study was to investigate on the diversity of cowpea landraces (farmers' varieties) and to know the ethnobotanical values of the crop. A total of 168 informants (84 men and 84 women) comprising 72 general informants and 12 key informants per zone aged between 19 and 75 years were interviewed. The field data were collected by using purposive sampling and random simpling technique in farmers' fields, threshing grounds, home gardens, stores and market places. Descriptive statistics, informant consensus, preference ranking, ANOVA (analysis of variance), Shannon-Wiener diversity index, post hoc test and t-test were employed for the analysis of the data by using R-software (R studio) v 3.2.2 and MS Excel spreadsheet 2016. Thirty six accessions were collected and classified under eleven farmer-named varieties. The Tepid sub-^{moist} mid-highland (SM3) agroecological zone of Wag-himra had high varietal diversity (H'=0.978049) while the Cool sub-moist highland (SM4) zone of Wag-himra came up with the least varietal diversity (H'=0.593763). Famers grow cowpea on farm sizes ranging from 0.24 ha and 0.30 ha. Area covered by cowpea by agroecological strata and zone had statistically significant differences ($p<0.05$). In the study area cowpea is widely intercropped with sorghum and maize and in addition to that in Wag-himra agroecological zone most cowpea is sole-cropped in part due to the sandy soil.

Key words: Cowpea, ethnobotany, farmers' knowledge, farmers' variety/Landrace, agroecology

Table of Contents

CHAPTER ONE 1

1. INTRODUCTION 1

1.1. Background 1

1.2 Statement of the problem 4

1.3 Research Objectives, Questions and Hypotheses 5

1.3.1 Research objectives 5

1.3.1.1General objectives 5

1.3.1.2 Specific objectives 5

1.3.2. Research question 5

1.3.3 Hypotheses 6

CHAPTER TWO 7

2. LITERATURE REVIEW 7

2.1 Cowpea Taxonomy 7

2.2 Origin, Domestication and Distribution 8

2.3 Botanical Description and Classification of Cowpea 9

2.4 Ethnobotany 10

2.5 Landrace 11

2.6 Environmental Requirements 11

2.6.1 Climatic requirements 11

2.6.1.1 Temperature 11

2.6.1.2 Water 12

2.6.1.3 Soil requirements 12
2.7 Adaptability of Cowpea for Drought Stress 13
2.8 Growth Habitat 15
2.9 Germplasm Collection, Conservation and Management 16
2.10 Socio- Economic Importance of Cowpea 17
2.11 Nutritional Value of Cowpea 18
2.12 Cowpea in Traditional Cropping Systems 18
2.13 Production Constraints 19
CHAPTER THREE 20
3. MATERIALS AND METHODS 20
3.1 Description of the Study Area 20
3.2. Materials Used 25
3.3. Methods 25
3.3.1. Informant selection 25
3.3.2 Methods of data collection 27
3.3.2.1. Field data collection 27
3.3.2.2. Ethnobotanical data collection 27
3.3.2.3. Market survey 30
3.3.2.4. Voucher specimen collection and identification 30
3.3.2.5. Seed collection 31
3.4. Methods of Data Analysis 31
3.4.1 Descriptive statistics 31
3.4.2 Analysis of variance (ANOVA) 32
3.4.3 Tukey test 32

3.4.4 Direct matrix ranking, comparisons, agreements 32
3.4.5. Diversity analysis 33
3.4.5.1Shannon-Wiener diversity index 33
3.4.5.2 Beta diversity 33

CHAPTER FOUR 34

4. RESULTS 34

4.1. Distribution, Diversity and Richness of Cowpea Varieties 34
4.1.1.1. Diversity of the farmers' varieties and richness within each stratum 43

4.2. Area of the Farms Covered by Cowpea 44

4.3. Use Value of Cowpea in Each Stratum 48

4.4. Cultivation and Management Systems of Cowpea 50
4.4.1. Gender roles in production and management 50
4.4.2. Planting time (cropping season) 54
4.4.3. Harvesting time 55
4.4.4. Crop rotation 57
4.4.5. Intercropping system 58

4.5. Farmers Seed Exchange, Selection and Storage 59
4.5.1. Farmers traditional seed storage systems 59
4.5.2. Seed source of the varieties 60
4.5.3. Wealth of farmers in relation to varieties 61
4.6. Ranking of Landraces (Farmers' Varieties) 61

4.8. Yield of Cowpea under Drought, Water Logging and High Rainfall 65

4.9. Market Value of the Varieties and Traditional Measurment 66
4.9.1. Price value of the varieties 66
4.9.2. Materials used for measuring landraces in the market 68

CHAPTER FIVE 69

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS 69

5.1. Discussion 69

5.1.1. Varietal diversity and distribution of cowpea varieties in Wag-himra and North Wollo 69

5.1.2. The area covered by cowpea crop in the study area 70

5.1.3. Use value of cowpea in each stratum 70

5.1.4. Yield of cowpea under drought, water logging and high rainfall 71

5.1.5. Cultivation and management systems of cowpea 72

5.1.5.1 Gender roles in production and management 72

5.1.5.2. Cropping systems 73

5.1.5.3. Cropping and harvesting season 74

5.1.6. Soil fertility suitable for cowpea 75

5.1.7. Farmers` seed supply, selection and storage of cowpea 76

5.1.8. Ranking of farmers' varieties 77

5.1.9. Market survey and Price 79

5.2. Conclusion 81

5.3. Recommendations 82

REFERENCES 84

APPENDICES 101

List of Figures

Page

Figure 1.Map of Ethiopia showing the study zones----------24

Figure 2.Land suitability map of cowpea in Ethiopia----------24

Figure 3.Flow diagram of the methodological framework of the study----------26

Figure 4.Interview with informants (On November, 2019 in Wag-Himra and December, 2019 in N. Wollo) ----------29

Figure 5.Mean values of area within zone, and corresponding 95% confidence intervals----------46

Figure 6.Mean values area within wealth, and corresponding 95% confidence intervals----------47

Figure 7.Mean values for area within agroecological zone, and corresponding 95% confidence intervals----------48

Figure 8.Flow diagram of the methodological framework of the study----------50

Figure 9.Gender roles in cropping practise in SM4 agroecological zone of Wag-himra ----------52

Figure 10.Gender roles in cropping practice in SM3 agroecological zone of Wag-himra ----------52

Figure 11.Gender roles in cropping practice in M3 agroecological zone of North Wollo----------53

Figure 12.Gender roles in cropping practice in M3 agroecological zone of Norh Wollo----------53

Figure 13.Sowing season of cowpea in M3 and SM3 agroecological zone of North Wollo----------54
Figure 14.Sowing season of cowpe agroecological zone of Wag-himra----------55
Figure 15.Harvesting time in Wg-himra----------56
Figure 16.Harvesting time in North Wollo----------56
Figure 17.Crop rotation system in Wag-himra and North Wollo with cowpea----------58
Figure 18.Intercropping practice of cowpea with different crops by informants in North Wollo and Wag-himra Zones----------59
Figure 19.Photo of traditional Seed storage containers (a, b) Gotera and Godo in Wag-himra and North Wollo----------59
Figure 20.Seed source for cowpea farmers' varieties----------60
Figure 21.Wealth of farmers in relation to varieties used----------61
Figure 22.Ranking of varieties----------64
Figure 23.Soil fertility suitable for cowpea in the four strata----------65
Figure 24.Yield of cowpea varieties during drought, shortage of rainfall and waterlogging----------66
Figure 25.Photo of measuring material of seed (a) Tasa from Kobo, Guba Lafto and Habru woredas of North Wollo zone (a,b)Tasa and Kubaya from Sekota and Gazigila woreda of Wag-himra zone .----------68

List of Tables

Table 1.Farmers' varieties recoding table----------35

Table 2.Diversity of landraces (farmers' varieties) in the study area----------39

Table 3.Diversity of the farmers" varieties within each stratum----------44

Table 4.ANOVA test for cultivated land size of field pea by agro-ecology, administrative zone and wealth status of farmers ----------44

Table 5.Average area of cowpea per zone ----------45

Table 6.Average area of cowpea by wealth status----------46

Table 7.Average area of cowpea per Agroecology zone----------47

Table 8.The type of food prepared from cowpea varieties----------49

Table 9.ANOVA test on price value of cowpea----------66

Table 10.Average price of cowpea----------67

List of Appendices

Appendix 1:- Informed oral consent ----------101

Appendix 2: Structured interview----------112

Appendix 3: The list of variety names, area of cowpea, Price of cowpea varieties per kg and agroecology with wealth status of informanta at different agroecological zone ----117

Acronyms

AEZ	Agroecological zones
ANOVA	Analysis of Variance
CSA	Central Statistical Agency
DA	Development Agents
EBI	Ethiopian Biodiversity Institute
EIAR	Ethiopian Institute of Agricultural Research
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization of the United Nations
GPS	Geographic positioning system
GRIN	Germplasm Resources Information Network
NW	North Wollo
SM3	Tepid sub-moist mid-highland
M3	Tepid moist mid-highland
SM4	Cool sub-moist highland
ODK	Open data kit
USDA	United States Department of Agricultur
WH	Wag-himra

CHAPTER ONE

1. INTRODUCTION

1.1. Background

The pulse (grain legume) crops as a group in Ethiopia constitute considerable number and diversity of crop species. Cowpea [*Vigna unguiculata* (L.) Walp., Fabaceae] is an important pulse crop in many countries of tropical Africa, Asia and South America. Both grain and leaves are edible products of cowpea that are rich and cheap sources of high-quality protein. They supplement to the lower quality cereal or root and tuber protein commonly consumed in tropical Africa (Kitch et al., 1998; Karikari & Molatakgosi, 1999). On average, cowpea grains contain 23-25% protein and 50-67% starch in dry bases (Quin, 1997). From a single planting, one may be able to have several products such as leaves, immature pods, immature and mature seeds. Careful and positive attention to cowpea would support 850 million people in the world with high incidence of undernourishment in sub-Saharan Africa as documented by FAO (2005, 2006). While cowpea seeds have long been considered as the only important product, leaf consumption from home gardens and field production is even becoming more wide-spread. Most commonly leaves are served boiled to accompany a starchy porridge. According to the study by Bittenbender (1990), cooked leaves contain two-thirds of the protein, seven times the calcium, three times the iron, half the phosphorus, eight times the riboflavin, five times the niacin and several hundred times the ascorbic acid and beta-carotene of the cooked seed. Amino acid composition was found to indicate cowpea leaf protein as superior to seed (Bittenbender, 1990).

Cowpea is a tropical grain legume which plays an important nutritional role in developing countries of the tropics and subtropics. Cowpea young leaves, pods and

seeds contain vitamins and minerals which have fuelled its usage for human consumption and animal feeding (Timko and Singh, 2008).

On the other hand, cowpea has many beneficial attributes to many desirable horticultural characteristics usually associated to non-food uses. It is an efficient nitrogen fixing, heat and drought-tolerant legume (Bittenbender, 1990). In most African countries, cowpea is either grown alone or intercropped with various other crops such as leafy vegetables, maize (*Eleusine coracana*), millet, sorghum (*Cajanus cajan*), beans, pigeon pea, banana and others (Bittenbender *et al*., 1984; Singh *al et*., 1997). In intercropping production systems, the spreading indeterminate type of cowpea serves as a ground cover and, thus, suppresses weeds as well as protects the soil against erosion. In addition, some cowpea varieties cause suicidal germination of the seed of *Striga hermonthica*, a parasitic plant that usually infests cereals with devastating effects (Quin, 1997). This is also a serious problem of sorghum production in northern and north-central Ethiopia.

The depletion of natural vegetation in many parts of the country has led to the threat and decline in number and area of distribution of many plant species. The pulse distribution study of Ethiopia by Westphal (1974), described the status and species composition in the country.

Furthermore, a number of biotic and abiotic stress factors remain to be among key constraints that reduce the growth and yield of cowpea in its major production areas. Also, cowpea is still challenged with little attention to improve it as leafy vegetable (Keller *et al*., 2005; Keding *et al*., 2007), though it is appreciated as vegetable in many parts of Africa (Barrett, 1990; Bittenbender, 1990; Angessa, 2006; Saidi *et al*., 2007). However, in order to enhance the use of these plants, Angessa (2006)

suggested that research is needed to increase their yield and quality levels while considering the target groups' preferences and desires.

The pulses or grain crops in Ethiopia consist of *Cajanus cajan (L.) Millsp., Canavalia ensiformis (L.) DC., Lablab purpureus L., Lathyrus sativus L., Lens culinaris Med., Lupinus albus L., Mucuna pruriens (L.) DC., Phaseolus species L., Pisum sativum L., Psophocarpus palustris Desv., Trigonella foenum-graecum L., Vicia faba L. Vigna unguiculata* and others (Westphal, 1974).

According to EBI (Ethiopian Biodiversity Institute) germplasm collection database 2014 (unpublished data), a total of 94 accessions of cowpea landrace material have been collected by the EBI for conservation and subsequent utilization. The major goal of this study was to identify and document the farmers' varieties and the ethnobotanical uses of cowpea in parts of northern Ethiopia. The important morphological traits and the germination potential of cowpea farmers' varaties were also investigated. However, there is no enough information on cowpea distribution and production in Ethiopia. Farmers have accumulated knowledge to protect farmers' varieties in their farm activities. Studies by Mulugeta Alemu (2015) and Sisay Alemu (2015) have shown that farmers in northern and southern Ethiopia cultivated a rich diversity of cowpea landraces used for food, feed and other purposes like medicines and income generation. Dry seed, young pod and leaves are consumed in different parts of Ethiopia. The leaves are also used as medicine by some societies particularly in Gambella region. However, these studies are still far from being complete being a single season survey. Additional data is needed to have a fair representation of the diversity of farmers' varieties cultivated in Ethiopia and for documentation of the indigenous knowledge on use and management of the different farmers' varieties, assessment of the status and preservation of the landraces.

Therefore, to fill the gap of information about the diversity status of cowpea crop and distribution of the species on the farmers' land, status and ethnobotanical knowledge held by farmers finding the major production areas in the study areas, Amhara region of Ethiopia is important; Furthermore, information on constraints of cowpea production in the study area. would be important hence, this research was initiated with the objective of identifying the diversity, distribution along with the study areas, ethnobotanical uses of cowpea, and utilization practices in Wag-hmira and North Wollo zones of Amhara region.

1.2 Statement of the problem

There are few researches conducted on farmers' varieties of cowpea in Ethiopia. Similar researches are also limited when the present study area is considered. Furthermore, there is only a few researchs conducted on ethnobotanical uses of cowpea in northern Ethiopia in particular. The agroecological variability in terms of distribution and diversity of the crop is not studied. However, a study on farmers' varieties diversity and germplasm collection of this potential resource is important to guarantee the improvement of the crop. Such studies can be a source of new genes for combating different threats to agricultural production. Therefore, this study was initiated to assess and document the landrace diversity, the ethnobotanical and agroecological conditions of cowpea in Wag-himra and North Wollo zones of Amhara Region. This research intends to address ethnobotanical and agroecological conditions of the cowpea crop and its landraces.

1.3 Research Objectives, Questions and Hypotheses

1.3.1 Research objectives

1.3.1.1General objectives

The aim of this research is to document the diversity of cowpea and the ethnobotanical knowledge on its use and management.

1.3.1.2 Specific objectives

- To describe the agroecological and geographical distribution and diversity of farmers' varieties of cowpea.
- To gather, record and document indigenous knowledge of the people on the ethnobotanical uses and sociocultural variability on the distribution, use and management of cowpea.
- To identify and document the farmers' varieties of cowpea through fieldwork in the study areas based on voucher specimens and field samples.
- To carry out conservation measurement of germplasm collection cowpea to Ethiopia Biodiversity institution (EBI) for guarantees the improvement of the crop.

1.3.2. Research question

- Which farmers' varieties of cowpea are found in Wag-himra and North Wollo zones of Amhara region?
- Do farmers in Wag-himra and North Wollo zones of Amhara region in the same agroecological zone grow the same varieties?
- Which agroecological zones in the study areas are very important for the growth and productivity of cowpea?
- What are the main production constraints faced by farmers in cultivation of cowpea in the study area?

- Which varieties of cowpea have the highest values for specific purposes in the study area?
- What conservation and management measures should be undertaken for cultivation of cowpea?
- Is there any difference in market price values and yield among cowpea farmers' varieties in the study area?
- What are the seed exchange systems among the farmers in the study area?

1.3.3 Hypotheses

- ✓ The type of cowpea varieties grown by farmers in Wag-himra zone of Amhara region differ from those grown in North Wollo of Amhara region**.**
- ✓ The average number of cowpea varieties planted per household in 2010 E.C by farmers in the same agroecological zone differs between Wag-himra and North Wollo zones of Amhara region.
- ✓ Agroecological zones affect the growth and productivity of cowpea
- ✓ Cowpea growers face different production constrains in the study area.
- ✓ Cowpea farmers' varieties are valued differently based on their specific purposes.
- ✓ Growing of cowpea requires different conservation and management measures in the study area.
- ✓ Different varieties of cowpea have got different market prices based on the farmers' preferences.
- ✓ There are different seed sources of cowpea in the study area.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Cowpea Taxonomy

Cowpea belongs to the class Dicotyledonae, order Fabales, family Fabaceae, subfamily Papilionoideae, tribe Phaseoleae, subtribe Phaseolinae, and genus *Vigna* (Padulosi and Ng, 1997). Linnaeus described it as *Dolicho sunguiculatus* L. (later renamed *Vigna unguiculata* (L.) Walp., Fabaceae) in 1753, Between 1753 and 1845, more than 20 binomials were described from cultivated *Vigna unguiculata* specimens. These binomials were considered specific and ranked at infraspecific levels during the second half of the 19th century. Recently cultivated forms are pooled in *Vigna unguiculata* ssp. *unguiculata* var. *unguiculata* and wild annual forms in ssp. *unguiculata* var. *spontanea* (Pasquet, 1993). Wild perennial forms are ascribed to ten subspecies (Pasquet, 1997). Wild annuals are easily crossed with cultivated cowpeas (Ng, 1995).

All cultivated cowpeas are grouped under *V. unguiculata* subspecies unguiculata, which is subdivided into four cultivars, namely *unguiculata, biflora, sesquipeda1is*, and *textilis* (Westphal, 1974; Ng and Marechal, 1985). There has been no major argument on this classification, since its adoption over 10 years ago. The classification and nomenclature of the wild taxa within V. unguiculata, however, is complicated, and could sometimes be confusing. More than 20 epithet names have been used in the past to designate wild taxa within *V. unguiculata* species complex. An extensive work on characterization of over 400 wild V. *unguiculata* accessions was conducted at IITA (Ng and Padulosi, 1991; Padulosi, 1993).

2.2 Origin, Domestication and Distribution

Origin, domestication and distribution cowpea [*Vigna unguiculata* (L.) is one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times (Summerfield et al. 1974). Cowpea is commonly referred to as "niébé," "wake," and "ewa" in much of West African countries, and "caupi" in Brazil. In the United States, other names include "southern peas," "blackeyed peas," "field peas," "pinkeyes," and "crowders." These names reflect traditional seed and market classes that developed over time in the southern United States. The name cowpea probably originated from the fact that the plant was an important source of hay for cows in the southeastern United States and in other parts of the world (Timko *et al*. 2007). Cowpea most likely originates from Africa, as wild cowpeas only exist in Africa and Madagascar (Steele 1976). The center of diversity of cultivated cowpea is found in West Africa, in an area encompassing the savannah region of Nigeria, southern Niger, parts of Burkina Faso, northern Benin, Togo, and the northwestern part of Cameroon (Ng and Marechal 1985). Carbon dating of cowpea (or wild cowpea remains from the Kimtampo rock shelter in central Ghana) has been carried out (Flight 1976) and is the oldest archaeological evidence of cowpea found in Africa. Cowpea is considered to have been domesticated in Africa from its wild ancestral form, V. unguiculata subsp. dekindtiana (Harms) Verdc. (Ng and Marechal 1985). However, the precise location of origin where cowpea was first domesticated is still under speculation. Ba *et al*. (2004) reported that the crop was probably domesticated by farmers in West Africa while Coulibaly *et al*. (2002) presented some evidence that domestication occurred in northeastern Africa, based on studies of amplified fragment length polymorphism (AFLP) analysis. Cowpea was introduced from Africa to the Indian sub-continent approximately 2000 to 3500 years ago (Allen 1983). Cowpeas had reached Europe from Asia and have been cultivated in southern Europe at least

since the 8th century BC and perhaps since prehistoric times (Tosti and Negri 2002). From the West Indies, cowpea was taken to the USA in about 1700 BC (Pursglove 1968). The slave trade from West Africa resulted in the crop reaching the southern USA early in the 18th century however, many US cultivars appear more closely related to germplasm from Asia or southern Europe than West Africa (Fang *et al*. 2007). Presently cowpea is grown throughout the tropic and subtropics around the whole world.

2.3 Botanical Description and Classification of Cowpea

Description and classification cowpeas are generally more robust in appearance than common beans with better developed root systems and thicker stems and branches. Summerfield et al. (1974), Kay (1979) and Fox and Young (1982) described cowpea as an annual herb reaching heights of up to 80 cm with a strong taproot and many spreading lateral roots in the surface soil. Growth forms vary and include erect, trailing, climbing, or bushy, usually indeterminate growers under favorable conditions. Fruits are pods containing seeds that vary in size, shape, color and texture. Pods may be held erect, crescent-shaped or coiled. They are usually yellow when ripe, but may also be brown or purple. The flowers are arranged in race mose or intermediate inflorescence at the distal ends of 5-60 cm long peduncles. Flowers are conspicuous, mostly self-pollinating, borne on short pedicels and the corollas may be white, dirty yellow, pink, pale blue or purple in color. Flowers open in the early day and close at approximately midday.

Verdcourt (1970) and Marechal et al. (1978) classified cowpea in the order Fabales, family Fabaceae, subfamily Faboideae, tribe Phaseoleae, subtribe Phaseolinae and genus *Vigna.* The genus *Vigna* has several species, but the exact number varies according to different authors. Cultivated cowpeas have been divided into five

cultivar groups based mainly on pod and seed characteristics (Pursglove 1968; Pasquet 1999). Cultivar group Unguiculata is the largest and includes most medium- and large-seeded African grain and forage-type cowpeas. Cultivar group Melanophthalmus includes “blackeye pea”-type cowpea with large, somewhat elongated seeds with wrinkled seed coats and fragile pods (Pasquet 1998).

2.4 Ethnobotany

Cowpea has been a staple crop and important protein source for many cultures since the Roman Empire. It was the most commonly cultivated bean used for human consumption in the Old World (Allen and Allen, 1981). Roman writers such as Pliny referred to it as phaseolus. Thomas Jefferson is credited with first using the name cowpea. Today the crop is still widely popular, and good harvests are critical to ensure adequate levels of protein in the diets of populations in India and East Asia (Allen and Allen, 1981).Studies by Mulugeta Alemu *et al* (2016) have shown that Pulses as a group in Ethiopia constitute considerable number and diversity of crop species. The Ethiopian Biodiversity Institute has a total of 94 germplasm accessions of cowpea at the gene bank EBI. Although indicated that Ethiopia is a secondary center of diversity for cowpea, there is limited information regarding the genetic resource, there are major production challenges and social factors related to cowpea production in the country. In addition, there is no published document regarding cowpea landraces, the status of diversity and ethnobotany in Ethiopia.Therefore, collecting and documenting cowpea landraces with the associated ethnobotanical information and farmers’ varieties are fundamental and urgent tasks.

2.5 Landrace

The term landrace refers to a dynamic population of a cultivated plant that has historical origin, distinct identity, and lacks formal crop improvement, as well as often being genetically diverse, locally adapted, and associated with traditional farming systems (Camacho Villa *et al*., 2005). Landraces have been selected by farmers for adaptation to specific sets of field conditions as well as particular uses within the food system. They are often highly variable in appearance, but they can be identified and almost always have distinct local names. They have particular characteristics (e.g. early or late maturing), a reputation for adaptation to local climatic conditions, cultural practices, and resistance or tolerance to diseases and pests (Harlan, 1992).

Major advantages of landraces are adaptation to their specific agro-systems and low input requirements, and ethnic reasons are also present in traditional agriculture practices. Therefore, landraces generally provide high yield stability and intermediate average yields under a low input agricultural system (Zeven, 1998). The genetic diversity of landraces is very important for global biodiversity conservation for future world production (Wood & Lenné, 1997). Diversity is expressed as genetic differences between species, subspecies, varieties, populations or individuals.

2.6 Environmental Requirements

2.6.1 Climatic requirements

2.6.1.1 Temperature

Cowpea tolerates annual mean temperatures of from 12.5-27.8 degrees C, with the mean of 54 cases being 22.1 (Duke, 1981); the species is cold sensitive and killed by frost (Duke, 1981; Miller, 1989). Cowpea is more sensitive to frost than is soybean (McLeod, 1982). The most productive heat-adapted legume (Miller *et al*., 1988, 1989), cowpea is adapted to almost the same hot, moist climatic conditions as corn although it requires more heat (McLeod, 1982).

2.6.1.2 Water

Cowpea tolerates from 2.8 to 41.0 dm of precipitation (11-161.42 inches), with the mean of 54 cases being 14.2 (55.91 inches); cowpea is usually grown under rain fed rather than irrigated conditions (Duke, 1981). Cowpea is regarded as fairly drought resistant (Peaceful Valley, 1988), slightly more so than soybean (McLeod, 1982), with a taproot that can explore deep soil profiles for moisture (Miller, 1988). However, most of the moisture used is obtained from the surface foot of soil (McLeod, 1982). A cover crop can be obtained in 60-90 days with very little irrigation (Miller, 1988). Cowpea is less tolerant of waterlogging than is soybean (Duke, 1981).

2.6.1.3 Soil requirements

Duke (1981) stated that cowpea does well on many types of soil from highly-acid to neutral but is less tolerant of alkaline conditions. Although adapted to a wide range of soil types, including low-fertility soils, best growth occurs on sandy loams, and for optimum growth, good drainage, aeration and water supply are important (McLeod, 1982; Peaceful Valley, 1988). Miller et al. (1989) stated that best growth is made on deep well-drained acid to neutral soils. Cowpea is sensitive to excess amounts of boron (Agbenin, Lombin, and Owonubi, 1990). This species is thought to be better than clover or alfalfa on thin soils or soils low in lime and those too poor and acid for clover (McLeod, 1982). For grain production, a poor soil is actually better because a poor soil produces little vegetation and ample seed, whereas a rich soil leads to abundant vegetative growth and little seed (McLeod, 1982).

Cowpea tolerates soil pH of from 4.3-7.9, with the mean of 46 cases being 6.2; cowpea or varieties thereof are said to be tolerant of low pH and high pH but in general are less tolerant of alkaline conditions (Duke, 1981). It is said to thrive in low-fertility soil if pH is between 5.5 and 6.5 (McLeod, 1982; Peaceful Valley, 1988).

Maas and Poss (1989) found used cowpea (CV 'California Blackeye No. 5') conducted pot studies in sand culture with saline solutions of various strengths (2:1 molar ratio of NaCl to CaCl) used for irrigation. Based data for the osmotic potentials that induced 50% reduction in pod and seed yields, cowpea was more susceptible to salinity increases in the vegetative (-0.45 MPA) than in the flowering (-0.76 MPa) or pod-filling (-0.88 MPa) stages. Seed number, but not individual seed size, was affected.

2.7 Adaptability of Cowpea for Drought Stress

Cowpea has been cultivated and domesticated in Africa for centuries. It is now grown worldwide, especially in the tropics. It is a warm-season crop that can be produced in semi-arid regions and dry savannas. It is better adapted to sandy soils and droughty conditions than soybeans (TJAI, 2010). It can be grown in regions with an average annual rainfall of 2.5 to 8 inches (Cook et al., 2005). The semi-arid zones where a large area of cowpeas is grown also are hot. In subtropical areas with long days, it has been shown that high temperatures late at night disturb flower production and pollination, causing reductions in pod production (Hall, 2004). These methods were used to breed a heat-tolerant cowpea cultivar for use in California (Ehlers *et al*., 2000). The main reason for the latter result may be that the heat tolerance genes are much more effective under the long-day conditions that occur during the growing season in California, than under the shorter days that occur during the growing season in Ghana and Senegal (Ehlers and Hall, 1998). Another possible reason is that to be effective in tropical zones of Africa, the heat tolerance genes must be combined with other compatible genes. For example, some of the heat-tolerant lines bred in California produced many pods in Senegal but the pods did not develop due to biotic stresses.

A method has been developed that may be useful for selecting for heat tolerance under either short- or long-day conditions (Thiaw and Hall, 2004). Lines selected for low leaf electrolyte leakage under heat stress also had reproductive-stage heat tolerance. In addition, lines selected for reproductive-stage heat tolerance in long-day field conditions also had low leaf electrolyte leakage under heat stress. The leaf electrolyte leakage test can be conducted in a laboratory, with relatively simple equipment, using leaves from plants growing in field nurseries. However, it has not yet been determined whether this method can be used to select under short-day tropical conditions for plants that also exhibit heat tolerance during reproductive development under hot short-day tropical conditions.

In addition, incorporating heat tolerance during reproductive development was shown to result in a semi-dwarf habit (Ismail and Hall, 1998). While a semi-dwarf habit may be useful under intensive irrigated production in subtropical areas such as California (Ismail and Hall, 2000), it is not suitable for use under harsh rain fed conditions in semi-arid tropical environments where the expression of dwarfing is more extreme due to the more rapid plant development that occurs at higher temperatures. It has not been determined whether the association between the heat tolerance effects and dwarfing can be separated, or whether it is a pleiotropic effect of the same set of genes. Consequently, while the value of breeding for reproductive-stage heat tolerance has been established for cowpeas in subtropical long-day conditions, its value for tropical short-day environments is not clear.

Many aspects of plant growth are affected by drought stress (Hsiao, 1973), including leaf expansion, which is reduced due the sensitivity of cell growth to water stress. Water stress also reduces leaf production and promotes senescence and abscission (Karamanos, 1980), resulting in decreased total leaf area per plant. Reduction in leaf

area reduces crop growth and thus biomass production. Seed production, which is positively correlated with leaf area (Rawson and Turner, 1982), may also be reduced by leaf area reductions induced by drought stress. For cowpea to be used as a forage or dual-purpose crop in the semi-arid areas, the effect of drought stress on leaf area, and the relationship between leaf area and seed yield, must be understood. Changes in plant water status due to drought stress also need to be investigated, since the growth of a leaf is intimately linked with its water potential. Since drought may occur at any stage of growth, cowpea was drought-stressed at the vegetative, flowering or pod-filling stages to assess responses of leaf water potential, leaf area and seed yield to water stress.

2.8 Growth Habitat

Cowpea is a warm-season, annual, herbaceous legume. Plant types are often categorized as erect, semi-erect, prostrate (trailing), or climbing. There is much variability within the species. Growth habit ranges from indeterminate to fairly determinate with the non-vining types tending to be more determinate. Cowpea generally is strongly tap rooted. Root depth has been measured at 95 in. 8 weeks after seeding (Timko *et al.,* 2008; Timko and Singh, 2008).

Cowpea seed ranges in size from the very small wild types up to nearly 14 in. long and the number of seeds per pounds range from 1600 to 4300. Seed shape is a major characteristic correlated with seed development in the pod. Seeds develop a kidney shape if not restricted within the pod. When seed growth is restricted by the pod the seed becomes progressively more globular.

The seed coat can be either smooth or wrinkled and of various colors including white, cream, green, buff, red, brown, and black. Seed may also be speckled. mottled, or

blotchy. Many are also referred to as "eyed" (blackeye, pinkeye purple hull, etc.) where the white colored hilum is surrounded by another color.

Emergence is epigeal (similar to common bean and lupin) where the cotyledons emerge from the ground during germination. This type of emergence makes cowpea more susceptible to seedling injury, since the plant does not regenerate buds below the cotyledonary node.

The trifoliate leaves develop alternately. Leaves are smooth, dull to shiny, and rarely pubescent. Commonly, the terminal leaflet is longer and larger than the lateral leaflets. There is a wide range in leaf size and shape.

Cowpea generally is day neutral. Flowers are borne in multiple racemes on 8 to 20 in. flower stalks (peduncles) that arise from the leaf axil. Two or three pods per peduncle are common and often four or more pods are carried on a single peduncle. The presence of these long peduncles is a distinguishing feature of cowpea and this characteristic also facilitates harvest. The open display of flowers above the foliage and the presence of floral nectarines contribute to the attraction of insects. Cowpea primarily is self- pollinating (Timko and Singh, 2008).

Cowpea pods are smooth, 6 to 10 in. long, cylindrical and generally somewhat curved. As the seeds approach the green-mature stage for use as a vegetable, pod color may be distinctive, most commonly green, Yellow or purple. As the seeds dry, pod color of the green and yellow types becomes tan or brown.

2.9 Germplasm Collection, Conservation and Management

Cowpea germplasm is maintained in collections around the world with varying levels of accessibility and documentation. The largest collections are held by the IITA with more than 14,000 accessions (Mulugeta, 2015). The United States Department of Agriculture (USDA) maintains a collection with ca. 8,000 accessions. Access to this

collection is through the USDA Germplasm Resources Information Network or GRIN system (www.ars-grin.gov). The University of California-Riverside has a collection with ca. 5,000 accessions accessible on a Microsoft Access database. There is also a large collection of Mediterranean and African landraces (ca. 600 accessions) held at the Istituto di Genetica Vegetale at Bari, Italy (www.ba.cnr.it). The collection mission is done yearly and the number of accessions is expected to rise with time. According to EBI data base, a total of 94 accessions of cowpea germplasm were collected by Ethiopian Biodiversity institute (Mulugeta, 2015).

2.10 Socio- Economic Importance of Cowpea

Members of the Phaseoleae (which cowpea belongs to) include many of the economically important warm season grain and oilseed legumes, such as soybean (*Glycine max*), common bean (*Phaseolus vulgaris*), and mungbean (*Vigna radiata*) (Timko *et al*. 2007). Cowpea is the most economically important indigenous African legume crop and has a wide variety of uses as a nutritious component in the human diet as well as nutritious livestock feed (Langyintuo et al. 2003). It is usually the first crop harvested before the cereal crops are ready and therefore is referred to as "hungry-season crop". With more than 25% protein in dry seeds as well as in young leaves (dry weight basis), cowpea is a major source of protein, minerals and vitamins in daily diets and is equally important as nutritious fodder for livestock (Singh *et al*., 2003). The high protein content of cowpea grain represents a major advantage for use in infant and children's food (Lambot 2002). The mature pods are harvested and the haulms are cut while still green and rolled into small bundles containing the leaves and vines. These bundles are stored on rooftops for uses as feed supplement in the dry season, making cowpea a key component of crop-livestock systems. Cowpea haulms fetch 50% or more of the grain price (dry weight basis). Therefore, cowpea plays a

critical role in the lives of millions of people in Africa and other parts of the developing world, and is a valuable and dependable commodity that produces income for farmers and traders (Singh 2002; Langyintuo *et al*., 2003). Additionally cowpea is a valuable component of farming systems in many areas because of its ability to restore soil fertility for succeeding cereal crops grown in rotation with it (Carsky *et al*., 2002; Tarawali *et al*., 2002; Sanginga *et al*., 2003).

2.11 Nutritional Value of Cowpea

The nutritional content of cowpea grain is important because it is eaten in quantity by millions of people who otherwise have diets lacking in protein, minerals, and vitamins. The nutritional profile of cowpea grain is similar to that of other pulses, with a relatively low fat content and a total protein content that is two to four times greater than cereal and tuber crops. Like other pulses, the protein in cowpea grain is rich in the amino acids lysine and tryptophan, compared to cereal grains.

In addition, because grain legume starch is digested more slowly than starch from cereals and tubers, their consumption produces fewer abrupt changes in blood glucose levels following consumption (Phillips *et al.,* 2003).

2.12 Cowpea in Traditional Cropping Systems

In agriculture, cowpea has traditionally exceptional importance for dry savannas of Africa because it requires relatively little water, which is a big limiting resource in these areas (Mortimore *et al*., 1997). The area along the coast covers eastern and southern parts of Africa including countries like Somalia, Kenya, Tanzania and Mozambique. Cowpea is also important for the in-land dry savannas of Kenya, Tanzania (Dodoma region), and Zambia etc. It is normally grown alone as pure crop in the coastal regions, and as mixed crop with maize in other regions (Mortimore *et al*., 1997). Ehlers (1994) stated that in Africa over 90% of cowpeas are produced as an

intercrop with maize, pearl millet, or sorghum although sole crops of cowpea are important in some parts of West Africa. In eastern Africa most of the farmers prefer to grow a dual purpose cowpea, which is a type where both leaves and grains are the final important products. In addition, it is common that many growers who are actually engaged in producing a dual purpose cowpea sequentially harvest leaves along the growing period followed by seed harvest at the end of the season (Saidi *et al*., 2007). In Tanzania, cowpea plays a big role in traditional agriculture where, in every growing season, most of the farmers accompany maize with cowpea. Common bean (Phaseolus vulgaris) highly competes with cowpea in grain production and consumption, but cowpea remains popular for the best and tasty leaf quality. Tanzania is among the major cowpea growing countries in the world with 145,000 ha area under cowpea cultivation and the average grain yield of 317 kg/ha.

2.13 Production Constraints

A major problem in cowpea production is the menace by insect pests. Currently, economic necessity and environmental destruction have rendered insecticide use socially unacceptable, although somewhat unrealistically so. In addition, there is increased advocacy for monitored rather than calendar– based insecticides application, if insecticides must be used (Jack and Daoust, 1986). Getting a good crop stand is paramount to getting good yield. Damage from insects as beetles, bean fly, can cause poor stand.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Description of the Study Area

The study was conducted in one of the regional states (Amhara) of Ethiopia, by selecting two major cowpea growing zones (Wag-himira and North Wollo) depending on production and economic and cultural roles of the crop. Two agroecological zones were select from each study zone. Wag-himra is one of the nine administration zones of Amhara National Regional Sate (ANRS) in Ethiopia. It is located in northeastern part of the region approximately between 12°7'13°17N and -38°20'-39°18'E E. It has six districts and one town administration: Abergelle, Dehana, Gazgibla, Sehalla, Sekota, and Ziqualla woredas and Sekota town administration. According to the third population and housing census conducted in May 2007, the total number of persons living in Wag-himra zone was estimated to be 426,038. Of the total population, female and male accounted for about 50% each. About 93% of the total population lives in rural areas (PCC, 2008).

Agriculture is the primary means of livelihoods for people living in Wag-himra azone. More than 90% of the total population in the administrative zone depends on agriculture for their livelihoods (EIAR and ARARI 2008). Crop-livestock mixed farming characterizes the agricultural system in the area (Adefris Tekle *et al.,* 2000; Belay Fantaye, 2006; Dereje Andualem, 2004; Ephrem Fufa *et al*., 2006). There are three agroecological zones in Wag-himra administrative zone: low land, mid land, and high lands. Different crop types and varies are produced across the different agro-ecologies. Almost all crop production is practiced under rainfed condition. Small-ruminants are the dominant livestock types raised in the area. However, given the recurrent drought, among many other factors, agriculture fails to meet the food

demand of the ever-increasing population even in normal years. As a result, the area remains one of the most food aid recipients in the country (Devereux *et al*, 2002).

North Wollo administrative zone is one of the eleven zones of the Amhara Regional State of northern Ethiopia. North Wollo acquired its name after the former Wollo province bisected into north and south. The North Wollo zone is geographically located between 11°N-11^{o}N and 38^{o}E to 40^{o}E. It is bordered on the north by Wag-himra, on the south by South Wollo, on the east by Afar Region State, on the west by South Gondar, on the northeast by Tigray Regional State and part of its southern border is defined by the Mille River. The zone has an estimated area of 12,172.50 square kilometers (km), which is about 20 per cent of the region. The administrative zone has nine Woredas, namely, Guba lafto, Habru, Delanta, Meket, Wadla, Bugna and Gidan. Its administrative town, Woldia, is located 380 km North East of Bahir Dar and 521 km north of Addis Ababa.

The altitude of the zone varies from 600 to 4284 meter above sea level (m.a.s.l). The North Wollo administrative Zone has four agro-ecological zones, namely, lowland (Kolla) 600 -1500 m.a.s.l 38%, Mid-altitude (Woina-Dega) 1500-2300 m.a.s.l is about 34%, Highland (Dega) 2300-3200 m.a.s.l is 21% and Wurch >3200 is about 7% of the Zone.

Most of the areas are unsuitable for agriculture as several parts of the zone are mountainous and steep slopes, which severely limit the cultivated area. About 24% of land in this zone is arable, 47.3% degraded or unusable, 17.4% shrub land, 4.6% pasture, 0.37% forest and the remaining 6.3% for other uses (Yassin, 2002).

According to 2007 census, the Zone has a total population of 1,500,303 in a total of 355,974 households. The average persons per household are 4.21 and have 343,504 housing units. Only 10.35% of the populations are urban inhabitants.

The study was conducted in Guba lafto, Kobo and Habru districts, which are three districts in the Amhara region. Guba lfto lies between 11^0 36' and 11^0 58' North latitude and 39^0 12' to 39^0 50' East longitude (Gesese and Mberengwa 2012). According to data obtained from the district agriculture office, the total area of the district is about 130,000 ha, out of which 34.1% is cultivable land, 17.9% is grazing land, 27.1% is forest and bushland, 9.9% makes up human settlement, 6% is wetland and water bodies and 5% is degraded land. The 2007 population census shows that the district has a total population of 139,825, out of which 70750 are male and 69075 are female. More than 95% of the populations live in rural areas (CSA 2007). The district has three agro-ecological zones, 17% lowland (Kolla), 46% mid-altitude (Weynadega), and 37% highland (Dega). In terms of rainfall, the highlands areas receive an average annual rainfall of 2500 mm, the midlands 1500-2500 mm and the lowlands 500-1500 mm (Gesese and Mberengwa 2012). The district has a bimodal rainfall pattern with two rainy seasons. The first season "belg" (spring) starts in March and lasts until May, while the second "mahar" (summer) lasts from July until September. The major crops cultivated in the study area include teff, barley, sorghum, bean, chickpeas, lentil, maize, onions and garlic. The production system is mainly mixed agriculture including crop and livestock farming. The area is known to be one of the most drought prone areas in the region (Tesfaye 2013).

Kobo District has a total population of 221, 958 out of which 111605 are male and 110353 are female. Over 85% of the population lives in rural areas (CSA, 2007). The District has a total area of 1,922,300 ha found in the Kobo valley. The lowlands of the valley are characterized by fertile alluvial soils and erratic rainfall. Much of the district is in a dry midland agroecological zone (61.83%), followed by a dry lowland (27%) and highlands (10.69%). The district is characterized by a high population

density and intensively cultivated land with crops including cereals, pulses and oil crops. Teff, maize, and sorghum are the major cereal crops in this area. The district has bimodal rainfall, with the first short rain season starting in February and ending in May. Although some villages in the district plant crops during this season, the majority do not because of the unreliable nature of the season. The main rain season starts in June and extends until September and is the main agricultural production season. The rainfall volume is more stable in this season, although recent years have exhibited variability, with negative impacts on local agricultural production. While the highlands receive 900-1400 mm of annual rainfall, the midland and the lowland areas receive less than 900 mm of annual rainfall which makes the district a drought prone area (MoWR 2007).

According to Fentabil *et al*., (2006), Habru woreda is located between 11°24'00"N-11°45'00"N, Latitude and 39°30'00"E-39°57'00"E, Longitude. Habru woreda is located in North Wollo administrative zone, Amhara regional state, Ethiopia. Mersa town is the center of the Woreda, which is 490 km northeast of Addis Ababa and 30 km south of Woldiya, capital of north Wollo zone of the region. Habru woreda is bordered on the south by Mille River, on the west by Guba Lafto woreda, on the north by the Alawuha River, and on the east by the Afar region. The topography is characterized by plane lands (40%), plateaus (35%), escarpment (22%), and other landscapes (3%). Figure 1 shows the sampling sites and Figure 2 demarcates areas in Ethiopia considered suitable for cultivation of cowpea based on the requirements of the crop.

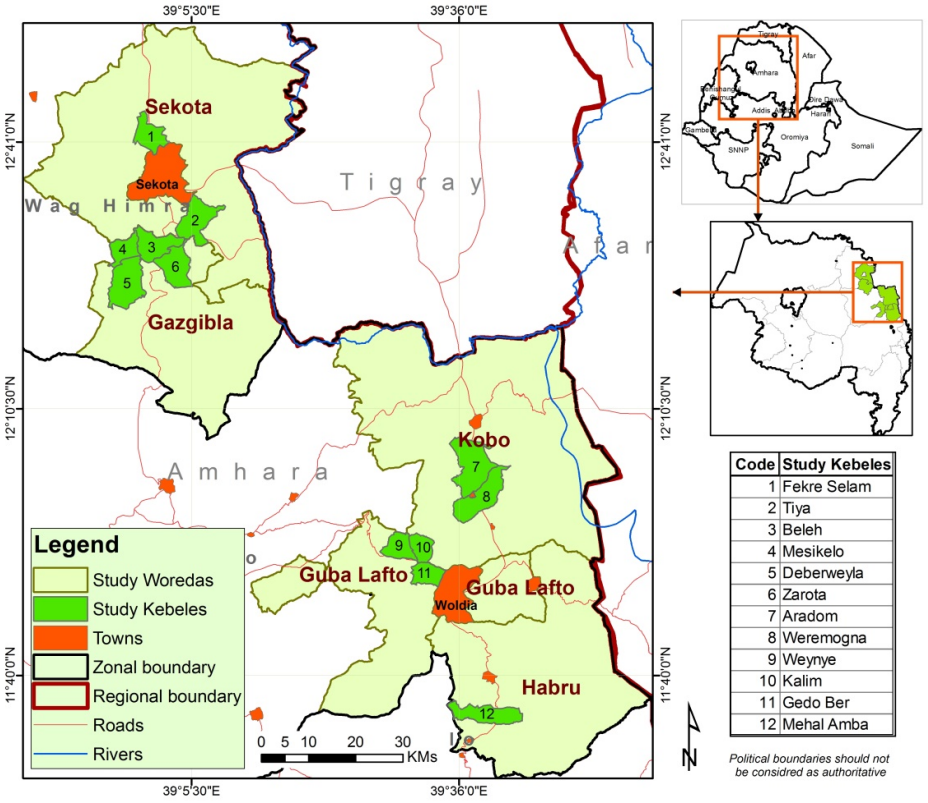


Figure 1: Map of Ethiopia showing the study zones

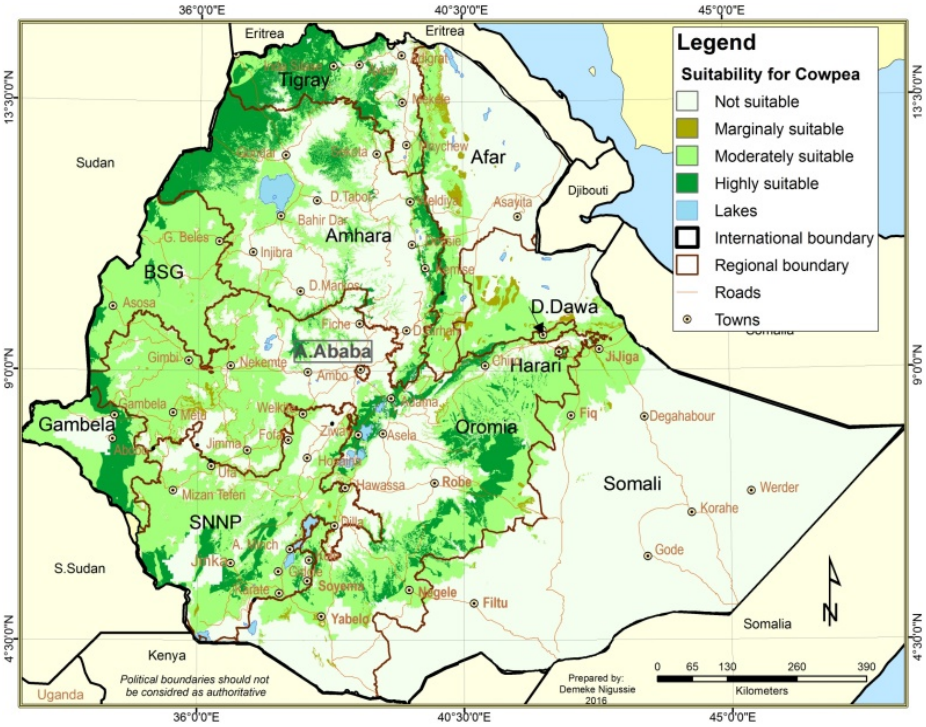


Figure 2: Land suitability map of cowpea in Ethiopia (Demeke Nigussie, 2018).

3.2. Materials Used

- Global positioning system (GPS) using android phone was used to collect georeferenced data of interviewee and seed collection sites.
- Digital camera was used to document pictures of the farmers' varieties, landscapes and data collection processes.
- Android phone was used to conduct structured interview wiith open data kit (ODK) (Appendix I)
- Semi-structured interview was conducted using pre-prepared hardcopy(Appendix II)

3.3. Methods

3.3.1. Informant selection

Lists of farmers who produce cowpea in the study area were obtained from Agricultural development agent considering their wealth. Accordingly, 144 households (of these 72 women and 72 men) were selected randomly from the membership list of their corresponding Peasant Association for the interview. Agricultural development agents were helpful in accessing relevant records and in each of 4 strata for a total of 144 interviews (12 informants' x 3 kebeles x 4 strata = 144). Three women from low-income households, three women from high or medium-income households, three men from low-income households, and three men from high or medium-income households were selected interviewed individually using the structured interview by ODK (open data kit). Two key informants, one man and one woman who are knowledgeable about cowpea were selected per Kebele and interviewed in each kebele one man and one woman who are knowledgeable about cowpea was selected. These key informants were selected among the farmers who have already responsed to the structured interview. The key informants were selected based on the recommendations made during the interviews, or selected based on information from other village members in addition to researcher assessment in the

process of the interview. The total number of key informant was 24 (4 strata x 3 kebeles x 2 key informant). Figure 3 shows the flow diagram of the sampling frame.

Sampling framework

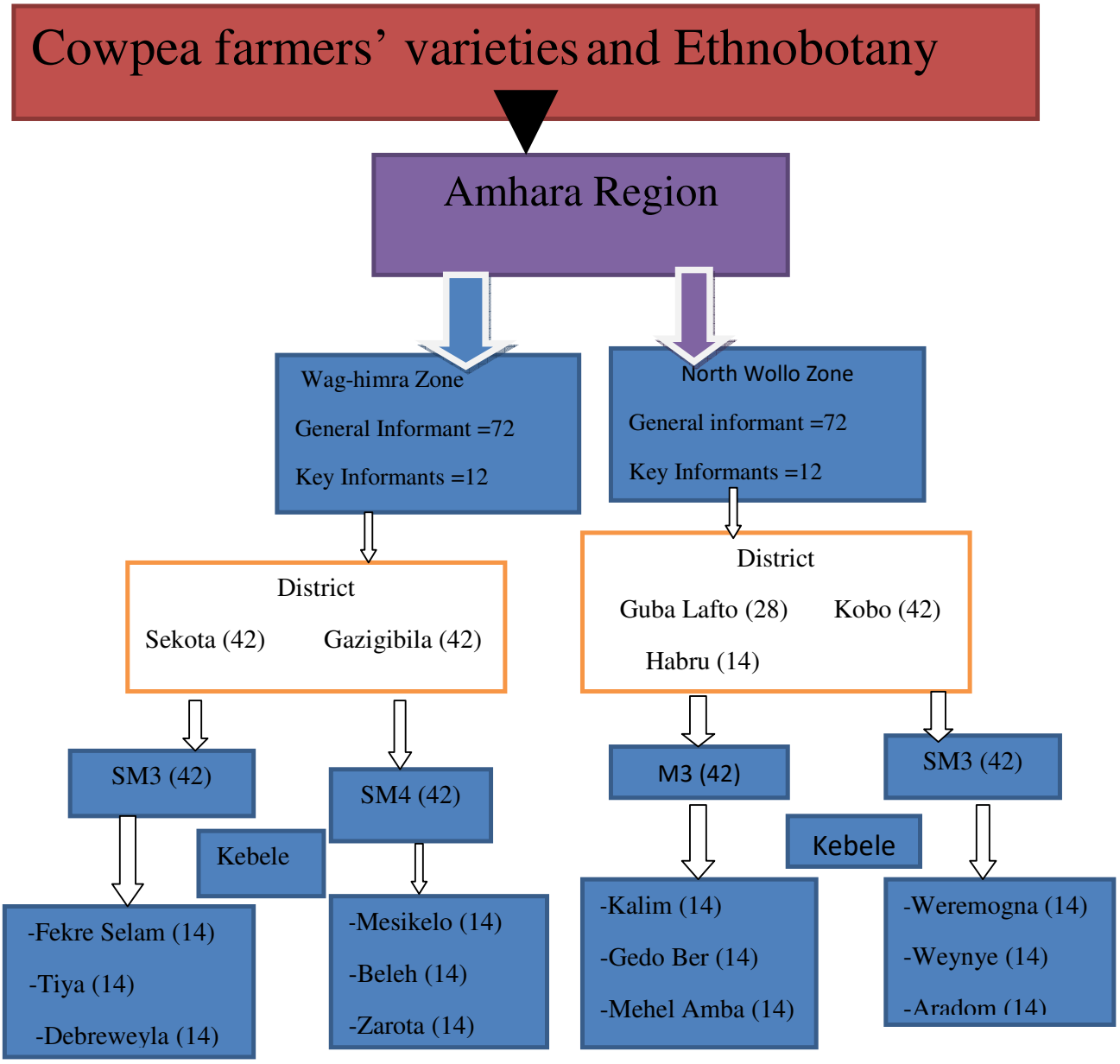


Figure 3.Flow diagram of the methodological framework of the study

3.3.2 Methods of data collection

3.3.2.1. Field data collection

The field survey was conducted from July, 2018 up to January, 2019. Botanical data and ethnobotanical profiles of cowpea and its farmers' varieties were acquired using primary and secondary data sources. Primary source of data was obtained from the farmers' who grow cowpea Secondary data were collected from the zone and wereda administrative centers by gathering information on cowpea production status of districts/wereda and overall description of the study area. Seed sample collection was undertaken; from each Kebele three up to four seed sample was collected from individual cowpea varieties.

Semi-structured interview was conducted with cowpea producers and or sellers at the market to record and determine the value or income generated from such practices.

3.3.2.2. Ethnobotanical data collection

Ethnobotanical data were collected in September 2018 and January 2019, following the method given by Martin (1995) and Cotton (1996). Different qualitative and quantitative ethnobotanical data collection methods like structured and semi-structured interview and also market surveys were used in order to gather the necessary information from the participants.

Voucher specimens were collected from farmers' fields as described in IBPGR (1983) descriptor list for cowpea. The botanical information (passport data) of the crop was collected using GPS. Colored photos of cowpea accessions were also used for ensuring the understanding of farmers and local guides to show where cowpea is growing as well as to know the local name of the crop before starting the interview.

3.3.2.2.1. Interview method

General informants were interviewed by using structured interview method via ODK and informant consent which comes first, which is one of the formal interview methods in ethnobotany study and the key informants were interviewed using semi-structured interview. This semi-structured interview method was selected because it is largely flexible and it is also the best tool to use when it is not possible to interview the same informant twice (Albuquerque et al., 2014). The semi-structured interview contains open ended and closed questions. The structured and semi-structured interviews were used to collect information on local knowledge on plant parts used, description of preparation of plant parts, management, cropping systems, seed supply, storage of the species, local name of the landrace, time of cultivation and harvesting, market value of the crop, production constraints and the management taken by farmers to control the constraints. Interviews were held at the household level or in farmers' cowpea fields. Local extension officers were asked to assist in conducting the interviews always in the presence of the researcher who always checked the correct administration of the interviews and use of appropriate interaction methods with informants. The interview was conducted by using Amharic language and the entire landrace names were recorded by Amharic by simultaneous translation from the English versions. Figure 4 shows interview administering with informants.

Figure 4: Interview with informants (On November 2018 in Wag-Himra and December 2018 in N. Wollo)

3.3.2.2.2. Field observation and guided field tour

The field observation was conducted with the help of local guides and participant informants to acquire the required information in the study area. The information on how cowpea is cultivated, intercropped used and marketed was then systematically recorded. The local perspectives on dominant crops produced, landscapes and soil type of the study area were identified by the researcher through personal observation and discussion with cowpea farmers as well as local agricultural experts. Observations were also documented with notes, photographs with narratives of some informants which were recorded upon getting informed consent from each informant involved in this exercise.

3.3.2.3. Market survey

During the study, market survey was undertaken to record the cowpea varieties that were available in the market. In addition, information on market values of cowpea was record. This is especially a good method to identify, use and conserve farmers' varieties of cowpea that have high economic value. Therefore, 4 local markets in the study areas (namely Tiya, Zarota, Aradom and Weynye) were visited. Semi-structured interview was conducted with cowpea producers and or sellers at the market to record and determine the value or income generated from such practices.

3.3.2.4. Voucher specimen collection and identification

In order to identify and describe cowpea landraces at subspecies and local variety levels by using qualitative and quantitative traits, specimen collection was carried out between 28th March and 17th May, 2019. The voucher specimens of cowpea landraces were identified by local and/or scientific names and then pressed, dried and brought to the National Herbarium (ETH), AAU, for further identification, confirmation and characterization. Identification of voucher specimens collected from the study areas was attempted in the field while doing observations and confirmed at the National Herbarium using taxonomic keys in volume 3 of the Flora of Ethiopia and by comparison with already identified herbarium specimens. Further confirmation of the accuracy of the identification was made with the assistance of taxonomic experts. Finally, the identified specimens with labels were stored at the National Herbarium as reference material for educational and research purposes. Hence, both qualitative and quantitative traits of collected specimens were identified and categorized based on similarity of morphological traits.

3.3.2.5. Seed collection

The seed samples were collected from farmers' fields, crop piles in the field, traditional seed storage containers and from local markets. Seed sample collection was undertaken; from each Kebele by taking three up to twelve seed samples from individual cowpea varieties. The collection strategy was to collect the maximum number of landrace diversity recognized by the farmers, and traders and end-users. The seed collections were then used for seed morphology description, morphological diversity study and then the delivered to EBI germplasm for preservation.

3.4. Methods of Data Analysis

3.4.1 Descriptive statistics

By following the relevant approaches of Martin (1995) and Cotton (1996), both qualitative and quantitative analytical tools of ethnobotany were used for data analysis. To identify the most widely used cowpea farmers' variety in the study area, ethnobotanical data were analyzed by entering the data in to the excel spreadsheet and summarized using descriptive statistics. The mean values, standard deviations, ranges and other tools were computed to identify the most commonly and widely used cowpea landraces using R software. To determine proportions of different farmers' varieties, ability to resist pest, ease of harvesting, taste, and yield during drought and source of seed, are analyzed by using various ethnobotanical scoring and ranking methods, percentage frequency methods and inferential statistics was employed in order to test the consistency of respondents' information and to obtain scientifically more reliable results. Then the results were presented with graphs, charts and in texts.

3.4.2 Analysis of variance (ANOVA)

Analysis of variance was computed to explore the differences in area coverage of cowpea landraces among study strata, farmers' wealth status and study zones. It was also use to understand the differences of the price of varieties among the study zones, agroecological zones. Shapiro-Wilk Test for normality test was used to test the normality of the distribution of data on farm land size where cowpea will be cultivated per mid-high and low income farmers. Two ways of ANOVA was used to test the difference of the yield of farmers' varieties in two consecutive years (2017, 2018) as well as to test the difference in morphological characteristics of the farmers' varieties.

3.4.3 Tukey test

Tukey test was used to assess differences among the study strata, agroecological zones with wealth status of the farmers or between the two regions on total number of respondents per zone/region. In general, Tukey test is used to determine the significant differences among mean values of the treatments.

3.4.4 Direct matrix ranking, comparisons, agreements

Direct matrix ranking was made following Martin (1995) in order to answer the question, which landrace is best for which properties and on what attributes these are based. Landraces and properties/attributes that were commonly reported by informants were selected. Then, each informant was asked to rank the landraces for each property listed. The values of each landrace will be summed up and ranked for each informant, and then for the total informants.

3.4.5. Diversity analysis

3.4.5.1Shannon-Wiener diversity index

It is used in genetic resource studies as a convenient measure of richness using phenotypic data (Shannon and Wiener, 1949). Diversity index was calculated as:

$$H' = -\sum_{i-0}^{n} pi \ln(pi)$$

Where: H'= Standardized relative diversity index; n= the number of phenotypic class per characters; pi the proportion of the total number of entries in the class; ln=natural Logarithm.

3.4.5.2 Beta diversity

Whittaker (1960) divided diversity into various components. The best known are diversity in one spot that he called alpha diversity, and the diversity along gradients that he called beta diversity. The basic diversity indices are indices of alpha diversity. Beta diversity should be studied with respect to gradients (Whittaker, 1960), but almost everybody understands that as a measure of general heterogeneity (Tuomisto, 2010): how many more species/variety do you have in a collection of sites compared to an average site.

Gamma diversity - the total number of farmers‟ varieties within a Region or among farmers of a certain group.

Alpha diversity - the average number of landraces listed by each farmer.

Beta diversity - gamma divided by Alpha. This indicates the degree to which farmers within the same ethnic group or Region share the same landraces

- The change in species diversity between the areas or ecosystems or just counting the total number of unique species to the ecosystems being compared.

CHAPTER FOUR

4. RESULTS

4.1. Distribution, Diversity and Richness of Cowpea Varieties

In both study zones, farmers have different vernacular names in Amharic and Agewgna used for the different farmers' varieties of cowpea cultivated in the area. A total of 36 accessions were collected from different kebeles of the study areas. Based on the names and descriptions given by farmers these accessions were categorized in to eleven farmers' varieties and the different vernacular names recorded during the field survey are given in Table 1 with their descriptions. It was observed that the vernacular names traditionally given to the farmers' varieties of cowpea in the study area vary more across administrative districts, agroeccological zone and villages and sometimes between farmers within a single village. The names given by farmers make references to agromorphological attributes mainly to the colour of the seed.

Table 1.Farmers' varieties recod tabled from North Wollo and Wag-himra zones of Amhara Region

No	Zone	Variety name	Variety code	Justification	Local names for cowpea	Total varieties found
1	North Wollo	Bolechima Lam ater	Bolechima	unique variety	lam ater (general Amharic)	Bolechima
2	North Wollo	Debara Arengade	Debera	spelling, arenguade is cowpea in Amharic	arenguade (local Amharic)	Debera

No	Zone	Variety name	Variety code	Justification	Local names for cowpea	Total varieties found
3	North Wollo	Debaraw Arengade	Debera	spelling, arenguade is cowpea in Amharic	tahira (local Amharic)	Key (NW)
4	North Wollo	Debaraw Tahira	Debera	spelling, tahira is cowpea in Amharic	kafira (local Amharic, different pronounciation of tahira)	Nech (NW)
5	North Wollo	Key Arengade	Key (NW)	arenguade is cowpea in Amharic	yeayit hareg (local Amharic)	Tikur (NW)
6	North Wollo	Key lam ater	Key (NW)	lam ater is cowpea in Amharic	chekele (used in Wag-himra Amharic)	Cheberima/Chechima
7	North Wollo	Key Tahira	Key (NW)	tahira is cowpea in local dialect of Amharic	egoyla (Agewegna)	Egoyla
8	North Wollo	Key Tahira/ Kafira	Key (NW)	tahira/kafira are both cowpea in local dialect of Amharic	Tahira or Kafira (local Amharic)	Key (WH)
9	North Wollo	Key Tahira/Kafira	Key (NW)	tahira/kafira are both cowpea in local dialect of Amharic	Tahira or Kafira (local Amharic)	Nech/Bula (WH)
10	North Wollo	Nech Arengade	Nech (NW)	arenguade is cowpea in Amharic	arenguade (local Amharic)	Senderima/Sendeyma/Shilimlima

No	Zone	Variety name	Variety code	Justification	Local names for cowpea	Total varieties found
11	North Wollo	Nech Arengadye	Nech (NW)	arenguade is cowpea in Amharic	arenguade (local Amharic)	Tikur (WH)
12	North Wollo	Nech Arengeda	Nech (NW)	arenguade is cowpea in Amharic	arenguade (local Amharic)	
13	North Wollo	Nech Kafira	Nech (NW)	kafira is cowpea in local dialect of Amharic	Tahira or Kafira (local Amharic)	
14	North Wollo	Nech Lam ater	Nech (NW)	lam ater is cowpea in Amharic	lam ater (general Amharic)	
15	North Wollo	Nech lam ater/ Yeayit Hareg	Nech (NW)	lam ater and yeayit harfeg are both cowpea in Amharic	lam ater (general Amharic)	
16	North Wollo	Nech lam ater/ Yeayjt Hareg	Nech (NW)	lam ater and yeayit harfeg are both cowpea in Amharic	lam ater (general Amharic)	
17	North Wollo	Nech Tahira	Nech (NW)	tahira is cowpea in local dialect of Amharic	Tahira or Kafira (local Amhari)	
18	North Wollo	Nech Tihra	Nech (NW)	tahira is cowpea in local dialect of Amharic	Tahira or Kafira (local Amharic	
19	North Wollo	Tikur Arengade	Tikur (NW)	arenguade is cowpea in Amharic	arenguade (local Amharic)	
20	North Wollo	Tikur lam ater/ Yeayit Hareg	Tikur (NW)	lam ater and yeayit harfeg are both cowpea in Amharic	Tahira or Kafira (local Amhari)	
21	North Wollo	Tikur Tahira/ kafira	Tikur (NW)	tahira/kafira are both cowpea in local dialect of Amharic	Tahira or Kafira (local Amhari)	
22	Wag-himra	Bula egoyla	Nech/Bula	nech and bula are synonyms, egoyla is	Nech or Bula Egoyla	

No	Zone	Variety name	Variety code	Justification	Local names for cowpea	Total varieties found
			(WH)	cowpea in Agewegna	(Agewegna)	
23	Wag-himra	Cheberima egoyla	Cheberima/Chechima	cheberima and chechima are different pronounciations of the same name, egoyla is cowpea in Agewegna	Cheberima or Chechima Egoyla (Agewegna	
24	Wag-himra	Chechima egoyla	Cheberima/Chechima	cheberima and chechima are different pronounciations of the same name, egoyla is cowpea in Agewegna	Cheberima or Chechima Egoyla (Agewegna)	
25	Wag-himra	Egoyla	Egoyla	general name for cowpea in Agewegna	General name of cowpea is Egoyla (Agewegna)	
26	Wag-himra	Key chekele	Key (WH)	egoyla is cowpea in Agewegna	Key Egoyla (Agewegna)	
27	Wag-himra	Key Egolya	Key (WH)	egoyla is cowpea in Agewegna	Key Egoyla (Agewegna)	
28	Wag-himra	Key egoyla	Key (WH)	egoyla is cowpea in Agewegna	Key Egoyla (Agewegna)	
29	Wag-himra	Nech Chekele	Nech/Bula (WH)	nech and bula are synonyms, chekele is cowpea in Amharic spoken in Wag Himra	Nech or Bula Egoyla (Agewegna)	
30	Wag-himra	Nech Egolya	Nech/Bula (WH)	nech and bula are synonyms, egoyla is cowpea in Agewegna	Nech or Bula Egoyla (Agewegna)	
31	Wag-himra	Nech egoyla	Nech/Bula (WH)	nech and bula are synonyms, egoyla is cowpea in Agewegna	Nech or Bula Egoyla (Agewegna)	
32	Wag-himra	Nich egoyla	Nech/Bula (WH)	nech and bula are synonyms, egoyla is cowpea in Agewegna	Nech or Bula Egoyla (Agewegna)	

No	Zone	Variety name	Variety code	Justification	Local names for cowpea	Total varieties found
33	Wag-himra	Sederima Egoyla	Senderima/Sendeyma/Shilimlima	senderima, sendeyma, and shilimlima are different pronounciations of the same name, egoyla is cowpea in Agewegna	Senderima, Sendeyma, and Shilimlima Egoyla (Agewegna)	
34	Wag-himra	Sendeyma egoyla	Senderima/Sendeyma/Shilimlima	senderima, sendeyma, and shilimlima are different pronounciations of the same name, egoyla is cowpea in Agewegna	Senderima, Sendeyma, and Shilimlima Egoyla (Agewegna)	
35	Wag-himra	Shilimlima egoyla	Senderima/Sendeyma/Shilimlima	senderima, sendeyma, and shilimlima are different pronounciations of the same name, egoyla is cowpea in Agewegna	Senderima, Sendeyma, and Shilimlima Egoyla (Agewegna)	
36	Wag-himra	Tikur egoyla	Tikur (WH)	egoyla is cowpea in Agewegna	Tikur Egoyla (Agewegna)	

All cowpea varieties observed in the field are annual herbaceous legume cultivated for their edible seeds or for fodder. There were both climbing and erect types, as well as prostrate and creeping ones. The eleven farmers' varieties collected from farmers according to the informant responses. In four of the farmers' varieties, seeds were found while in the cases of seven of them seeds were not found except the names and descriptions by farmers as they were not cultivated during the field season (Table 2). Farmers explained that the seeds are used as food and medicine while the whole plant and crop residues are used as fodder.

Six of varieties are local types while five of them are improved types. These landraces were varied in maturity, habit of growth, yield potential, stress tolerance, end-use qualities, seed color and other agronomic traits as listed in Table 2. The naming and descriptions of the landraces reflect key quantitative, qualitative traits and end-use qualities as well as other information such as planting time or origins.

Table 2.Diversity of landraces (farmers' varieties) in the study area

No	Local name	Translation of local name	Image	Zone	Identifying Characteristics	Advantages reported	Growth habit	Variety type	Flower Color	Non-culinary use	Remark
1	Bolechima (Amharc)	Cannot grow upright		North Wollo	Seed color	Use as fodder during dry time	Herbaceous and climber	Improved	Purple	None	Seed is not found
2	Debera (Aharic)	Cannot grow upright		North Wollo	Seed color	Use as fodder during dry time	Herbaceous and climber	Improved	Purple	None	Seed is not found
3	Key (NW) (Amharic)	climber on stand plants		North Wollo	Seed color	Use as fodder during dry time	Herbaceous and climber	Improved	Purple	Vitamines	
4	Nech (NW)	Cannot grow		North Wollo	Seed color	Use as fodder	Herbaceous and	Improved	Purple	None	Seed is not

No	Local name	Translation of local name	Image	Zone	Identifying Characteristics	Advantages reported	Growth habit	Variety type	Flower Color	Non-culinary use	Remark
	(Amharic)	upright				during dry time	climber				found
5	Tikur (NW) (Amharic)	climber on standing plants		North Wollo	Seed color	Use as fodder during dry time	Herbaceous and climber	Improved	Purple	None	
6	Cheberima/Chechima (Agewgna)	A herb plant whose seeds are as food in the dry season		Wag-himra	Seed color	Highly yield during drought	Herbaceous and upright	Local	Purple	None	Seed is not found
7	Egoyla (Agewgna)	A herb plant that use its seed as food in the dry season		Wag-himra	Seed color	Highly yield during drought	Herbaceous and upright	Local	Purple	Gastrointestinal pain and Constipation medicine	Seed is not found

No	Local name	Translation of local name	Image	Zone	Identifying Characteristics	Advantages reported	Growth habit	Variety type	Flower Color	Non-culinary use	Remark
8	Key (WH) (Agewgna)	A herb plant that use its seed as food in the dry season		Wag-himra	Seed color	Highly yield during drought	Herbaceous and upright	Local	Purple	Gastrointestinal pain and Constipation medicine	
9	Nech/Bula (WH) (Agewgna)	A shrub plant that use its seed as food in the dry season		Wag-himra	Seed color	Highly yield during drought	Herbaceous and upright	Local	Purple	Gastirointestinal pain and Constipation medicine	
10	Senderima /Sendeyma/Shilimlima (Agewgna)	Upright Plant		Wag-himra	Seed color	High Yield during drought	Herbaceous and upright	Local	Purple	None	Seed is not found

No	Local name	Translation of local name	Image	Zone	Identifying Characteristics	Advantages reported	Growth habit	Variety type	Flower Color	Non-culinary use	Remark
11	Tikur (WH) (Agewgna)	A shrub plant that use its seed as food in the dry season		Wag-himra	Seed color	High yield during drought	Herbaceous and upright	Local	Purple	Gastrointestinal pain and Constipation medicine	Seed is not found

4.1.1.1. Diversity of the farmers' varieties and richness within each stratum

Some of the key informants reported that the cowpea farmers' varieties could be related to factors such as low supply of improved varieties; lack of ability to cross-fertilize and create new varieties by farmers by themselves and low access to find some improved varieties from DA, and research centers.

The result of the study revealed that the diversity of farmers' varieties and richness is different among the study agroecologycal zone (Table 3). The total number of varieties (gamma diversity) is higher in SM3-Wag-himra (6) followed by M3-North Wollo (5), SM3-North Wollo (4) and lower in SM3-Wag-himra (3). The average number of varieties per agroecology (alpha diversity) is high in SM3-Wag-himra (1.638889) followed by SM3-North Wollo (1.166667) and low in M3-North Wollo (1.111111) followed by SM4-Wag-himra.

Beta diversity was highest in M3-North Wollo (4.5) and followed by SM3-Wag-himra and SM3-North Wollo (3.661017,3.428571), this shows that farmer's planted different landraces in these agroecological zones while in SM4-Wag-himra (3.176471) the beta diversity is lowest indicating that the farmers were planting almost similar landraces.

In terms of the Shannon Wiener Diversity Index, the four study strata in SM3-Wag-himra had the highest varietal diversity (H'=0.97804), followed by SM3-North Wollo (H'= 0.825323). The lowest diversity indices (H'=0.823906) and (H'=0.593763) were computed for M3-North Wollo and SM4-Wag-himra respectively (Table 3).

Table 3.Diversity of the farmers' varieties of cowpea within each stratum

Strata	Number of varieties	Alpha diversity	Gamma diversity	Beta diversity	H'
SM4-Wag-himra	34	0.944444	3	3.176471	0.593763
SM3-Wag-himra	59	1.638889	6	3.661017	0.978049
M3- North Wollo	40	1.111111	5	4.500000	0.823906
SM3-North Wollo	42	1.166667	4	3.428571	0.825323

4.2. Area of the Farms Covered by Cowpea

The total area covered by cowpea in the two zones of the study area (N. Wollo and Wag-himra) was sigificantly different (P=0.0006837). Based on wealth status of farmers, statistically there is no significant difference in the area planted to cowpea as the p value shows 0.4973 (P>0.05). The area planted to cowpea by high income, medium income and low income farmers was equal. However, the area covered by cowpea in the three aagroecological zones was sigificantly different (P=0.003556) (Table 4).

Table 4 ANOVA test for cultivated land size of cowpea by agroecology, administrative zone and wealth status of farmers

	Degree of Freedom	Sum Square	Mean Square	F Value	Pr (>F)
Zone	1	0.1447	0.144697	11.962	0.0006837 ***
Agroecology	3	0.17019	0.056731	4.6928	0.003556 **
Wealth status	1	0.00597	0.0059667	0.4626	0.4973

The average area devoted to cowpea was compared across the two zones using analysis of variance. Post-hoc analysis was conducted on statistically significant results using the

Tukey HSD method at the 5% significance level. There was strong evidence regarding the difference in the average areas across zones (F=2.79, p=0.0006837 ***) (Table 4). Post-hoc analysis shows that average areas in Wag-himra zone was significantly higher ($p<0.05$) than in North Wollo zone (Table 5).

Table 5 Average area of cowpea per zone

Zone	Mean Area Devoted to Cowpea (zone)	Tukey Post-Hoc Group
NorthWollo	0.240	a
Wag-himra	0.298	b

The mean area of cowpea planted in N. Wollo and Wag-himra was 0.240 ha and 0.298 ha respectively.Wag-hmra zone have the highest mean area of 0.298 ha and is significantly different from North Wollo (table 5). The size of most farms ranged between 0.24 ha and 0.30 ha (Figure 5). Statistically there was no significant difference among the area planted to cowpea in 2009 and 2010 years. The mean farm sizes of cowpea in the two years were 0.099623 and 0.144697 respectively.

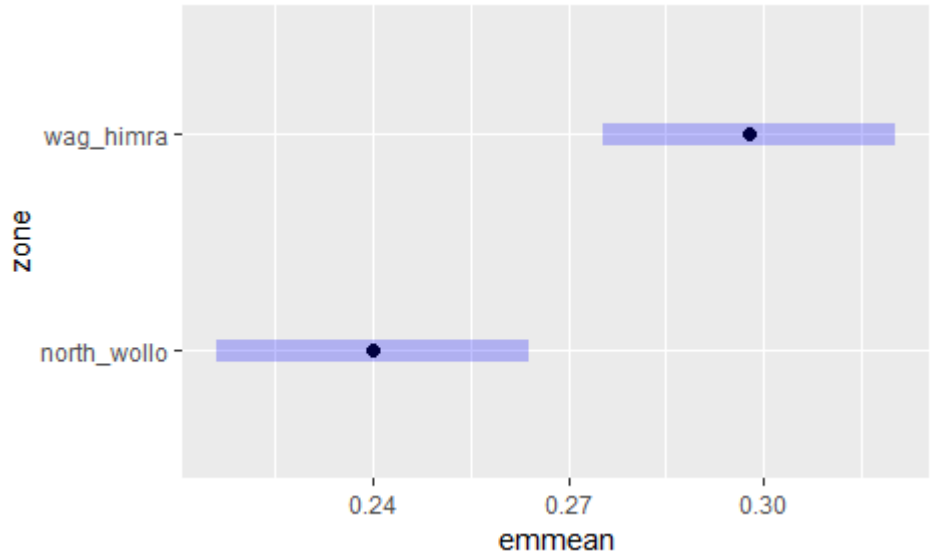


Figure 5 Mean values for area within zone, and corresponding 95% confidence intervals

Average area of cowpea was compared across wealth status using analysis of variance. Post-hoc analysis was conducted on statistically significant results using the Tukey HSD method at the 5% significance level. The area plant with cowpea by high income, medium income, and low income farmers was equal (Table 6) and (Figure 6). Statically, the area of cowpea coverage between the wealth status (Low & Mid to high income) was not significantly different ($P<0.05$) (Table 6).

Table 6 Average area of cowpea by wealth status

Wealth	Mean Area of Cowpea (Wealth)	Tukey Post-Hoc Group
Low income	0.265	a
Mid to high income	0.276	a

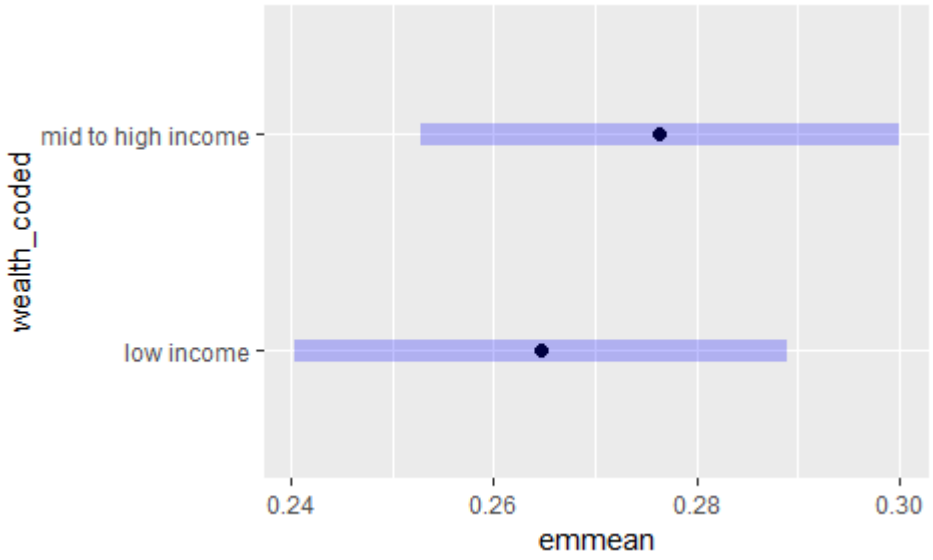


Figure 6 Mean values for area within wealth, and corresponding 95% confidence intervals

Average area of cowpea was compared across four agroecological zones using analysis of variance. Post-hoc analysis was conducted on statistically significant results using the Tukey HSD method at the 5% significance level. The area covered by cowpea in the three agroecological zone was siginificantly different (p=0.003556) (Table 4). Post-hoc analysis shows that average areas in SM4 and SM3 agroecologicaal zone of Wag-himra were significantly higher ($p<0.05$) than in SM3 and M3 agroecologicaal zone of North Wollo. (Table 7)

Table 7. Average area of cowpea per agro-ecology

Agro-ecology	Mean Area of Cowpea (Per Agro-ecology)	Tukey Post-Hoc Group
M3-North Wollo	0.230	A
SM3-North Wollo	0.250	Ab
SM3-Wag-himra	0.288	B
SM4-Wag himra	0.316	B

The mean area of SM4 agroecological zone of Wag-himra is 0.316 ha and the mean area of SM3 agroecological zone of Wag-himra is 0.288 ha. They are not significantly different from each other but are significantly different from M3 and SM3agroecological zones of North Wollo.

In SM4 agroecological zone of Wag-himra, there was high area coverage 0.316 ha. This is because cowpea is greatly adapted in this area. In SM3 Wag-himra, M3 and SM3 North Wollo cowpea area coverage is 0.288 ha, 0.250ha and 0.230 ha respectively (Figure 7).

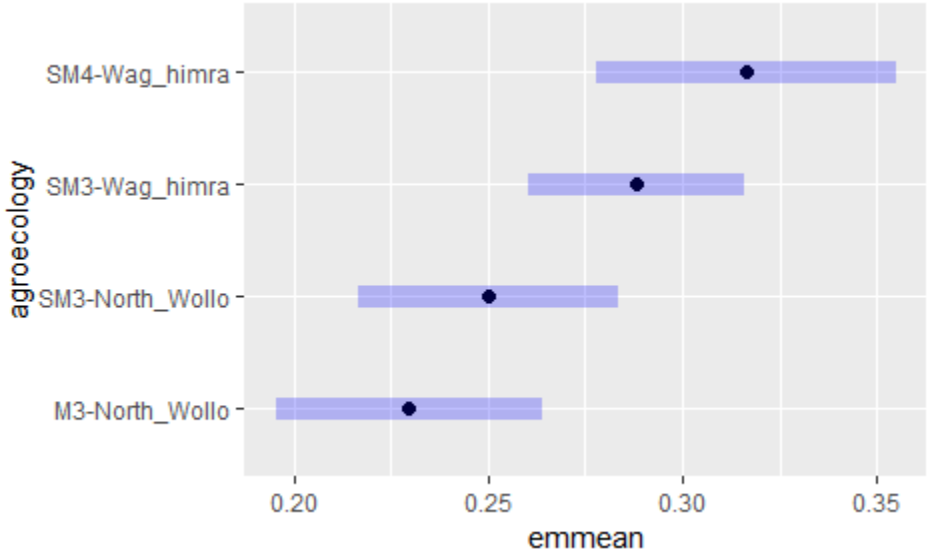


Figure 7 Mean values for area within agro-ecology, and corresponding 95% confidence intervals

4.3. Use Value of Cowpea in Each Stratum

The farmer's in Wag-himra and North Wollo use cowpea for different purposes (Figure 8). The crop is used for marketing, food and as fodder in the sampled agroecological zones of the study area. About 95% of the farmers in M3 agroecological zone and 97% of the farmers in SM3 agroecological zones of North Wollo used the crop for animal fodder. However, 100% of the farmers in SM3 and SM4 agroecology of Wag-himra zone used

the crop for animal fodder. About 58% and 36% of farmers in M3 agroecological zone and 17% of the farmers in SM3 agroecological zone of North Wollo used the crop for food and market. However, about 97% and 94% of the farmers in SM3 agroecological zones and around 97% and 100% of the farmers in SM4 agroecological zones of Wag-himra used the crop for both food and market (Figure 8).

The key informants of the area indicated that the fodder and food from cowpea is very important for their livestock and humans in all agroecological zones.

Different types of foods are prepared from cowpea such as sauces (Shiro), boiled grains (Nifro), roasted grains (Kollo), Porridge (Genfo) and raw green (Eshet) are the major food types that farmers prepared from seed of cowpea (Table 8).

Table 8.The type of food prepared from cowpea varieties

Name of food in Amharic	Common English Name	Parts Used	Vernacular name of most referred variety	Mostly Preferred Variety	Zone	The reason why this variety was preferred
Eshet	Row green	Seed	Egoyla and Tahira and Yelam ater	All	All	
Nifro	Boiled grains	Seed	Egoyla	White	Wag-himra	It is very attractive in color
Kollo	Roasted	Seed	Egoyla and Tahira and Yelam ater	All	All	
Shiro	Sauces	Seed	Egoyla	Red	Wag-himra	It takes short period of time to cook
Kita	Bread	Seed	Egoyla	White	Wag-himra	It is very attractive in color
Genfo	Porridge	Seed	Nech (NW)	White	North Wollo	It is very attractive in color

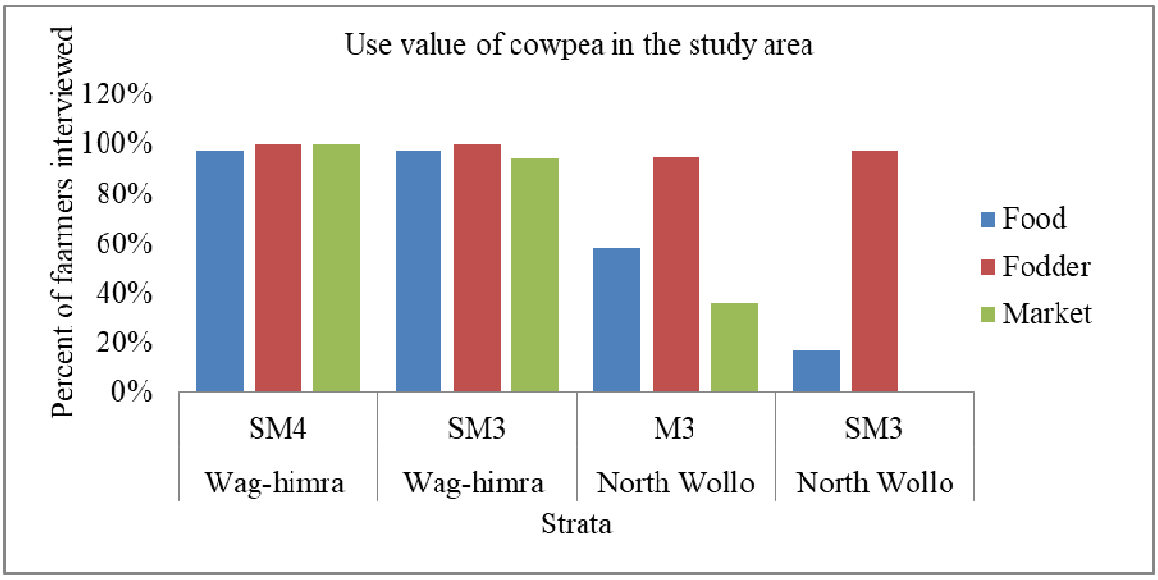


Figure 8 Use value of cowpea in the study

4.4. Cultivation and Management Systems of Cowpea

4.4.1. Gender roles in production and management

This study showed that local farmers played a great role in maintaining the landraces of cowpea by applying traditional farming systems, seed selection and seed storage practices.

The traditional farming systems that cowpea growing farmers used in all the study areas were the same in all agroecological zones. However, farming practices for cowpea were not easier as the field of cowpea is ploughed for sowing or ploughed only two times or three times.

Plowing, planting, hoeing, harvesting, cleaning, storing, threshing, marketing, seed selection, food preparation and fodder collection are practices related to cowpea in which different gender and age groups participated in all of the study strata (Figures 9, 10, 11, 12 and 13). Fertilizer application by farmers is not common in all agroecological zones.

Key informants mentioned that some farmers manage weeds by using hand weeding method.

Gendered roles and activities involved males and female adults only in all study strata that the practices are exercised. Male and Female adults in SM3 agroecological zones of Wag-himra and female (adults and elders) and male adults participated in storing the harvested crop. This activity requires carrying (transporting) of the yield from threshing field to the storage. Male and female adults participated in marketing of the crop in all study strata (except male in SM3 agroecological zone of North Wollo). Seed selection for sowing purpose is the activity which is done by male (adults and elders) and female adults, but the result of the study in Figures 9, 10, 11, and 12 indicates that the practices are predominantly done by female adults. Male and female adults in M3 and SM3 agroecological zones of North Wollo participated in harvesting the crop and more female adults in SM3 were articipating in harvesting the crop than in M3 (Figure 11 and 12). However, in SM4 and SM3 agroecological zone of Wag-himra male and female adults participated in harvesting the crop and few female and male elders participate in harvesting the cowpea.

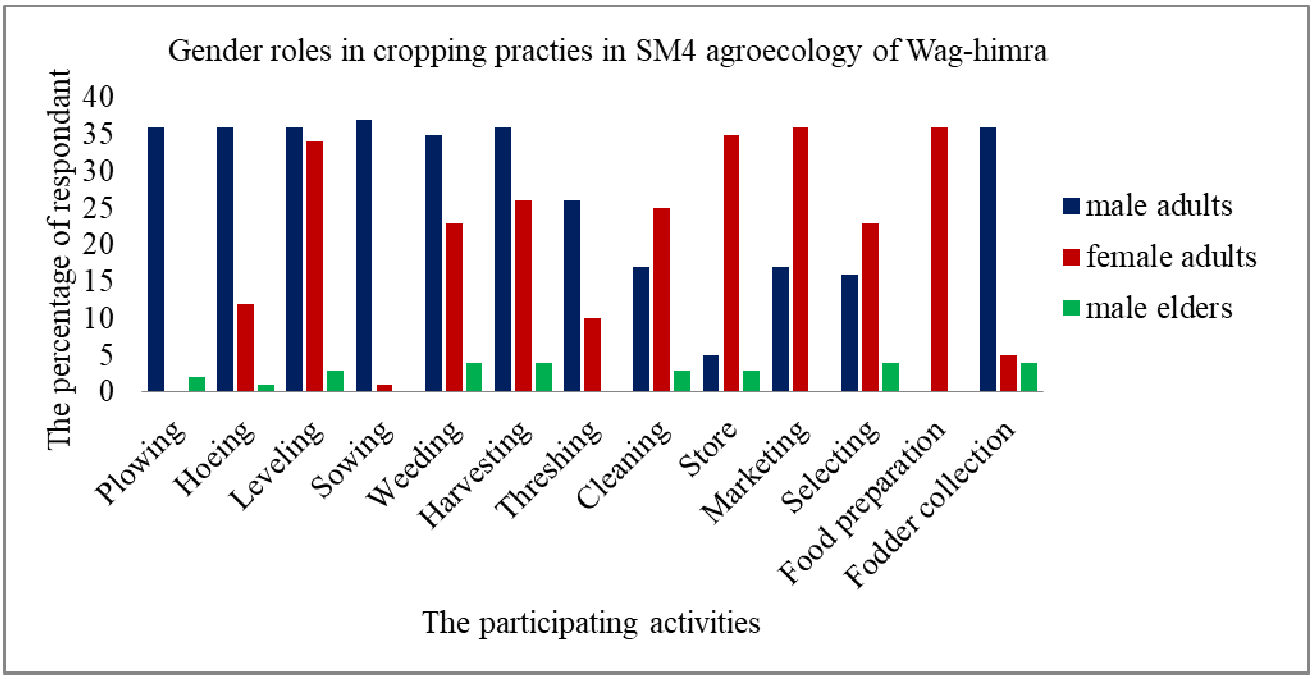


Figure 9: Gender roles in cropping practice in SM4 agro-ecology of Wag-himra zone

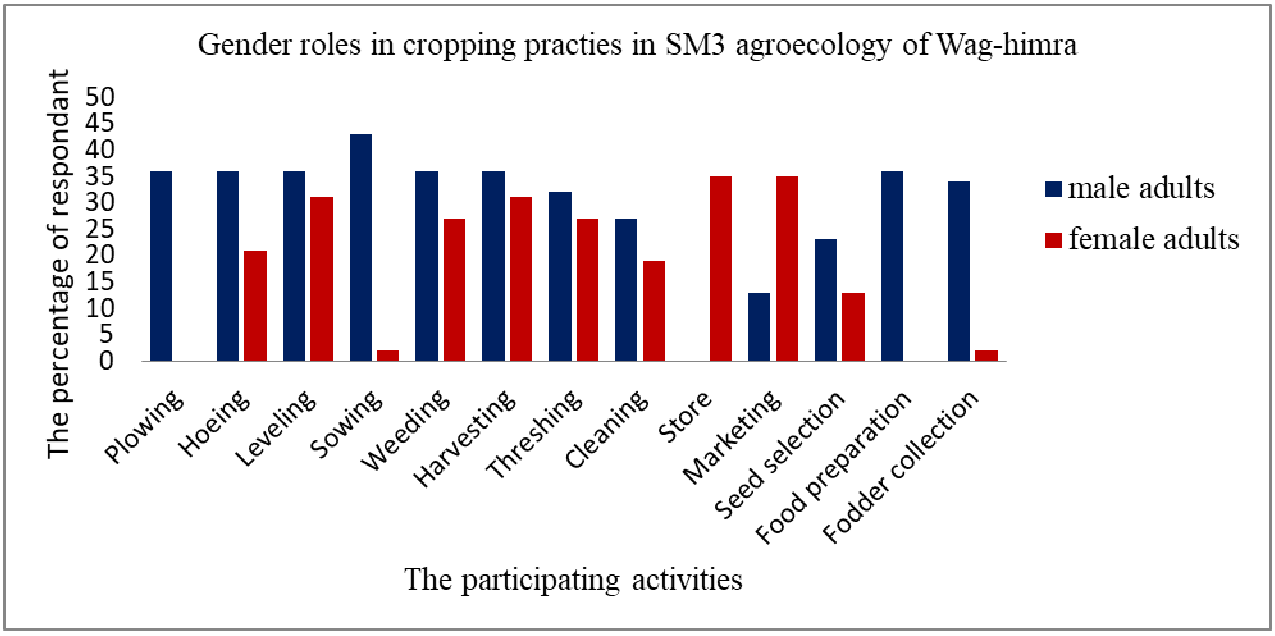


Figure 10 Gender roles in cropping practice in SM3 agro-ecology of Wag-himra zone

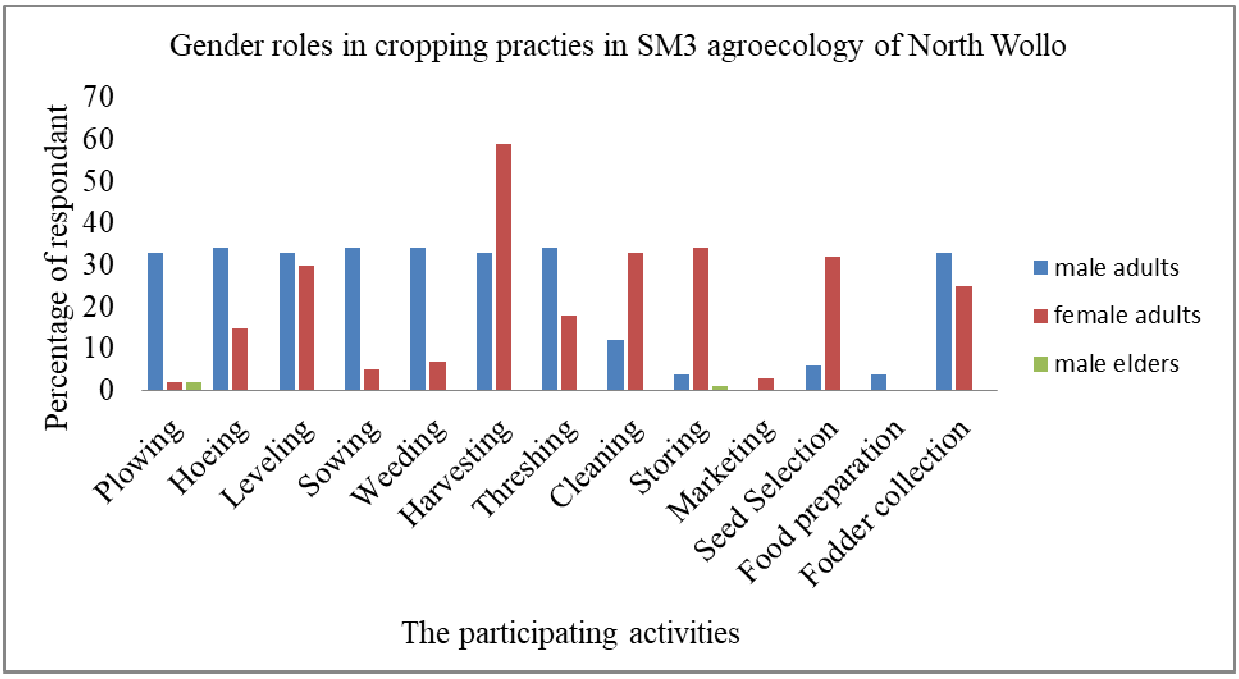


Figure 11: Gender roles in cropping practice in SM3 agro-ecology of North Wollo zone

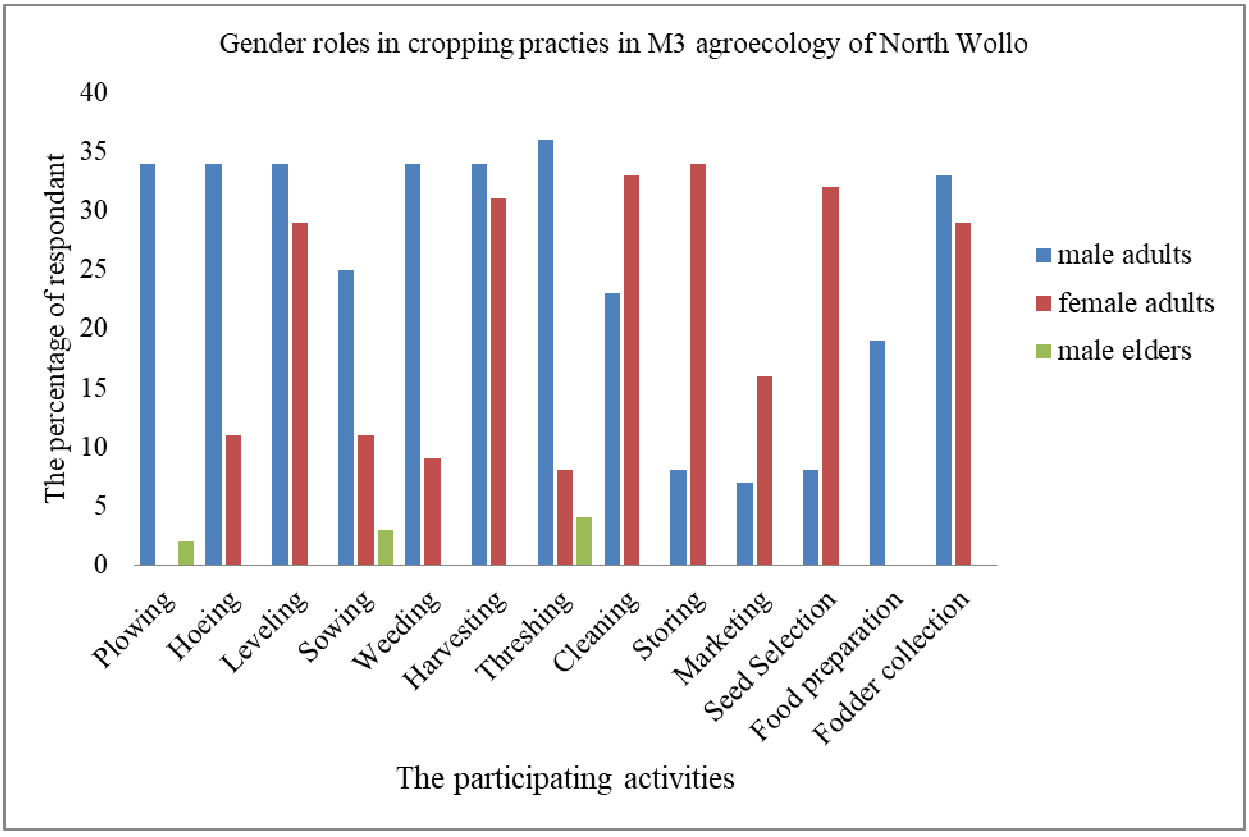


Figure 12: Gender roles in cropping practice in M3 agro-ecology of Norh Wollo zone

4.4.2. Planting time (cropping season)

Farmers in Wag-himra and North Wollo plant cowpea only once and two times in a year but the planting (sowing) months could differ in different agroecological zones of the study areas. In M3 agroecological zones of North Wollo the sowing seasons (time) for cowpea was completed from late February to mid-March, from late June to early July and from mid-July to late July (Figure 13). The time "between" late June is the most suitable sowing season for all varieties. In SM3 agroecological zones of North Wollo the sowing seasons (time) for cowpea extended from late-June to mid July, besides there were a few farmers who plant their variety at early April (Figure 13). In SM3 agroecological zones of Wag-himra late June was the most suitable sowing season for their varieties (Figure 13). Sowing season of the cowpea in SM4 agroecological zone of Wag-himra was included from late February,early April, late May, early June, mid June, late June , early July to late July (Figure 14). In this agroecological zone of Wag-himra most farmers choose late June as the best sowing season for the farmers.

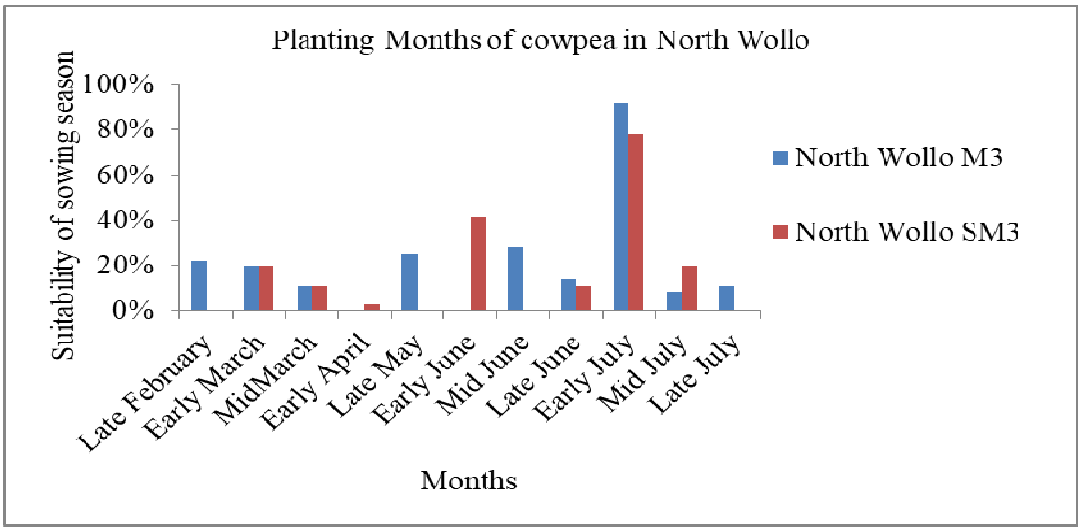


Figure 13: Sowing season of cowpea in M3 and SM3 agroecological zones of North Wollo

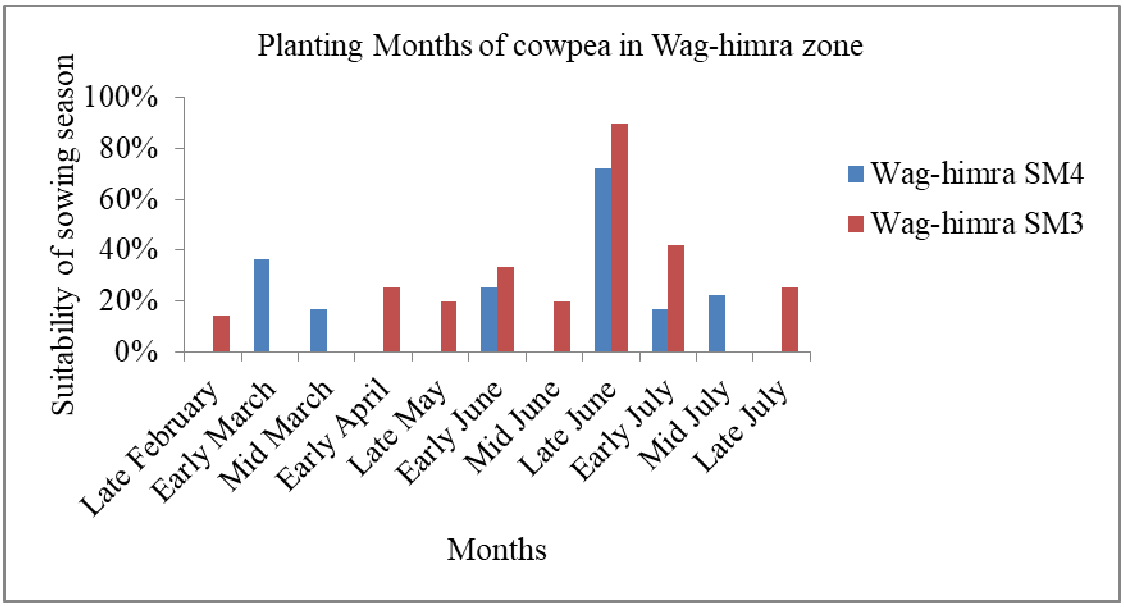


Figure 14 Sowing season of field pea in SM4 and SM3 agroecological zones of Wag-himra

4.4.3. Harvesting time

Harvesting of cowpea in the study area was two or three times per year because cowpea is a perennial legume. The harvesting times are between early September to late September, early October to late October and mid-May to late May and early July for the main cropping season. In general, cowpea takes 3-4 months for harvesting. In both agroecological zone of Wag-himra and North Wollo, cowpea can be harvested at three different stages of maturity: a) green snaps, b) green-mature, and c) dry.

A majority (78%) of the farmers in SM4 agroecological zone of Wag-himra harvest their cowpea in early Octobe r, mid October (8%), late-October (3%), whereas in SM3 they harvest in early Sebtember (22%), mid Sebtember (14%), early October (83%), mid October (11%) to early November (25%) (Figure 15). However, harvesting time of cowpea in M3 agroecological zone of North Wollo is late September (7%), early October

(11%), mid-October (8%), late October (7%), late-May (3%) and early June (6%), whereas in SM3 they harvests in late September (1%), early October (9%), mid-October (5%), late October (1%), mid-May (2%), late May (3%) and early June (3%) (Figure 16).

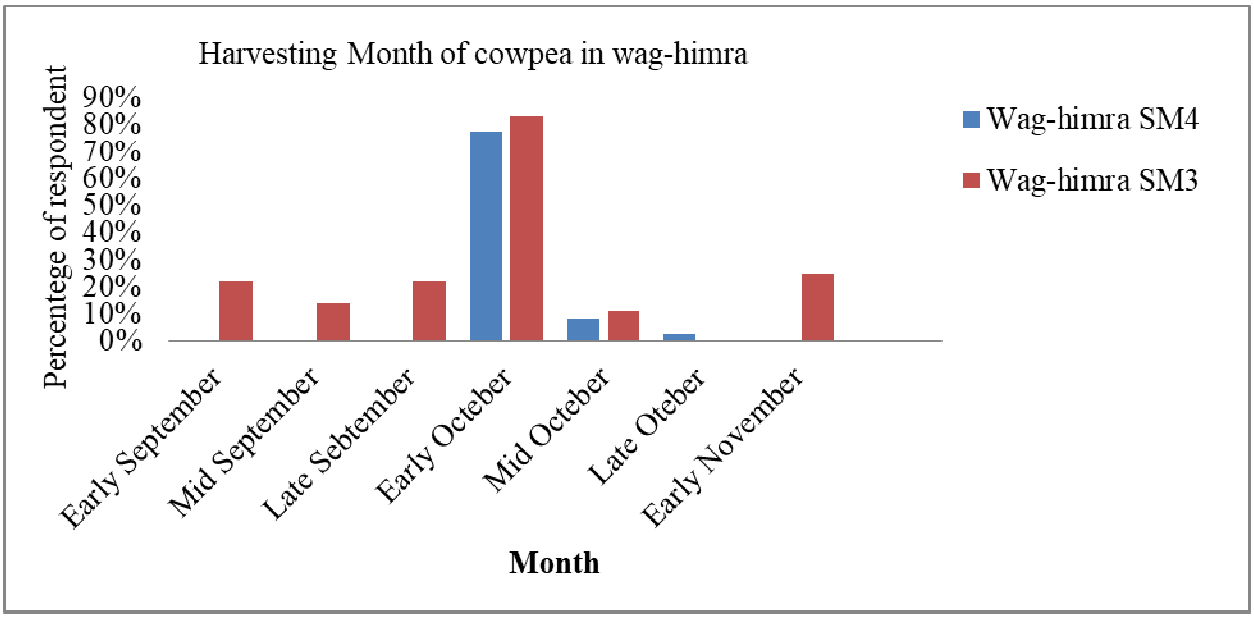


Figure 15: Harvesting time in Wag-himra

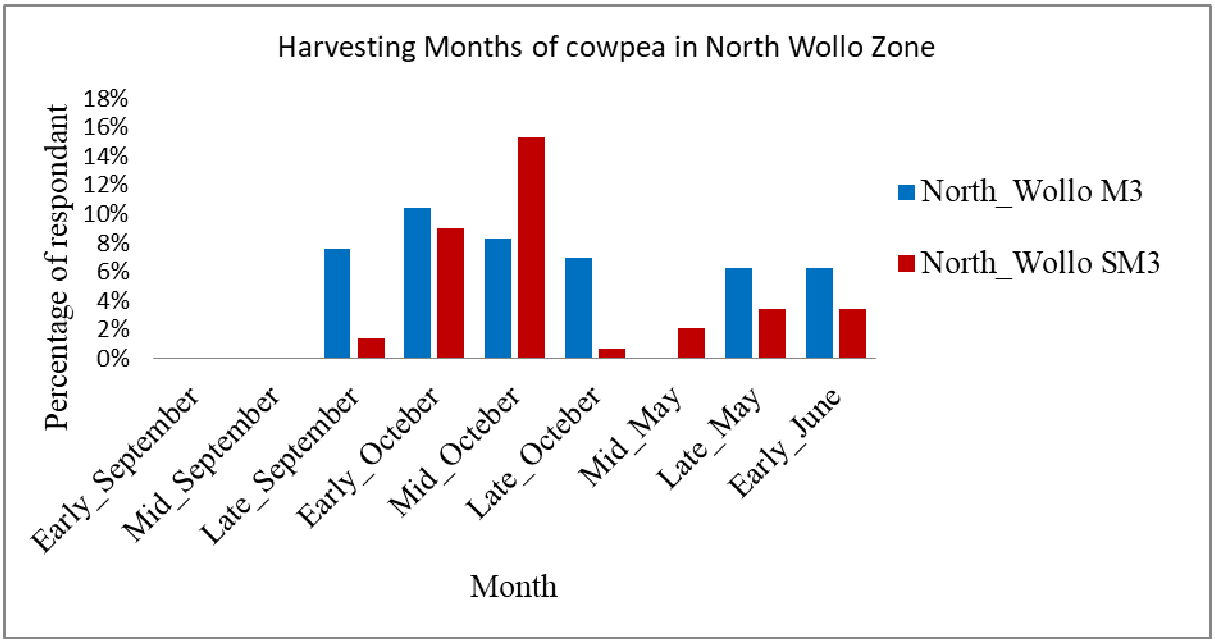


Figure 16: Harvesting time in North Wollo

4.4.4. Crop rotation

The result of the study in Figure 17 reveals that the majority of the farmers in all zones of the study areas used crop rotation program. Different crops were grown after cowpea is harvested in the next season (Figure 17). The majority of farmers in SM4 agroecological zone of Wag-himra, in SM3 agroecological zone of Wag-hira, in M3 agroecology of North Wollo and in SM3 agroecology of North Wollo cultivated barley (100%, 94%,25% and 3%) respectively and wheat (17%, 61%, 11%) respectively. 33%, 53%,67 and 72% of the farmers cultivated Teff after cowpea is harvested. Also about 22%, 44%, 31% and 39% of the farmers cultivated sorghum after cowpea is harvested in SM4 agroecological zone of Wag-himra, in SM3 agroecological zone of Wag-himra and in M3 agroecological zone of North Wollo, in SM3 agroecological zone of North Wollo respectively. Also about 3%, 3%, and 6% of the farmers cultivated maize after cowpea is harvested in SM4 agroecological zone of Wag-himra and in M3 agroecological zone of North Wollo, in SM3 agroecological zone of North Wollo respectively. About 3%, of farmers from SM4 and3 8% of farmers in M3 agroecological zone of North Wollo cultivated chickpea after harvesting of cowpea. About 3% of the farmers cultivated field pea after cowpea is harvested in SM4 agroecological zone of Wag-himra and in M3 agroecological zone of North Wollo. However, a few farmers 11% from from M3 agroecological zone of North Wollo cultivated faba bean after harvesting of cowpea, and 6% of farmers from SM4 agroecological zone of Wag-himra and 14% of farmers from SM3 agroecological zone of North Wollo grew lentil (Figure 17).

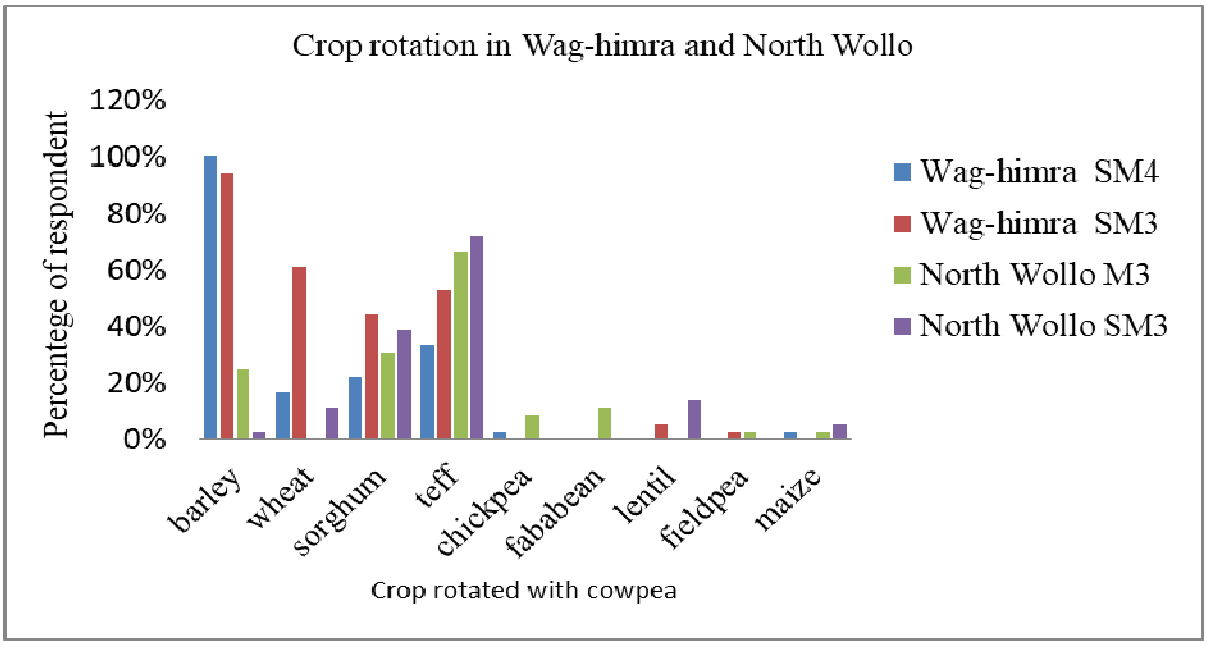


Figure 17: Crop rotation system in Wag-Himra and North Wollo with cowpea.

4.4.5. Intercropping system

Fifty percent (50%) of farmers in the study area grow cowpea by intercropping with other crops (Figure 18). Cowpea is intercropped with different crops. Greater numbers of informants use sorghum to intercrop with cowpea in North Wollo M3 and SM3 agroecological zones (Figure 18). But less numbers of informants use maize and other crops to intercrop with cowpea in the aforementioned agroecological zones. On the other hand, informants in SM4 (100%) do not grow any crop intercropped with cowpea and in SM3 agroecological zone of Wag-himra most farmers do not grow any crop with cowpea. Few farmers in M3 and SM4 agroecological zone of North Wollo do not intercropped any crop with cowpea.

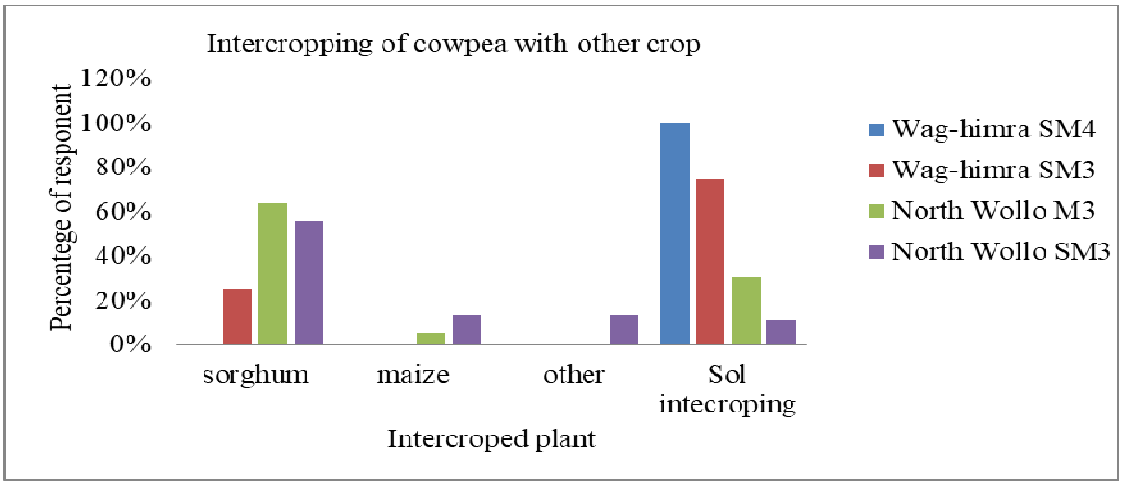


Figure 18: Intercropping practice of cowpea with different crops by informants (n=144)

4.5. Farmers Seed Exchange, Selection and Storage

4.5.1. Farmers traditional seed storage systems

Farmers in the study areas used different traditional storing materials but the majorly (85%) used the modern sacks woven from plastic locally called Kesha because it is better for easy air circulation than the other traditional storing materials like Gotera and Godo (Figure 19) which are considered good for storing the crop for longer period of time without human and animal contact.

A

B

Figure 19 Photo of traditional seed storage containers Gotera (A) and Godo (B) in Wag-himra and North Wollo

4.5.2. Seed source of the varieties

Farmers obtain the seeds of cowpea varieties from different sources (Figure 20). 46% of the farmers obtained the seed of the traditional varieties from market as traditional and 8% from their family members like their fathers, uncles, bothers and 1% obtained seed from traditional and improved varieties. About 41% and 3% of them obtained the seeds of the improved and traditional varieties from rural agriculture extension workers (D.A). About 1% of the farmers got improved variety from the market for the first time, 20% of them found from research centers as improved varieties.

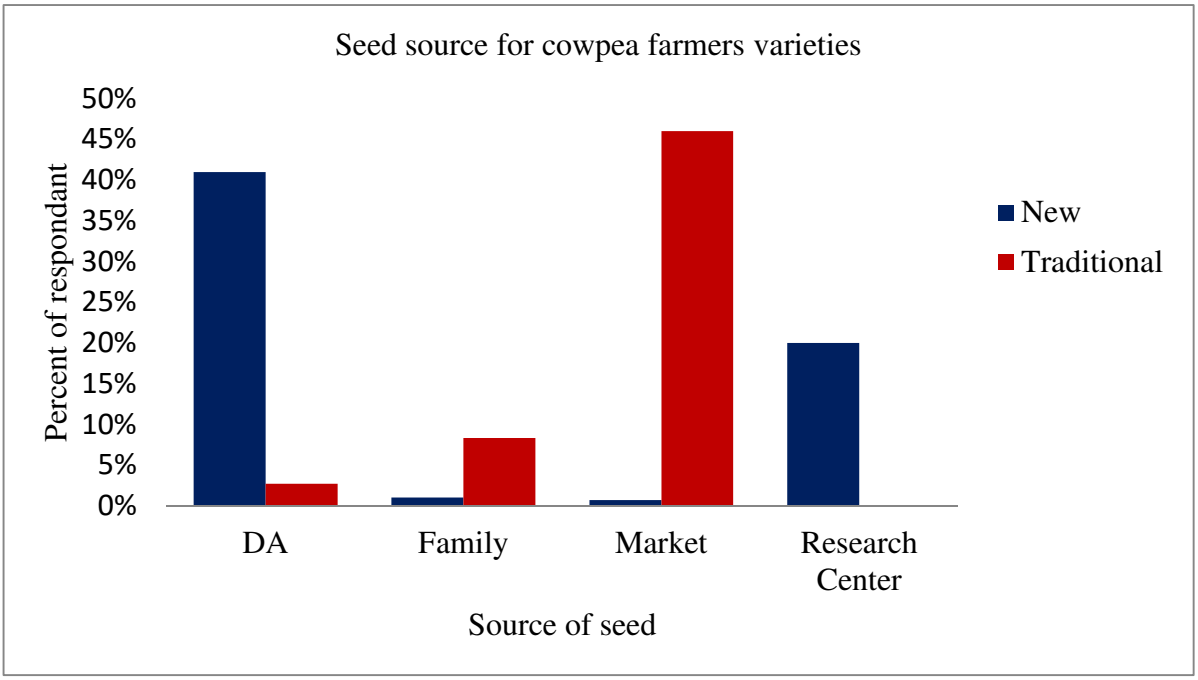


Figure20: Seed source for cowpea farmers' varieties

4.5.3. Wealth of farmers in relation to varieties

Seed usage based on income level, 23% low and 35% mid-high income farmers used landraces (traditional) farmers'varieties, whereas 36% low and 28% mid-high income use new (improved) types. In both mid-high income and low income farmers prefer to use landraces (improved/ new) seed (see Figure 21).

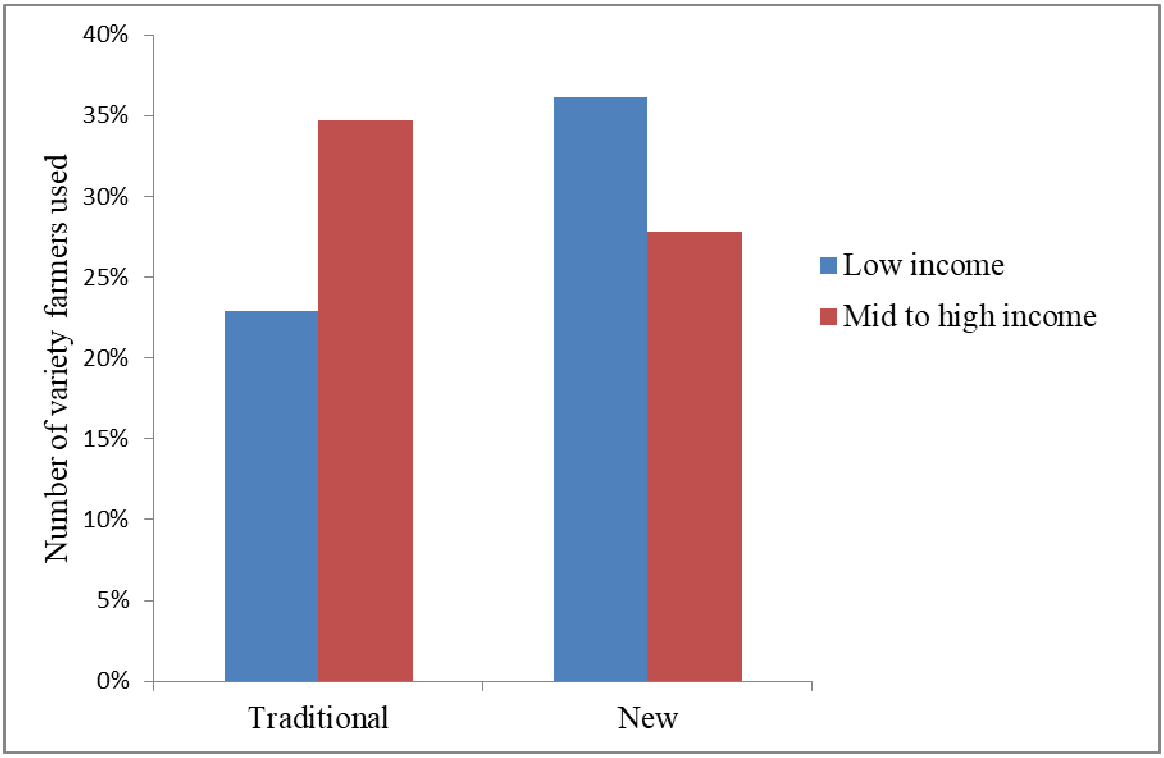


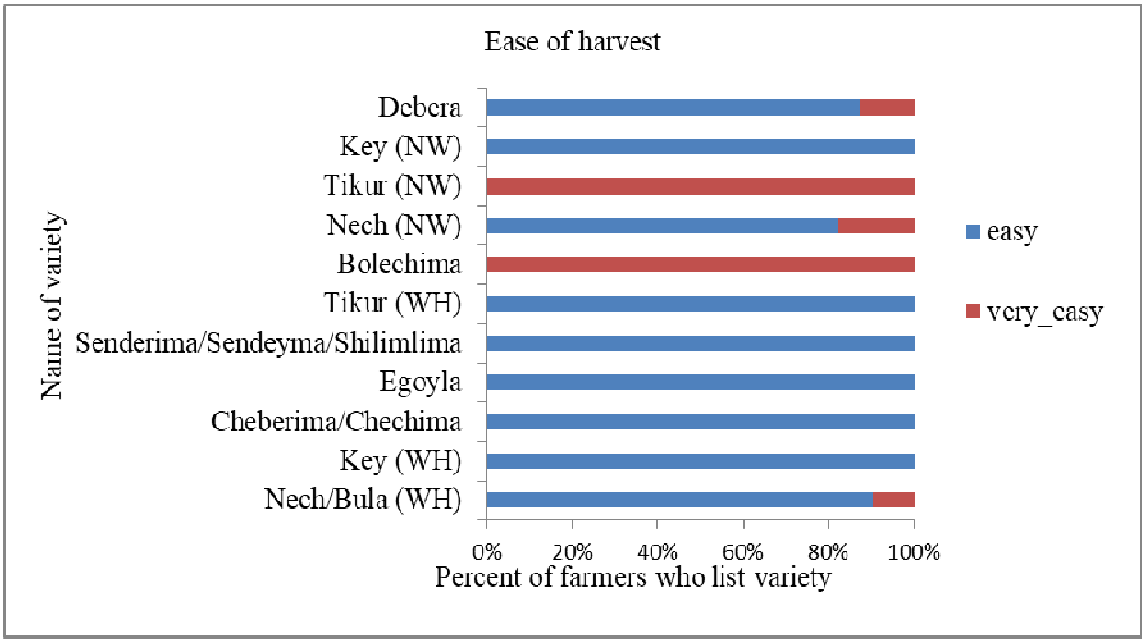
Figure 21: Wealth of farmers in relation to varieties used

4.6. Ranking of Landraces (Farmers' Varieties)

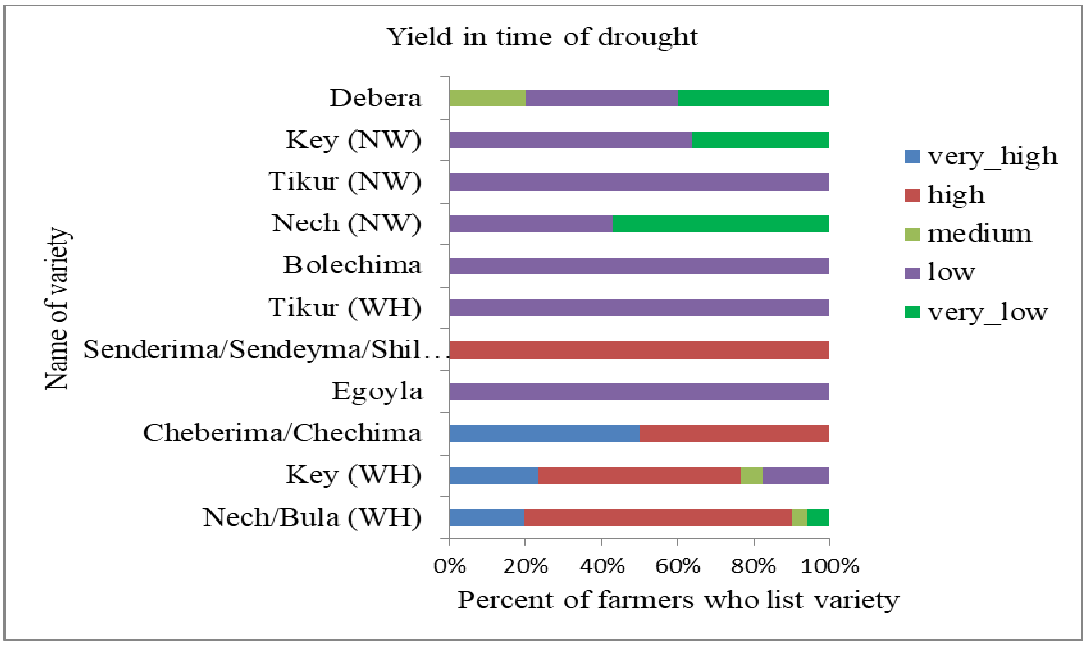
Eleven farmers' varieties of cowpea were collected from the study area (Table 1). In these study farmers were asked to rank the landraces of cowpea for selected properties (Figure 21 A, B, C and D).

The result of the study in Figure 21A shows that Tikur (WH), Senderima/Sendeyma/Shilimlima, Egoyla, Cheberima/Chechima, Key (WH) and Nech/Bula (WH) are the varieties that are very easy to harvest than the others due to their

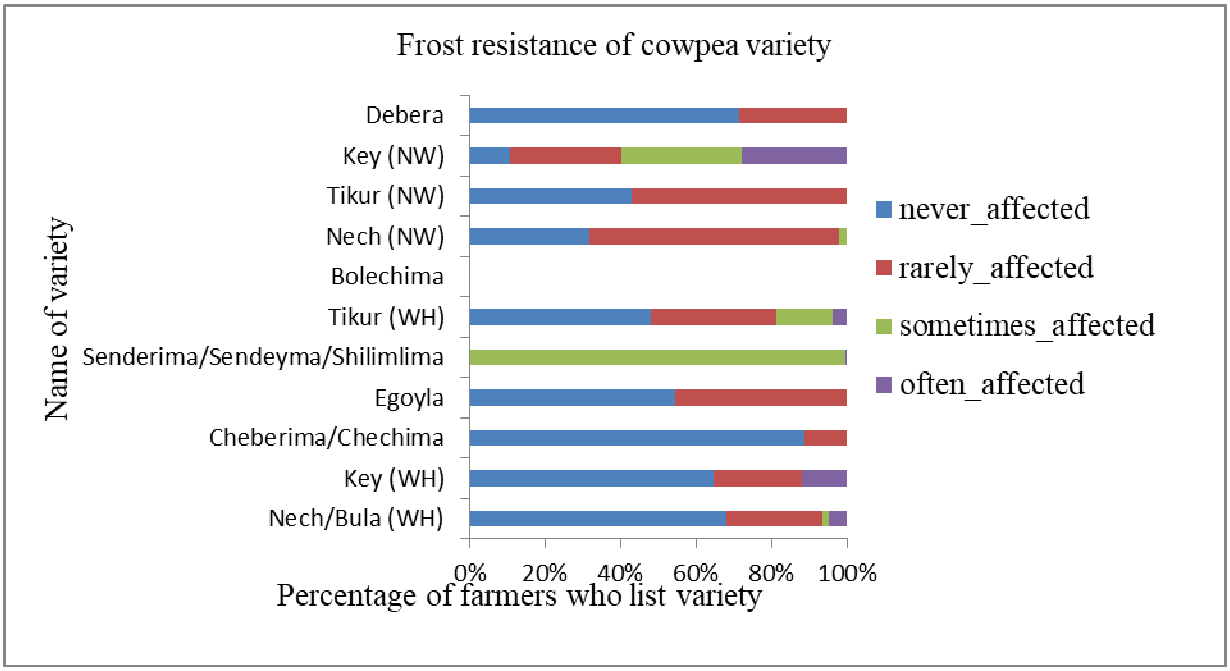
better growing habit. Farmers ranked Cheberima/Chechima followed by Debera based on frost resistance in Figure 21C. Farmers were also asked to rank the varieties by yield during time of drought (Figure 21B). The ranking result revealed all varieties do not produce very high yield at times of drought. However, the varieties Cheberima/Chechima, Key (WH) and Nech/Bula (WH) produced relatively better resistance at times of drought. Comparison based on resistance to Disease showed that Key (WH) and followed by Key (NW) were ranked as the best (Figure 21D).



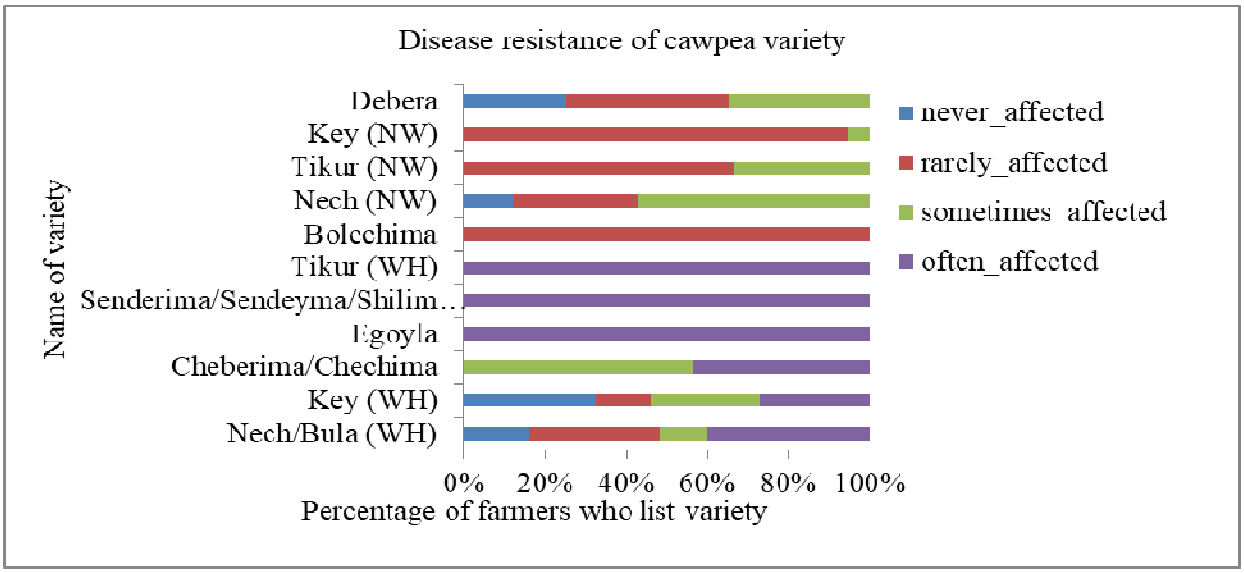
A


Yield in time of drought
Debera
Key (NW)
Tikur (NW)
Nech (NW)
Bolechima
Tikur (WH)
Senderima/Sendeyma/Shil…
Egoyla
Cheberima/Chechima
Key (WH)
Nech/Bula (WH)
Name of variety
0%
20%
40%
60%
80%
100%
Percent of farmers who list variety
very_high
high
medium
low
very_low

B


Frost resistance of cowpea variety
Debera
Key (NW)
Tikur (NW)
Nech (NW)
Bolechima
Tikur (WH)
Senderima/Sendeyma/Shilimlima
Egoyla
Cheberima/Chechima
Key (WH)
Nech/Bula (WH)
Name of variety
0%
20%
40%
60%
80%
100%
Percentage of farmers who list variety
never_affected
rarely_affected
sometimes_affected
often_affected

C



D

Figure 22: Ranking of varieties (A), Ranking of the varieties by ease of harvesting (B), Ranking of cowpea varieties by resistance to abiotic factor (drought) (C), Ranking of varieties by the ability to resist abiotic stress (Frost) (D), Ranking of varieties by resistance of biotic factor (Diseases).

4.7. Soil Fertility Suitable for Cowpea in Wag-himra and North Wollo Zones

In SM4 and SM3 agroecological zones of Wag-himra 92% and 89% of farmers reported planting cowpea in low soil content respectively (Figure 23). But few farmers (3% and 8%) said they plant cowpea in medium and high quality soil. However, in M3 agroecoligal zone of North Wollo 95% and 93% of farmers plant the cowpea in high and medium quality soil and 39% in low quality soil. In SM3 agroecological zone of North Wollo 90% and 67% of cowpea is planted in high and medium quality soil and 8% in low quality soil as described by farmers.

The results (Figure, 23) indicate that in the agroecological zones of SM3 and M3 in North Wollo the soil is more fertile than the agroecological zone of SM4 and SM3 of Wag-himra.

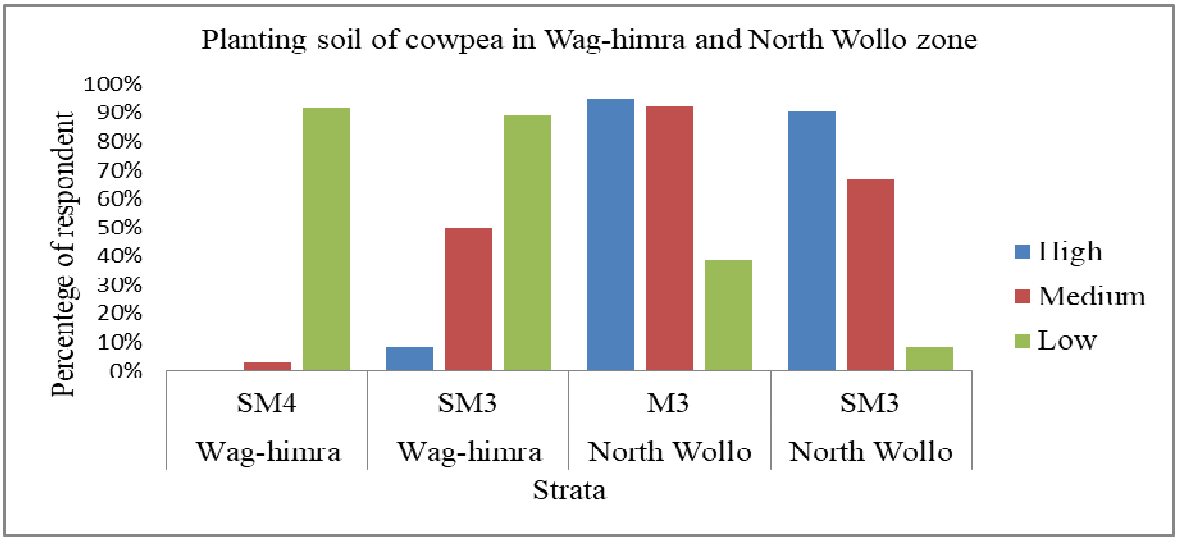


Figure 23: Soil fertility suitable for cowpea in the four strata

4.8. Yield of Cowpea under Drought, Water Logging and High Rainfall

In the study area, yields fluctuated during different conditions (Figure, 24). Under drought condition the majority of the farmers said that they get very high yield (17%), higher yield (35%), medium (3%) and only 25% and 20% of the farmers said low and very low yield. Under water logging condition it is between very high (6%), high (4%), medium 34%, low (50%) and very low (6%). However, under high rainfall it is between high (2%), low (85%) and very low (13%). Therefore, under high rainfall the majority (85%) of the farmer said they get low yield (Figure 24).

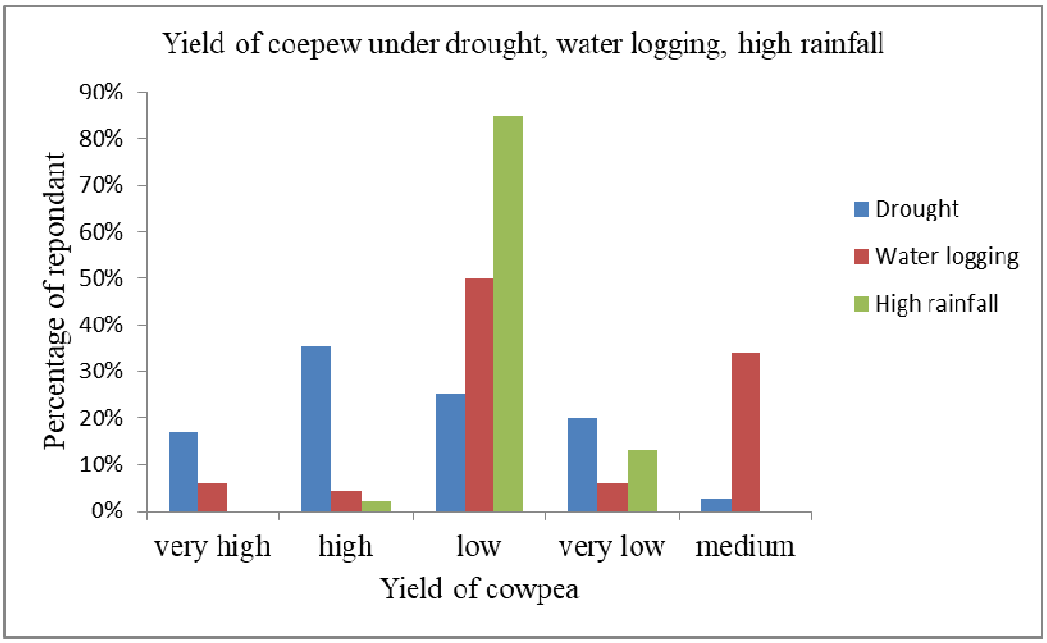


Figure 24: Yield of cowpea varieties during drought, shortage of rainfall and water logging

4.9. Market Value of the Varieties and Traditional Measurment

4.9.1. Price value of the varieties

The market values of landraces in the study zones and study strata (agroecological zones) were significantly different ($p < 0.001$) (Table 9). The market price of farmers' varieties of cowpea varies from variety to variety (Figure 25).

Table 9.ANOVA test on price value of cowpea

	Degree of Freedom	Sum Square	Mean Square	F Value	Pr (>F)
Zone	1	25473.5	25473.5	400.9724	< 2.2e-16 ***
Agroecology	2	1412.9	706.4	11.1199	2.983e-05 ***
Variety	10	26259	2625.88	37.31	< 2.2e-16 ***

The average price value of cowpea listed in the two zones of the study area (N. Wollo and Wag-himra) statistically has significant differences as the p value shows **< 2.2e-16 *** (P<0.05). the average price of cowpea among the four agroecological zones has statistically significant difference as the p value shows **2.983e-05 *** (P<0.05). Based on price value statistically there is significant difference in the price cowpea by variety the p value shows **< 2.2e-16 *** (P>0.05

Table 10 Average price of cowpea

Variety name	Average price of Variety	Tukey Post-Hoc Group
Bolechima	16.56	abc
Nech (NW)	4.46	a
Debera	8.11	a
Tikur (NW)	15.23	ab
Key (NW)	9.75	a
Cheberima/Chechima	29.60	bcd
Senderima/Sendeyma/Shilimlima	36.23	bcd
Nech/Bula (WH)	29.17	cd
Key (WH)	31.49	cd
Tikur (WH)	46.23	d
Egoyla	56.56	d

Confidence level used: 0.95

P value adjustment: tukey method for comparing a family of 11 estimates significance level used: alpha = 0.05

The result of Tukey test on price value of farmers' varieties of cowpea in Figure 26 indicated that the market price of Egoyla is significantly different from the varieties (Table 9). Accordingly, Egoyla is expensive (56.56 ETB/kg) on their market value, followed by Tikur (WH) and Senderima/Sendeyma/Shilimlima 46.23 and 36.23 ETB /kg. However, Key (WH)

has a market value of 31.49 ETB/KG during the time of this market. Cheberima/Chechima and Nech/Bula (WH) 29 ETB /kg and Nech (NW) (17 ETB /kg were the cheapest varieties in the study area.

Post-hoc analysis shows that average price in Egoyla and Tikure (WH) variety were significantly higher ($p<0.05$) than in Nech (NW) (Table 10)

4.9.2. Materials used for measuring landraces in the market

People in the study are used different measuring devices or units (house hold utensils) to measure crop in the market (Figure 25). Tasa and Kubaya are some of the measuring devices used by the community.

A

B

Figure 25: Photo of measuring material of seed (a) Tasa from Kobo, Guba Lafto and Habru woredas of North Wollo zone (a,b)Tasa and Kubaya from Sekota and Gazigila woreda of Wag-himra zone .

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Discussion

5.1.1. Varietal diversity and distribution of cowpea varieties in Wag-himra and North Wollo

The 36 accessions collected from the study areas had distinct names in the area of cultivation and each constitutes a landrace or a farmers'variety. Based on names and descriptions given by farmers these accessions were categorized into eleven major landrace groups. Most of the name categories that farmers used to name their varieties were used for landrace identification; particularly morphological traits were used for identification of landraces, such as seed color, seed size, flower color and habit of growth; it was also found that some farmers give name to their variety based on their uses and source of seed. For example, the variety called Key (WH), Nech/Bula (WH), and Tikur (WH) from Wag-himra was named based on its seed color meaning Red, White seed and Black seed respectively in Agewugna language and based on growth habit and the origin of seed the meaning of the variety which grows upright without support in Wag-himra. However, the same variety (Egoyla) was given another name in different areas of Amharic language as Lam ater, Yeat Hareg, Arengade, Tahira/Kafira and based on growth habit and the origin of seed meaning the variety which does not grow upright without support and one which came from North Wollo. Tahira/Kafira has also the other name in Amharic language which means its seed is split from its pod explosively with a popping sound, Kiwa/Tiwa. According to Hegde and Mishra (2009), landraces also known as farmers' varieties are coming from natural and artificial selections by farmers

for better adaptation to local growing conditions over long period. Cowpea landraces in the study area show a great variation i.e. higher in Wag-himra zone than in North Wollo zone. Hence, there is higher gamma diversity in SM3 agroecological zone of Wag-himra than in SM4-Wag-himra and North Wollo zone. This might be due to the agroecological requirements and accessibility of the crop in local market. The average number of landraces listed in each agroecological zone was highest for SM3-Wag-himra followed by SM3-North Wollo, whereas M3-North Wollo and SM4-Wag-himra was the lowest, this might indicate SM3 agroecology is suitable for the landrace.

5.1.2. The area covered by cowpea crop in the study area

Farmers cultivate cowpea on farm sizes ranging from 0.230-0.316 hectare. Most of the farmers cultivate cowpea in farm size of 0.250-0.316 ha in the study area. This indicates the farmers grow cowpea in addition to other cereals and pulse crops. In general, there was no significant difference between the farm size of cowpea cultivated by low income and mid-high income farmers. However, the farm size of cowpea in Wag-himra agroecological zones (SM3 and SM4) was more significantly different as compared to North Wollo agroecological zone (M3 and SM3) due to the presence of wide area.

5.1.3. Use value of cowpea in each stratum

In the study area farmers also mainly use cowpea as food, fodder and for income generation. Most farmers in M3 (25%) and SM3 (24%) agroecological zones of North Wollo did not know the use of cowpea as food but use it mostly for animal fodder because of the presence of alternative cereal crops. Many farmers in SM3 (25%) and SM4 (25%) agroecological zone of Wag-himra used cowpea as food because farmers have no alternative cereal crops and it is used as hungry season food for the people. In

addition to that in Wag-himra zone cowpea is used as income generation than North Wollo zone because seriously peoples need cowpea as source of food during the famine time. Cowpea is a multi-purpose crop and it is used for food, forage, income generation and improving soil fertility as asserted by all respondents of the present study, similar with the study reported by Ehlers *et al*. (1997) in which cowpea is described as one of the most widely adapted, versatile, and nutritious grain legumes. In Ethiopia, cowpea seed is mostly used in the form of food dishes 'Nifro', 'Shiro' etc (Belay *et al*., 2017; Timko *et al*., 2008). As asserted by all respondents of the present study, cowpea is a multi-purpose crop and it is used for food, forage, income generation and improving soil fertility. Similar with study reported by Akinlade *et al.* (2005) and Alemayehu (1997) wherein cowpea is the most important forage plant that substantially improves the feed available for livestock as they can provide the essential protein for animals, improving soil fertility, food crop production and household nutrition through a more reliable supply of milk and meat.

5.1.4. Yield of cowpea under drought, water logging and high rainfall

In the study area, yields were said to fluctuate during different conditions. The majority of the farmers said that they get very high yield (17%), higher yield (35%), medium (3%) and only 25% and 20% of the farmers said low and very low yield under drought condition. Under water logging and high rainfall condition the majority farmers said that they get 50% and 85% low yield. Drought is the most important abiotic stress limiting production all crops worldwide, even the most drought tolerant cowpea (Hall, 2004). Cowpea is inherently more drought-tolerant than other crops; water availability is still among the most significant abiotic constraints to growth and yield. Erratic rainfall at the

beginning and towards the end of the rainy season adversely affects plant growth and flowering resulting in a substantial yield reduction. Selection for early flowering and empirical yield testing of breeding lines under dry production conditions have been successfully used to develop cowpea cultivars adapted to low rainfall areas of the Sahel (Hall and Patel, 1985; Cisse *et al*., 1995, 1996). Waterlogging is a major constraint for production ofcowpea by impairing plant performance, although many of the plant species have the ability to develop a combination of mechanisms enabling them to grow under flooding (Minchin *et al.* 1978).

5.1.5. Cultivation and management systems of cowpea

5.1.5.1 Gender roles in production and management

In the study areas most of the management practices/agronomic practices in the cropping of cowpea were mostly done by both men and women adults and male elder sons except storing, marketing and preparation of food which were only done by male and women adults, female elders and men, women adults and female adult and elders respectively. This might be associated with socio-cultural influence on gender role. However, women were exclusively involved in food preparation of cowpea for home consumption in the form of local recipes. In the study area moreover women's important role in agriculture often remains invisible, and their knowledge is often ignored instead of being put to use in agricultural decision making. This might be due to the socio-economic and cultural dimensions. Other studies reported by Fernando (1998) assert that activities, resources and opportunities of people are significantly influenced by gender- that is, by the socio-economic and cultural dimension of being male or female. In Malawi, Bezner-Kerr *et al.*

(2013) observed that women's agency and access to agricultural resources are very limited.

5.1.5.2. Cropping systems

Cowpea is intercropped with different crops. Greater numbers of informants use sorghum to intercrop with cowpea in M3 (64%) and SM3 (56%) agroecological zones of North Wollo because intercropping provides better weed control and reduces pest and disease incidence. But less numbers of informants use maize and other crops to intercrop with cowpea in the aforementioned agroecological zones. This is comparable with the study reported by Jerany (1998) where cowpea is a short-lived annual legume that can best be intercropped with cereals like maize and sorghum and Blade *et al*. (1997) that reported that most cowpea grown in Africa is intercropped with sorghum, and less frequently as a sole crop or intercropped with maize, cassava (*Manihot esculenta Crantz*), or cotton (*Gossypium* spp.). Sole crops are becoming important as cowpea production is commercialized to meet the demands of a rapidly increasing urban population. However, in SM4 (100%) cowpea is predominantly grown as a sole crop because of its main adventage of restoring soil fertility for the productivity of the next crop which is sown after harvest. In Senegal, most cowpea is sole-cropped (Thiaw *et al*., 1993), in part due to the light sandy soils and availability of easily modified horse-drawn peanut seeders. In SM3 (3%) agroecological zone of North Wollo traditional cropping systems reported by farmers showed that cowpea is also intercropped with other crops like coffee and sugar cane. Crop rotation played a great role in the life of farmers by adding a positive impact on their farm fields. As mentioned by key informants, it helped them to increase and restore soil fertility because the cowpea plant is efficient symbiotic nitrogen fixers, and

by the ability of holding water in the soil for the next crops that is sown after it. In addition to increased crop yield and profit rotating cowpea with other crops is used by farmers for better control of weeds by breaking the life cycle and suppressing the growth of weeds. Because of this quite a number of farmers included cowpea in their crop rotation sequences for the same purposes. As shown in Figure 20, cereals and legume crops were included in most of the farmers' crop rotation sequences; barley, wheat, sorghum, and maize were mostly grown after cowpea in Wag-himra. The farmers in North Wollo used chickpea, faba bean and lentil next to teff, fieldpea and maize to rotate with cowpea. Farmers rotate cowpea with other crops by carful observation of their land fertility. Other studies of cropping systems research indicates that rotation of cereal and legume crops will enhance grain yields (Bationo *et al.,* 1996) and crop rotation can improve soil nutrient levels through biological nitrogen fixation (Hoshikawa, 1990).

5.1.5.3. Cropping and harvesting season

There was only one cropping season for cowpea production in Wag-himra and two cropping seasons in North Wollo zone. From late May to late July was the main cropping season for cowpea in Wag-himra; however from early March to early April and from late June to late July was the main cropping season for North Wollo. This might be due to the availability of water. Quinn *et al*., (1999) reported that black-eye or purple-eye pea varieties should be planted in early June in Indiana, although planting dates from the latter part of May through mid-June are appropriate. Therefore, North Wollo farmers sow earlier than Wag-himra farmers at different season due to the presence of irrigation in North Wollo and the presence of shortage of rain through cropping season in Wag-himra. In M3 and SM3 agro-ecological zone of North Wollo most farmers were sown their crop

at early July because the presence of high rain fall. In SM3 and SM4 most farmers were sow their crop at let June to early July. Harvesting activities was in different time in North Wollo and Wag-himra. In North Wollo zone cowpea was sown after other dominant cereal crops of the area (sorghum and maize). From early September to Mid-October was the main harvesting time for cowpea in Wag-himra. However, mainly from late September to late October and from late May to early June is the main harvesting period for North Wollo. Harvesting should be carried out before the crop is too dry to avoid damaging the seed. In mechanized harvest, drum speed must be low (250-300 rpm) to avoid seed damages. (Cameron, 1999).

5.1.6. Soil fertility suitable for cowpea

In the study area, cowpea is a valuable component of the farming system in areas where soil fertility is limiting, medium and high and where it is grown in rotation and/or intercropped with cereals in both Wag-himra and North Wollo zones. In Wag-himra zone most farmers plant their crop in low soil fertility since most of the soil is eroded because of the topography of the land. But some farmers plant their crop in high and medium type of soil fertility. Whereas in North Wollo zone most farmers plant the crop in high and medium soil fertility type intercropping with sorghum and maize because these need suitable soil fertility for their growth. In this zone, some farmers plant the crop in low soil fertility during the dry season in sole cropping because cowpea has a high rate of nitrogen fixation and the presence of irrigation. As reported by Turk *et al* (1980), cowpea is well adapted to the harsh growing conditions, including low soil fertility, high temperatures, and drought. Related studies indicated that the cowpea grows well in soils which range from acidic to neutral, and, therefore, performs satisfactorily even on soils with low

fertility (Quass, 1995). In the same vein, relative to other grain legume and vegetable crops, cowpea possesses multiple advantages to farmers including high yield on poor, sandy soils unsuitable for the production of other crops high rates of symbiotic nitrogen fixation and low fertilizers requirements (Carsky *et al*., 2001; Timko and Sigh, 2008) and cowpea can be grown in a wide variety of soils, but yields better on well-drained soils with medium fertility (Arnon, 1972). Cowpea is also a valuable component of farming systems in areas where soil fertility is limiting. This is because cowpea has a high rate of nitrogen fixation (Elawad and Hall, 1987).

5.1.7. Farmers` seed supply, selection and storage of cowpea

The present study result also showed that farmers obtain seeds of cowpea varieties from different sources. Market and DA are the main sources for both traditional (local) varieties and improved (New) varieties respectively. This might be associated with the availability of the seeds in the market and with developmental agent. Also the seeds of both improved and traditional varieties are mainly used for income generation of farmers. Most of the farmers obtained the seeds as improved varieties of cowpea from research center next to DA (20%). This implies there is an availability of seed source from the DA and research center to the farmers. Few farmers (8%) obtained the seeds of traditional varieties of cowpea from family next to market. This implies there is a genetic /gene/ transfer of traditional varieties from generation to generation. In addition to the above sources, improved varieties are provided by development agents of the kebele and by research centers. Separately, Sirinka research center plays a great role in providing the seed of improved varieties for the farmers. The farmers in SM3 agroecological zone of wag-himra have an experience to share the seed of high yielding varieties with each other

that is why the SM3 agroecological zone of wag-himra has higher gamma diversity than SM3 agroecological zone of Wag-himra and North Wollo zone. The reliance of local farmers mainly on sources of home saved seed and exchanging with their neighbors is a good support in maintaining and conserving the distinct types, but at the same time there is little driving force to create new types and maintain a high level of diversity (Munisse *et al*., 2011). Storage is aimed at creating time utility with very minimum spoilage and improvement of quality of the product. The primary objective of storage is to make the commodity available throughout the year for the consumers. The storage life of cowpea depends on its moisture content before storage; and the lower it is the better the quality of seeds for storage (AFF, 2011). In developed countries, one alternative is the use of cold storage and that exposure to minus 18^0C during 6 to 24 h reduced pest numbers by more than 99% (Carlos, 2004). Harvested green cowpeas will "heat" resulting in spoilage unless kept cool. Post-harvest facilities have to provide shade and adequate ventilation on the way to the cooler. Cowpeas cooled below 5.555^oC may show chilling injury (Davis *et al*., 1991). For seed storage farmers in the study areas used different traditional storing materials but the majorly used the modern sack locally called Kesha because it is better for air flow than the other traditional storing materials such as Gotera and Godo because it is better for a long period of time without human and animal contacts.

5.1.8. Ranking of farmers' varieties

Farmers' varieties tend to possess significant phenotypic variability some have developed tolerance to particular biotic and abiotic stresses and some are lauded for their yield stability while the others are not (Cleveland *et al*., 2000). In the study area, landraces exhibited differences based on different properties. In general, all varieties of cowpea are

not drought tolerant. However, Cheberima/Chechima, Key (WH) and Nech/Bula (WH) and Senderima/Syndeyma/Shilmlima produce a relatively better yield than the other varieties in time of drought because of their batter low water demands and due to high water demand. Farmers ranking of varieties on ability of frost resistance, even though all varieties are susceptible for frost, Cheberima/Chechima has relatively better ability to resist frost due to the presence of two different varieties by mixture. However, farmers' ranking of varieties on ability of disease resistance, even though all varieties are susceptible for disease, Cheberima/Chechima have relatively more ability to resist disease due to the presence of two different varieties. Long taproot and mechanisms such as turning the leaves upwards to prevent them to become too hot and closing the stomata, give to cowpea an excellent drought tolerance (Gómez, C. 2004). Frost and disease are the major production constraints of the area as similarly studied by Sisay Alemu. (2015). Cowpea tolerate heat and dry conditions but intolerant to frost Futuless, K. N., (2010). It grows best in hot areas and can produce a yield of one ton seed and five tons hay per hectare with as little as 300 mm of rainfall.The low yield of cowpea is attributed to farmers' use of local land races that have low yield potential and high susceptibility to diseases, insect pests and parasitic flowering plants like Striga and Alectra (Gómez, C. 2004).

5.1.9. Market survey and Price

In the study area marketing of cowpea like the other crops is mainly confined to local markets and farm gate. This is attributes largely to lack of access to urban markets by farmers partly because of poor road network and poor modes of transportation. Only few farmers produce and sell their products either to nearby local or primary markets (buyers who buy directly from the producers include rural retailers, rural assemblers, brokers, and primary cooperatives) with variable prices ranging from 4.46-56.56 ETB per kilo gram. The price of the crop becomes low during harvesting time of the new cowpea and high after harvesting period. The result from market survey indicated that Egoyla had the highest demand from the buyers because quality value could be higher than the others. This resulted showed that a considerable local trade exists in cowpea. More generally, it explains the relationship between two markets that are spatially or temporaly separated. Markets are integrated when their price levels are closely related (Stingler, 1969). Market integration studies attempt to investigate the extent of markets by analyzing the development of price over time for potential competing products (Asche *et al*., 2005).

In the study area cowpea prices fall soon after harvest being lower than those several months thereafter as growers rush to sell their marketable surpluses to urban traders. In the market farmers select the cowpea by size of grain, testa color and texture, eye color and damage levels were recorded. Pricing of cowpea is determined by qualitative and quantitative characteristics of cowpea and ability of the potential buyer to pay and take possession. As reported by Faye *et al*. (2004) the impact of testa colour and texture is significant where consumers are willing to pay more compared with cowpea with speckled skin. Cowpea consumers in Nigeria, Ghana and Mali prefer larger grain size and are willing to pay a premium for larger grain size (Fulgence *et al*., 2009). Standard can be

established by grading the cowpea based on the purity, moisture content (<12% moisture) and size of the seeds.

5.2. Conclusion

A total of 36 accessions from different kebeles of the study area were collected and categorized into eleven farmers' varieties by depending on farmers' identification. Most of the farmers' varieties were named by their morphological traits, uses, source of seed, and productivity. In general, Wag-himra zone has high varietal diversity, richness and evenness (high value) than North Wollo zone. Also, the total number of varieties and average number of varieties is high in Wag-himra zone than North Wollo. This means the Wag-himra zone was not only dominated by one or two landraces rather by a number of successful landraces of cowpea. Nech/Bula (WH) and Key (WH) in Wag-himra zone and Key (NW), Tikur (NW) and Debera in North Wollo zone are the most dominant varieties of the area. The land size on which farmers grow cowpea is significantly different in the two study zones. However, most of the farmers from Tepid moist mid-highland and Tepid sub-moist highland agroecological zones of North Wollo grow cowpea within small land size than Tepid sub-moist highland and Cool sub moist highland of Wag-himra zone. Cowpea is mainly used for food and income generation and fodder in Wag-himra zone. However, using it as food is not a common habit for most farmers in SM3-North Wollo. The fields where cowpea is sown were either plowed once after sowing or plowed twice, one before sowing and the other after sowing at different times. Fertilizer was not used in both zones. Except plowing, which was done by males and food preparation which was done mainly by females, all the other agronomic and management practices of cowpea involve both males and females. Most of the farmers obtained the seeds of both traditional and improved varieties for the first time from the market. Next to market, family sharing of seeds also plays a great role as source of seeds for traditional varieties regarding from where the farmers obtained the seeds for the first time. In

general, harvesting of cowpea is an easy practice, where the varieties Tikur (WH), Senderima/Sendeyma/Shilimlima, Egoyla, Cheberima/Chechima, Key (WH) and Nech/Bula (WH) are very easy for harvesting. Key (WH) and Nech/Bula (WH) are very good drought resistance as compared to other varieties. Even though frosts are the major production constraint of the area for all varieties, Cheberima/Chechima followed by Debera is not always affected varieties. Even though all varieties have low ability to resist disease, Key (WH) and followed by Key (NW) have very high ability to resist disease.

5.3. Recommendations

Based on the results of this study, the following recommendations are made for future consideration for some stakeholders like governmental and nongovernmental organizations and research centers.

- This study documented that only landraces of *Vigna unguiculata* were cultivated and that the crop is a good source of income, which has increased over time making strengthening trade linkages of farmers and merchants highly important. Thus conservation and utilization of the cowpea landraces found in cultivation, research and development centers must be given due attention.
- Further ethnobotanical studies with seed collection of landraces, their characterization and evaluation must be conducted particularly in areas not covered by this study in order to have a complete country-level account on this crop.
- Efforts towards distribution of field cowpea to areas of the country where the landrace diversity is low need to be given due consideration in view of the importance of the crop and the preferences shown by farmers.

- It would also be necessary to engage in awareness rising on cowpea use, nutritional value, compositions of the landraces studied particularly taking the different food types (Shiro, Genfo, Nifro, Kollo, and Eshet).
- Conservation measures carried out by EBI for cowpea landraces were very low and restricted in few localities as compared to other crop species so that intensive collection and rescue conservation task needed to secure threatened cowpea variety.

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APPENDICES

Appendix 1

PART I: INFORMED ORAL CONSENT Hello, my name is Meresa Gufuy and I am a student at Addis Ababa University. This is my colleague [name], who is assisting me as a local guide and translator. It is a pleasure to meet you. We are conducting a study about cowpea as part of my education at the university. The purpose of this study is to identify different types of cowpea and to understand their use and management by farmers. With your permission, I would like to ask you questions about cowpea. Of course, your participation is entirely voluntary. These interviews require up to two hours. I do not anticipate that the interview will pose any risks to you. Because I am a student, I cannot pay you. We hope that our research will benefit farmers in Ethiopia by promoting the diversity of cowpea. If you agree to an interview, you do not have to answer all of my questions, and you can tell me at any time if you would like to stop. I would record your answers to my questions using my notebook. I would include this information in my thesis, and it would be shared with other researchers who are interested in cowpea. Do you have any questions? [Allow time for questions.] In case you have any questions in the future, here is my contact information. [Provide printed contact information, including name and cell phone number.] Do you agree to participate in this study of cowpea [If yes, proceed with interview. If no, thank the individuals for their time and continue to the next household.]

PART II: STRACTURED INTERVIEW WITH GENERAL INFORMANT

Section 1: Basic information

Date of interview:	*Start time of interview:*
Name of interviewer:	
Region:	Zone:
Woreda/District:	Kebele/Sub-District:
Latitude (in decimal degrees):	*Longitude (in decimal degrees):*
Altitude (in meters):	
Agro ecological classification	
Random number of household from farmers' association list:	
Relative wealth on farmers' association list: ☐ Low income ☐ Middle/High income	

Section 2: General information about informant

Name of informant:
Language spoken by informant during interview: ☐ Amharic ☐ Other (specify): _____
Age (observed): ☐ 18 to 30 ☐ 30 to 45 ☐ 45 to 60 ☐ 60+
Gender (observed): ☐ Male ☐ Female
Is the informant the household head? ☐ Yes ☐ No
If no, household-head gender: ☐ Female-headed ☐ Male-headed

Section 3: Market access

How far is the closest market from your home? In minutes on foot

Do you go to any other larger market? ☐ Yes ☐ No
If yes, how far is this larger market from your home? In minutes (on foot)
How far is the nearest road with vehicle transport from your home? In minutes (on foot)

Section 4: Interspecific diversity of legume crops

Are you growing any legumes this year? ☐ Yes ☐ No If yes, how many hectares.
Which legumes did you plant in 2010 (Meskerem to Pagume)?
For each of the legumes you listed, how many hectares of land did you plant in 2010 (Meskerem to Pagume) including any areas under intercropping? *Convert any local units to hectares* (e.g. 1 timad or qurt = 0.25 hectare).

Section 5: Use of Cowpea (*Vigna unguiculata)*

How do you use Cowpea (*Vigna unguiculata)*? ☐ Food ☐ Spice ☐ Medicine ☐ Fodder/Forage ☐ Fuel ☐ Market ☐ Bee forage ☐ Other (specify): _____

Section 6: Cropping practices

Do you rotate cowpea with other crops? ☐ Yes ☐ No
If yes, with which crops do you rotate Cowpea*?*
If yes, how often do you plant Cowpea within the crop sequence?
Do you intercrop cowpea with other crops? ☐ Yes ☐ No
If yes, with which crops do you plant Cowpea in the same field?

What are the major production constraints for cowpea in your KEBELE (check all that apply)? ☐ Land shortage ☐ Drought ☐ Poor soil fertility ☐ Wild animals ☐ Diseases ☐ Insect pests ☐ Weeds ☐ Lack of seeds ☐ Theft ☐ Flooding ☐ Erratic rain ☐ Low market value ☐ Price of inputs ☐ Other: _____
What do you use to improve soil fertility for cowpea]? ☐ DAP ☐ Urea ☐ Compost ☐ NPS ☐ Manure ☐ Nothing ☐ Other (specify):
Do you do anything to control insect pests on cowpea? ☐ Yes ☐ No →If yes, how do you control insect pests on [legume of interest]? ☐ Chemicals ☐ Other (specify): ____
Do you do anything to control weeds around cowpea? ☐ Yes ☐ No →If yes, how do you control weeds around cowpea? ☐ Chemicals ☐ Other (specify): _____
Do you do anything to control diseases affecting cowpea? ☐ Yes ☐ No →If yes, how do you control diseases affecting cowpea? ☐ Chemicals ☐ Other (specify): ___

Section 7: Intraspecific diversity of Cowpea (*Vigna unguiculata)*

Note: Be sure to include all varieties, including landraces and released/improved types.

What varieties of cowpea have you grown in the past three years (for the 2009, 2010, and 2011 harvests)?
Are there any other varieties that you have grown in the past, prior to 2009?

Are there any other varieties of Cowpea grown by other farmers in your community, but not by yourself?
Are there any other varieties of cowpea that you remember from a long time ago, or have heard about from Elders, that are no longer grown by your community?
If you run out of a particular variety of cowpea, whom would you ask to replenish your seeds? (*Record name as a potential key informant*).

Section 8: Key attributes of varieties

Instructions: At the top of each column, write the names of all varieties harvested in 2009, 2010, and 2011. Use additional sheets if necessary

Question	Variety 1	Variety 2	Variety 3	Variety 4
Local vernacular name of variety				
Is this a traditional or a new variety?				
Where did you first obtain this variety? (e.g. family, neighbors*, DA, market, food aid, research center)				
For how many years have you planted this variety?				
Where do you plant this variety? (e.g. main fields, field margins, home gardens, fence lines, other places)				
Are the places where you grow this variety rain fed, irrigated, or both?				
Do you plant this variety on soils with low,				

moderate, and/or high fertility?				
How many times per year do you sow this variety?				
When do you usually sow this variety?				
When do you usually harvest this variety?				
Is this variety grown mainly for home use or mainly for the market?				
How many hectares of these varieties did you harvest in 2009 and 2010, including area under intercropping? *Make sure you convert any local units to hectares* (e.g. 1 timad or qert = 0.25 hectare).	2010: 2009:	2010: 2009:	2010: 2009:	2010: 2009:
How much of this variety did you harvest in 2008 and 2007? *Record with local units to be converted later. Be sure to include the name of the units. Later, go to a local market to determine the conversion factor from local units to kilograms.*	2010: 2009:	2010: 2009:	2010: 2009:	2010: 2009:
Based on your experience, was the yield for this variety in 2010 and 2011 a very high yield, a high yield, a medium yield, a low yield, or a very low yield?	2010: 2009:	2010: 2009:	2010: 2009:	2010: 2009:
What is the current price of this variety at your local market? (use farmer units)				

* If a particular variety came from friends or family, ask for the name of the individual who provided it as a potential key informant. Record that person's name in your notebook.

Section 9: Rating of attributes for varieties of Cowpea (*Vigna unguiculata)*

Ask the informant to rate the varieties of Cowpea (*Vigna unguiculata)* planted for the 2009, 2010, and 2011 harvests. This is NOT a ranking activity, so multiple varieties may receive the same score.

Rating criteria and scale	Var. 1	Var. 2	Var. 3	Var. 4	Var. 5
Local name (copied from previous pages)					
Best yield this variety has ever given you (5=very high, 4=high, 3=medium, 2=low, 1=very low)					
Yield under drought conditions (5=very high, 4=high, 3=average, 2=low, 1=very low)					
Yield when excessive rain causing water logging (5=very high, 4=high, 3=average, 2=low, 1=very low)					
Yield when rainy season begins late (5=very high, 4=high, 3=average, 2=low, 1=very low)					
Yield when rainy season ends early (5=very high, 4=high, 3=average, 2=low, 1=very low)					
Resistance to frost (5=never affected by frost, 4=rarely affected by frost, 3=sometimes affected by frost, 2=often affected by frost, 1=always affected					

by frost)					
Resistance to common diseases (5=never affected by diseases, 4=rarely affected, 3=sometimes affected, 2=often affected, 1=always affected by diseases)					
Tolerance to common insect pests (5=never affected by insect pests, 4=rarely affected, 3=sometimes affected, 2=often affected, 1=always affected)					
Tendency for seeds to detach/shatter (5=seeds never detach/shatter 4=rarely detach/shatter, 3=detach/shatter about half the time, 2=often detach/shatter, 1=always detach/shatter)					
Importance as food for the household (5=extremely important, 4=very important, 3=somewhat important, 2=not so important, 1=not at all important)					
Importance as a source of income (5=extremely important, 4=very important, 3=somewhat important, 2=not so important, 1=not at all important)					
Importance as fodder for livestock (5=extremely important, 4=very important, 3=somewhat					

important, 2=not so important, 1=not at all important)					
Effect on soil fertility (5=very positive effect on soil fertility, 4=some positive effect, 3=no effect, 2=some negative effect, 1=very negative effect on soil fertility)					
Ease of harvesting (5=Very easy to harvest, 4=easy, 3=neither easy nor difficult, 2=somewhat difficult, 1=very difficult to harvest)					
Ease of preparing as food (5=very easy to harvest, 4=easy, 3=neither easy nor difficult, 2=somewhat difficult, 1=very difficult to harvest)					
Taste (5=very good taste, 4=good taste, 3=neither good nor bad taste, 2=bad taste, 1=very bad taste)					

Section 10: Gender roles in production and management of Cowpea (*Vigna unguiculata)*

Which gender and age groups live in your household (including the respondent)?	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No

When it comes to Cowpea (*Vigna unguiculata))*, who within the family usually participates in the following activities? Check any that apply.

Activity	Gender and age groups*			Is this true for all varieties?*
Ploughing with animals (mares)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Preparing the soil by hand with a hoe (mekofer)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Leveling soil and removing uprooted weeds (gulgualo)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Sowing (zer mezerat)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Weeding (marem) and cultivation (kutkuato)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Fertilizer application (madaberia, fig, kompost…)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Harvesting (mached ena mesebseb)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Threshing (mewkat)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Storage (makemachet)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No

Marketing (meshet)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Seed selection (zer memret)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Food preparation (megib mazegajet)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Collection of fodder for animals (meno mesebsebe)	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No
Other activity (specify):	☐ M-children ☐ F-children	☐ M-adults ☐ F-adults	☐ M-Elders ☐ F-Elders	☐ Yes ☐ No

* Note: For this classification only, children are individuals 14 and younger, adults are ages 15 to 59, and Elders are 60 or older.

** Take detailed notes of any exceptions for particular varieties.

Section 11: Closing and follow-up questions

We are looking for both men and women who have a lot of knowledge about different lima bean. Is there anyone from your community who you recommend? (*Ask this if I haven't recorded any names of potential key informants in my notebook)*
Thank you very much for answering my questions. Do you have any comments and/or questions you would like to raise at this time? (Record farmers' questions in my notebook, if relevant.)
At any point during the interview, did the informant indicate that s/he had gained some

new knowledge? ☐ Yes ☐ No	
If yes, what knowledge did he/she report to have gained as a result of the interview (Record farmers' statements in your notebook)	
Time interview was completed:	*Duration of interview (minutes):*

Appendix 2

SEMI-STRUCTURED INTERVIEW WITH KEY INFORMANT

Note: You must take additional notes in your notebook. Informants will raise their own points during the interview – not necessarily as responses to questions - and these must be recorded. Second, interviewers must dig deeper by asking additional questions whenever she or he senses interesting information or ideas. This approach generates a richer, more complete understanding.

Section 1: Basic information about Key Informant Date of interview: Start time of interview: Name of interviewer: Region: Zone: WEREDA/District: KEBELE/Sub-District: Language spoken during interview: ☐ Amharic ☐ Other (specify): _____ Name of informant: Age (observed): ☐ 18 to 30 ☐ 31 to 45 ☐ 46 to 60 ☐ 61 and older Gender (observed): ☐ Male ☐ Female

Section 2: Knowledge of varieties listed within the same KEBELE Compile a list of all of the varieties that have been mentioned by the general informants within the same KEBELE. For each variety, ask the following questions of the key informant. Remember to note if the key informant says that two or more local names refer to the same variety. Are there any other varieties that you know that we can add to our list? You may include any that you remember or have heard about from a long time ago, but are no longer

planted in the KEBELE. Names of varieties (from ODK survey) have you heard of this variety? Is this variety planted in this KEBELE? Have you planted this variety yourself?

1. ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No 2. ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No 3. ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No 4. ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No 5. ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No 6. ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No 7. ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No 8. ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No

Section 3: Attributes/characteristics of varieties Instructions: Ask the key informants the following questions about each of the varieties with which s/he is familiar. Record the information in your notebook. The following table is intended to keep track of the questions you have asked. Question V1 V2 V3 V4 V5 V6 V7 V8 V9 V1 0 what is the direct translation of the local name? What is the reason for giving this name? Are there alternative names for this variety? How do you recognize this variety? How does it differ from similar varieties? (By appearance or other features?) What are the ideal growing conditions for this variety (e.g. amount and timing of rainfall, sunlight, temperature)? Characterize the soil types on which the variety is planted. What fraction of the farmers in your community plants this variety? (e.g. almost all, half, one out of ten) over the past 5 years, has this variety become more commonly planted or less commonly planted in your community? If applicable…What is the main reason that this variety is becoming more or less common?

Section 4: Use of cowpea as food What foods do you prepare using (cowpea]? Note: Add a note if foods are of special cultural value. You may include foods that the key informant does not prepare her/himself. Name of food which parts are used? Which

variety is preferred? Why is this variety preferred?* *for example, color, taste, ease of preparation, etc.

Section 5: Nutritional value of foods prepared with (cowpea) Do any of the foods you prepare with (cowpea) have any special health benefits? Name of food Health benefit Specific group who use it or for whom it is recommended*? Which variety is preferred? Why is this variety preferred? *For example: children, elderly, pregnant women, lactating women, sick people, people with broken bones, people who have lost a lot of blood.

Section 6: Use of cowpea as medicine Do you use [cowpea] as medicine? Name of ailment treated with cowpea which parts are used? Which variety is preferred? Why is this variety preferred?*

Section 7: Use of (cowpea] as fodder Do your animals consume cowpea? Which animals consume cowpea? Which part(s) of the plant do they consume?

Section 8: Other specific uses of cowpea Do you use common bean for any other purpose? Description of use which parts do you use? Which variety do you prefer? Why do you prefer this variety?

Section 9: Crop Management what are the major insects that affect (cowpea) Please list in order of their importance, from most important to least important.

What types of control measures do people in your community use to control insects on (cowpea)

Are there any differences among the varieties of [cowpea] in terms of their tolerance of or resistance to insect pests? If yes, which ones tolerant/resistant or susceptible and how?

What are the major diseases that affect (cowpea) Please list in order of their importance, from most important to least important?

What types of control measures do people in your community use to control diseases (cowpea)

Are there any differences among the varieties of (cowpea) in terms of their tolerance or resistance to disease?
If yes, which ones are tolerant/resistant or susceptible and how?

What are the major weeds that affect (cowpea) Please list in order of their importance, from most important to least important?

What types of control measures do people in your community use to control weeds affecting (cowpea)

Are there any differences among the varieties of (cowpea) in terms of their tolerance to weeds?

If yes, which ones are tolerant or susceptible and how?

Are there any varieties of (cowpea) that produce more residues (stems, leaves, etc.) than others?

What do people in your community do with the residues from (cowpea) after the harvest?

How do people in your community store (cowpea)?

Section 10: Closing and follow-up questions I have asked all of the questions I had for you. Thank you very much for spending this time with me and sharing your knowledge. Do you have any comments and/or questions you would like to raise at this time?

(Record farmers' questions below)

Time interview was completed: Duration of interview (in minutes):

Appendix 3: The list of variety names, area of cowpea, Price of cowpea varieties per kg and agroecology with wealth status of informants at different agroecological zone

No	Varieties	Total area of cowpea	Price of cowpea varieties per kg	Zone	Wealth	Agroecology
1	Nech/Bula (WH)	1	25	North Wollo	Mid to high	SM3
2	Nech/Bula (WH)	1	30	North Wollo	Mid to high	SM3
3	Nech/Bula (WH)	1	18	North Wollo	low	SM3
4	Nech/Bula (WH)	1	25	North Wollo	Mid to high	SM3
5	Nech/Bula (WH)	1	30	North Wollo	Mid to high	SM3
6	Nech/Bula (WH)	1	36	North Wollo	low	SM4
7	Nech/Bula (WH)	1	22	North Wollo	Mid to high	SM4
8	Nech/Bula (WH)	1	20	North Wollo	Low	SM4
9	Nech/Bula (WH)	1	18	North Wollo	Low	SM4
10	Nech/Bula (WH)	1	25	North Wollo	Low	SM4
11	Nech/Bula (WH)	1	25	North Wollo	Mid to high	SM4
12	Nech/Bula (WH)	1	25	Wag-himra	Mid to high	SM4
13	Nech/Bula (WH)	1	25	Wag-himra	Mid to high	SM4
14	Nech/Bula (WH)	3	18	Wag-himra	Mid to high	SM4
15	Nech/Bula (WH)	1	18	Wag-himra	Low	SM4
16	Nech/Bula (WH)	2	19	Wag-himra	Mid to high	SM4
17	Nech/Bula (WH)	2	23	Wag-himra	Mid to high	SM3
18	Nech/Bula (WH)	0.5	35	Wag-himra	Mid to high	SM4
19	Nech/Bula (WH)	2	25	Wag-himra	Mid to high	SM4
20	Nech/Bula (WH)	3	19	Wag-himra	Mid to high	SM4
21	Nech/Bula (WH)	2	30	Wag-himra	Mid to high	SM4
22	Nech (NW)	1	0	Wag-himra	Low	M3
23	Tikur (NW)	5	0	Wag-himra	Low	M3
24	Nech/Bula (WH)	2	16	Wag-himra	Low	SM4
25	Nech/Bula (WH)	1	20	Wag-himra	Mid to high	SM4
26	Nech/Bula (WH)	1	19	Wag-himra	Low	SM4

No	Varieties	Total area of cowpea	Price of cowpea varieties per kg	Zone	Wealth	Agroecology
27	Nech (NW)	1	0	Wag-himra	Mid to high	M3
28	Nech (NW)	1	0	Wag-himra	Low	M3
29	Egoyla	1	40	Wag-himra	Mid to high	SM3
30	Nech/Bula (WH)	0.25	40	Wag-himra	Low	SM3
31	Nech/Bula (WH)	1	40	Wag-himra	Low	SM3
32	Nech/Bula (WH)	1	35	Wag-himra	Low	SM3
33	Nech/Bula (WH)	1	40	Wag-himra	Mid to high	SM3
34	Nech/Bula (WH)	1	45	Wag-himra	Mid to high	SM3
35	Nech/Bula (WH)	1	30	Wag-himra	Low	SM3
36	Key (WH)	1	35	Wag-himra	Low	SM3
37	Cheberima/Chechima	2	35	Wag-himra	Mid to high	SM3
38	Nech/Bula (WH)	2	15	Wag-himra	Low	SM3
39	Cheberima/Chechima	1	15	Wag-himra	Mid to high	SM3
40	Key (WH)	2	15	Wag-himra	Mid to high	SM3
41	Nech/Bula (WH)	2	17	Wag-himra	Low	SM3
42	Key (WH)	1	17	Wag-himra	Low	SM3
43	Cheberima/Chechima	0.5	17	Wag-himra	Low	SM3
44	Nech/Bula (WH)	0.5	20	Wag-himra	Low	SM3
45	Key (WH)	1.5	20	Wag-himra	Mid to high	SM3
46 47	Senderima/Sendeyma/ Shilimlima	1.5	20	Wag-himra	Mid to high	SM3
48	Key (WH)	3	40	Wag-himra	Mid to high	SM3
49	Nech/Bula (WH)	0.5	40	North Wollo	Low	SM3
50	Senderima/Sendeyma/	2	40	North Wollo	Mid to high	SM3

	Shilimlima					
No	Varieties	Total area of cowpea	Price of cowpea varieties per kg	Zone	Wealth	Agroecology
51	Nech/Bula (WH)	1	30	North Wollo	Mid to high	SM3
52	Key (WH)	0.5	20	North Wollo	Low	SM3
53	Cheberima/Chechima	2	20	North Wollo	Mid to high	SM3
54	Nech/Bula (WH)	1	20	North Wollo	Low	SM3
55	Nech/Bula (WH)	1	25	North Wollo	Mid to high	SM3
56	Nech/Bula (WH)	1	30	North Wollo	Mid tohigh	SM3
57	Key (WH)	1	30	North Wollo	Low	SM3
58	Nech/Bula (WH)	2	35	North Wollo	Low	SM3
59	Nech/Bula (WH)	1	20	North Wollo	Mid to high	SM3
60	Nech/Bula (WH)	1	30	North Wollo	Low	SM3
61	Nech/Bula (WH)	1	18	North Wollo	Low	SM4
62	Nech/Bula (WH)	0.25	25	North Wollo	Low	SM4
63	Nech/Bula (WH)	1	50	North Wollo	Mid to high	SM3
64	Nech/Bula (WH)	1	50	North Wollo	Low	SM3
65	Nech/Bula (WH)	0.25	20	North Wollo	Mid to high	SM3
66	Nech/Bula (WH)	0.25	20	North Wollo	Mid to high	SM3
67	Tikur (WH)	1	20	North Wollo	Low	SM3
68	Nech/Bula (WH)	1	40	North Wollo	Mid to high	SM3
69	Key (WH)	1	40	North Wollo	Low	SM3
70	Tikur (WH)	2	40	North Wollo	Mid to high	SM3
71	Nech/Bula (WH)	1	50	North Wollo	Mid to high	SM3
72	Tikur (WH)	1	50	North Wollo	Low	SM3
73	Key (WH)	1	50	North Wollo	Mid to high	SM3
74	Nech/Bula (WH)	1	20	North Wollo	Mid to high	SM3
75	Nech/Bula (WH)	1	20	North Wollo	Mid to high	SM3
76	Key (WH)	1	30	North Wollo	Low	SM3

No	Varieties	Total area of cowpea	Price of cowpea varieties per kg	Zone	Wealth	Agroecology
77	Cheberima/Chechima	1	30	North Wollo	Mid to high	SM3
78	Nech/Bula (WH)	1	30	North Wollo	Mid to high	SM3
79	Nech/Bula (WH)	1	20	North Wollo	Low	SM3
80	Key (WH)	1	20	North Wollo	Mid to high	SM3
81	Nech/Bula (WH)	1	20	North Wollo	Low	SM3
82	Senderima/Sendeyma/ Shilimlima	1	20	North Wollo	Mid to high	SM3
83	Nech/Bula (WH)	1	30	North Wollo	Low	SM3
84	Nech/Bula (WH)	1	25	North Wollo	Low	SM3
85	Nech/Bula (WH)	0	25	Wag-himra	Mid to high	SM4
86	Key (WH)	1	25	Wag-himra	Low	SM4
87	Nech/Bula (WH)	0	30	Wag-himra	Mid to high	SM4
89	Key (WH)	0	30	Wag-himra	Low	SM4
90	Nech/Bula (WH)	0	40	Wag-himra	Mid to high	SM4
91	Nech/Bula (WH)	0	20	Wag-himra	Low	SM4
92	Key (WH)	0	20	Wag-himra	Mid to high	SM4
93	Cheberima/Chechima	0	20	Wag-himra	Low	SM4
94	Nech/Bula (WH)	1	20	Wag-himra	Low	SM4
95	Key (WH)	1	20	Wag-himra	Mid to high	SM4
96	Nech/Bula (WH)	0	35	Wag-himra	Low	SM4
97	Key (WH)	0	35	Wag-himra	Low	SM4
98	Nech/Bula (WH)	5	20	Wag-himra	Mid to high	SM4
99	Key (WH)	3	20	Wag-himra	Low	SM4
100	Bolechima	5	0	Wag-himra	Low	M3
101	Nech (NW)	3	0	Wag-himra	Low	M3
102	Nech (NW)	4	0	Wag-himra	Mid to high	M3

No	Varieties	Total area of cowpea	Price of cowpea varieties per kg	Zone	Wealth	Agroecology
103	Nech (NW)	3	0	Wag-himra	Low	M3
104	Nech (NW)	1	20	Wag-himra	Mid to high	M3
105	Nech (NW)	4	0	Wag-himra	Mid to high	M3
106	Nech (NW)	1	0	Wag-himra	Low	M3
107	Key (NW)	4	0	Wag-himra	Low	M3
108	Nech (NW)	3	18	Wag-himra	Mid to high	M3
109	Debera	2	18	Wag-himra	Mid to high	M3
110	Nech (NW)	2.5	0	North Wollo	Mid to high	M3
111	Debera	1	0	North Wollo	Mid to high	M3
112	Nech (NW)	1	25	North Wollo	Mid to high	M3
113	Nech (NW)	2	0	North Wollo	Low	M3
114	Nech (NW)	1	0	North Wollo	Low	M3
115	Debera	1	0	North Wollo	Low	M3
116	Key (NW)	2	15	North Wollo	Low	M3
117	Nech (NW)	1	0	North Wollo	Low	M3
118	Key (NW)	1	0	North Wollo	Mid to high	M3
119	Nech (NW)	3	0	North Wollo	Low	M3
120	Nech (NW)	2	0	North Wollo	Low	M3
121	Key (NW)	1	0	North Wollo	Low	M3
122	Key (NW)	0.5	0	North Wollo	Low	SM3
123	Debera	1	0	North Wollo	Low	SM3
124	Nech (NW)	1	0	North Wollo	Low	SM3
125	Nech (NW)	1	0	North Wollo	Low	SM3
126	Nech (NW)	1	15	North Wollo	Mid to high	M3
127	Debera	1	0	North Wollo	Mid to high	SM3
128	Nech (NW)	1	0	North Wollo	Mid to high	SM3
129	Debera	1	0	North Wollo	Low	SM3
130	Nech (NW)	2	0	North Wollo	Mid to high	SM3

No	Varieties	Total area of cowpea	Price of cowpea varieties per kg	Zone	Wealth	Agroecology
131	Nech (NW)	1	0	North Wollo	Low	SM3
132	Key (NW)	1	18	North Wollo	Mid to high	M3
133	Nech (NW)	1	0	North Wollo	Mid to high	SM3
134	Debera	1	0	Wag-himra	Low	SM3
135	Nech (NW)	1	0	Wag-himra	Low	SM3
136	Nech (NW)	1	0	Wag-himra	Mid to high	SM3
137	Nech (NW)	2	0	Wag-himra	Mid to high	SM3
138	Nech (NW)	1	0	Wag-himra	Low	SM3
139	Debera	1	0	Wag-himra	Mid to high	SM3
140	Nech (NW)	1	0	Wag-himra	Mid to high	SM3
141	Key (NW)	1	0	Wag-himra	Low	SM3
142	Nech (NW)	1	0	Wag-himra	Mid to high	SM3
143	Nech (NW)	2	0	Wag-himra	Mid to high	SM3
144	Nech (NW)	2	0	Wag-himra	Low	SM3

Declaration

I, the undersigned declare that this Thesis is my original work and it has not been presented in other universities, colleges or institutes for a degree or other purpose.

All sources of the materials used have been duly acknowledged.

Name: _____ Signature: _____ Date: _____

This work has been done under my/our supervision.

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Name: _____ Signature: _____ Date:_____

Name: _____ Signature: _____ Date:_____

Name: _____ Signature: _____ Date:_____