



Cowpea (*Vigna unguiculata* (L.)Walp.) (Fabaceae)
Landrace Diversity in Southern Ethiopia

Sisay Alemu Deresse

Addis Ababa University

Addis Ababa, Ethiopia

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Sisay Alemu Deresse

A Thesis Submitted to

The Department of Plant Biology and Biodiversity Management
Presented in Partial Fulfillment of the Requirements for the Degree of
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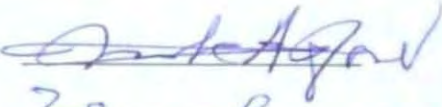



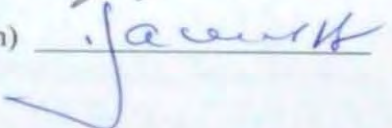
Cowpea (*Vigna unguiculata* (L.) Walp.) Landrace Diversity in Southern, Ethiopia

By

Sisay Alemu Deresse

A Thesis Presented to the Graduate Programme of the Addis Ababa University in Partial Fulfillment of the Requirements for the Master of Science (Plant Biology & Biodiversity Management)

Approved by Examining Board:

- | | | |
|--------------------------|------------|--|
| 1. Prof Zemedu Asfaw | (Advisor) |  |
| 2. Prof Zerihun Woldu | (Advisor) |  |
| 3. Prof Ensermu Kelbessa | (Examiner) |  |
| 4. Dr Tesfaye Awas | (Examiner) |  |
| 5. Dr Tamrat Bekele | (Chairman) |  |

ABSTRACT

Cowpea (*Vigna unguiculata* (L.) Walp.) (Fabaceae) Landrace Diversity in Southern Ethiopia

Sisay Alemu Deresse “MSc. Thesis”

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*The present research has been carried out to identify and document the landrace diversity and ethnobotanical uses of cowpea (*Vigna unguiculata* (L.) Walp.) (Fabaceae) in three regions of southern Ethiopia (Gambella, Oromia, Dire Dawa and SNNPR). Ethnobotanical data were collected using semi-structured interview, field observations, guided field walk and market survey. The data were analyzed using descriptive statistics, preference ranking and informant consensus. A total of 44 accessions were collected from different geographical locations of south of Addis Ababa. These landraces had diverse seed sizes, colors, growth habits and germination potentials. Among the collections, *Vigna unguiculata* subspecies *dekindtiana* farmers variety RAPO (Anywaa language) was found in Gambella Region), subspecies *cylindrica* and subspecies *unguiculata* farmers' variety ATERA BABILE (Afaan Oromo) found in all regions of southern Ethiopia and grown for the purposes of human food, livestock feed, improving soil fertility and as medicinal plant. Other collections, *Vigna unguiculata* subspecies *unguiculata* farmers' variety ATERA BABILE was preferred by the majority of farmers' because of its spreading nature, ability to produce more leaves than other varieties, improving soil fertility and ability to supersede weeds via ground covering. All in all ten landrace varieties were recorded from southern Ethiopia in which four were recorded in SNNPR, three in Oromia three in Gambella and one in Dire Dawa. As indicated by local farmers, wild relatives of cowpea still persist in southern Ethiopia. Therefore, conducting further researches on both local landraces and wild relatives of cowpea is recommended in this study.*

Key words:- Landrace, Cowpea, Ethnobotany, Intercropping, Sole cropping

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Acronyms

AAU	Addis Ababa University
DA	Agricultural development workers(agent)
DAFFS	Department of Agriculture, Forestry and Fisheries in South Africa.
DDT	Dichloro Diphenyl Trichloroethane
EBI	Ethiopian Biodiversity Institute
ECXA	Ethiopian Commodity Exchange Authority
FAO	FAO: Food and Agricultural organization
GIS	Geographical information system
GP	Germination Percentage
IBC	Institute of Biodiversity Conservation (former name now changed to EIB)
IBPGR	International Board for Plant Genetic Resources
IITA	International Institute of Tropical Agriculture
SNNPR	Southern Nations and Nationalities Peoples Region
USDA	United States Department of Agriculture

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Biological diversity or biodiversity refers to all forms of microorganisms, plants and animals and the ecosystems in which they exist and interact. Agricultural biodiversity is a broad term that includes all the components of biological diversity of relevance to food and agriculture. Crop diversity refers to the biological diversity found in crops used for food and agriculture. It includes the knowledge of farmers and other users and sometimes also referred to as plant genetic resources for food and agriculture. Genetic diversity simply means all the variety of genes that exist in a particular variety or species (Joanne *et al.*, 2000).

Landraces have originated together with agriculture and horticulture, during the past 10,000 years. Although landraces are commonly considered endemic to a particular region, they have always been moved over short or even long distances, and thus brought into competition with autochthonous landraces (i.e. variety with a high capacity to tolerate biotic and abiotic stress resulting in a high or intermediate yield stability level under a low input agricultural system) if present (Zeven, 1998). They may disappear, or they may replace these autochthonous landraces or more likely, they may together form a new landrace complex and they become adapted to the conditions of that site.

Grain legumes are important sources of proteins (20 - 35%) for food and can therefore replace animal protein in the regions of the Third World where plant production is by far more important than animal production (Fall *et al.*, 2003). The characteristic of the principal legumes by Vavilov was Mungbean (*Vigna radiat* (L) R. Wilczek), Chickpea (*Cicer arietinum* L.), Lentil (*Lens esculenta* Moench), Pea (*Pisum sativum* L.) and Lupin (*Lupinus albus* L.). (Ba *et al.*, 2004)

The pulses or grain crops in Ethiopia consist of *Cajanus cajan* (L.) Millsp., *Canavalia ensiformis* (L.) DC., *Dolichos lablab* 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. and *Vigna unguiculata* (Westphal, 1974).

Among grain legumes, Cowpea (*Vigna unguiculata*) is the most widely cultivated and the most consumed especially in Asia and in tropical Africa (Lemma Geberemariam *et al.*, 2009). However, Africa is the main area of production, where the crop is very important for low input agriculture, which characterizes most countries of the continent (Pasquet, 1998; Ba *et al.*, 2004). Its world annual production is estimated at 5,249,571 tons of dried grains (Ogbemudia *et al.*, 2010).

Cowpea is a multipurpose crop; the entire plant can be used for either human or livestock consumption. It's major importance is to the livelihoods of millions of relatively poor people in less developed countries of the tropics. According to the emphasis by Islam *et al.*, (2006), all parts of the plant are used as food, which as a nutritious providing protein and vitamins. Immature pods and seeds are used as vegetables while several snacks and main dishes are prepared from the grains (Agbogidi and Egho, 2012).

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. It further describe and that cereal crops status of the country will be the national crop improvement effort of the cowpea program that utilizes exotic material that has come through the various international institutions, despite the existence of remarkable diversity in the indigenous material. However, cowpea distribution and production in Ethiopia does not have enough information. Whereas; farmers and their farming compound has accumulated knowledge to protect landraces varieties in his farm activity.

Therefore, to fill the gap of information about the diversity of population status of the cowpea crop species on the farmers' land, distribution status, finding the suitable solution for the major production areas in the study area, what are the constraints of cowpea productions in the study area and so on? Hence, this research was initiated with the objective of identifying the diversity, distribution along the study areas, ethnobotanical

uses of cowpea (*Vigna unguiculata*), and utilization practices in the southern and eastern parts of Ethiopia.

1.2. Statement of the Problem

The pulse crops as a group in Ethiopia constitutes considerable number and diversity of crop species. Cowpea (*Vigna unguiculata*), is a tropical grain legume which plays an important nutritional role in developing countries of the tropics and subtropics, especially in Sub-Saharan Africa, Asia, Central and South America. 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).

The depletion of natural vegetation in many parts of the country has also 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. After his research some uncoordinated research as were done here and there in research institutes and universities, but there is no detail study conducted on the cowpea and other pulse crops of the country. The base line data and crop cultivation activities, distribution and utilization of such crops have a gap of information. Thus, the present studied focused on cowpea species documentation and classification, describing the status of cultivation activities and distribution along the study area to fill the scientific information gaps.

1.3 Research Question and Objectives

Research questions

- ✓ What landraces of cowpea are found in southern Ethiopia?
- ✓ Which part of south and eastern Ethiopia commonly produce cowpea?
- ✓ How do farmers of the study area utilize these cowpea landraces?
- ✓ What are the problems on the production of cowpea in southern Ethiopia?
- ✓ How do farmers manage and conserve these landraces?

General objective

The general objective of this study was to identify and document the landrace diversity and ethnobotanical uses of cowpea (*Vigna unguiculata*) in the study areas of southern Ethiopia.

Specific objectives

- To identify and document the landrace diversity of cowpea in the study areas based on voucher specimens from field.
- To gather, record and document indigenous knowledge of the people on the ethnobotanical uses and managements of cowpea.
- To propose plausible use, management and conservation options in the production system of the crop species.
- To study seed germination based on samples collected from the study area and evaluate the germination capacity and follow up the growth of the plant.

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 unguiculatus* L. (later renamed *Vigna unguiculata* (L.) Walp.) 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. Now, 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*, *Sesquipedalis*, 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). This work, coupled with surveys of live materials in the field and specimens in major herbaria in Europe and Africa, as well as cytological studies, has led to the description of new taxa, and a change of nomenclature of some species (Padulosi, 1993; Ng, 1995). Parallel work on taxonomy of wild species within section *Catiang* was also conducted elsewhere (Piennaar and Wyk, 1992).

2.2. Origin and Domestication

The precise location of the center of origin of a species is rather difficult to determine. Previous speculation on the origin and domestication of cowpea had been based on botanical and cytological evidence, information on its geographical distribution and cultural practices, and historical records (Faris, 1965; Ng and Marechal, 1985; Ng, 1995).

As mentioned by many authors (Faris, 1963; Steele, 1972; Rawal, 1975; Baudoin and Marechal, 1985; Ng, 1995; Pasquet, 2000), the exact centers of diversity and origin of cowpea is still uncertain. Thus, the aforementioned authors described, Ethiopia, West Africa and Eastern and Southern Africa were assumed as a center of diversity and origin.

Several authors have reported different probable centers of domestication of cowpea in Africa. Faris (1963; 1965) concluded, that cowpea arose from the domestication of *Vigna unguiculata* subspecies *dekindtiana* forms in West Africa. Steele (1972) noted, that there is greater variability in subspecies *dekindtiana* the probable ancestor of cowpea in Ethiopia than West Africa and suggested that domestication could actually have occurred in Ethiopia and dissemination went westwards across Africa and eastwards across the Indian-sub continent. Rawal (1975) suggested that cowpea was domesticated in the sub-humid and semi-arid regions of West Africa.

Africa is the origin of cowpea where domestication took place as well (Zeven and de Wet, 1982; cited in Angessa, 2006). Centers of diversity have been identified in both Africa and Asia, however, the exact region of domestication is still under speculation (Angessa, 2006).

2.3. Morphological Descriptions of Cowpea

Physiological, morphological, or phenological criteria could be implemented to select the improved adaptation to dry environments (Blum, 1988). Traditionally, diversity is estimated by measuring variation in phenotypic or qualitative traits (starts flowering, time to maturity, plant type, flower color, seed type, seed color, seed size, hilum color) and

quantitative agronomic traits However, this approach is often limited and expression of quantitative traits is subject to strong environmental influence (Kameswara, 2004).

Cowpea (*Vigna unguiculata*) exhibits a considerable variation in leaf shape. Cowpea leaves are compound, having two asymmetrical side leaflets and one central terminal leaflet which is symmetrical. Typically, the central leaflet of the trifoliate is used in classifying the leaf shape due to variability of the side leaflets. In cowpea, the leaf shape is important for taxonomic classification and also for distinguishing cowpea varieties. However, there isn't a central naming convention for cowpea leaves nor detailed descriptions of the leaf shapes, thus, many researchers name the leaf shapes differently. The two largest cowpea germplasm agencies are the International Institute of Tropical Agriculture (IITA) and the United States Department of Agriculture (USDA). IITA, which houses 14,500 cowpea accessions from 65 different countries, classifies cowpea leaf shapes into four categories, sub-globose, sub-hastate, globose and hastate/lanceolate (<http://genebank.iita.org>). The USDA, which houses 6,841 cowpea accessions from 50 countries, classifies cowpea leaf shapes into five categories; globose, hastate, sub-globose, sub-hastate, strip and ovate-lanceolate (Pottorff *et al.*, 2012).

Cowpea is an annual herbaceous leguminous crop with cylindrical and glabrous, twisting and colored (green or purple) stem. Buds in the leaf axils may develop into a slender branch or a flower bearing peduncle. Different cultivars of cowpea show a range of growth habit from erect, semi-erect, spreading to climbing and twinning. The height of the plant varies from dwarf (15 cm) to tall (over 100 cm) depending on the growth habit. The first pair of leaves is unifoliate and opposite while the second and subsequent leaves are alternate, trifoliate with one terminal and two lateral leaflets. The plant bears a slender taproot with fibrous lateral roots. Petioles vary in length from three to 25 cm (Rachie *et al.*, 1975). The shapes of the leaves are mostly hastate, ovate, lanceolate, sub-hastate and rhombic. Flowers and pods arise at the terminal end of peduncles. Flowers have the typical leguminous standard, keel and wings. Usually 2-6 flowers are found per peduncle. They are borne singly or in multiples. Flower is complete and colour varies through many shades

of purple to yellow and white, depending on the concentration of anthocyan in pigment present (Mashi, 2006).

The stamens are diadelphous (9 forming a tube of filaments and 1 free). The ovary is straight with a bent style, which is hairy along the inner side and a globular, glandular stigma. Flowers are self-pollinated but a low percentage of out crossing may occur depending on season and varieties of pollen vectors (Rachie and Roberts, 1974). Fruits are dehiscent pods, which usually shatter when dry. The shape and length of pod varies. It is pendulous, mostly linear although curved and coiled forms occur. The pod is green at early stage and when maturing it becomes usually yellow, light brown, pink or purple. The pod length may vary from less than 11cm to more than 100 cm (Rachie and Rawal, 1976). Seeds of cowpea cultivar vary considerably in colour (such as brown, purple, white and speckled), shape (reniform or kidney shaped, ovoid, rhomboid etc.) and are of different sizes ranging between 0.4cm to 1.2 cm in length and 0.3cm to 1.0cm in width. Seed coat texture can be smooth, rough, wrinkle and loose (IITA, 1975).

2.4. Traditional Cropping Systems of Cowpea

A cropping system has been defined as the sequence of crops grown in one field, and the way in which they are managed. If sole crops consist of identical plants which have the same type and timing of resource demands, then intercrops with different plant types which possess variable requirements could use more "space" when grown in association.

Cowpea is cultivated in Ethiopia using essentially three systems: Sole cropping and relay intercropping during the rainy season; and the flood-water recession system during the dry season. Cowpea serves multiple roles when intercropped with either grains or tubers. In addition to fixing nitrogen, farmers commonly grow cowpea types that mature quickly and create an understory that cools the soil, prevents soil loss, and minimizes weed pressure (Zuofa *et al.*, 1992). Intercropping cowpeas with cereals such as sorghum may benefit both crops. Another hemiparasitic plant, *Striga hermonthica*, impacts cereal crops. Cowpea can reduce *Striga hermonthica* damage by increasing soil fertility. In addition, cowpeas stimulate suicidal germination of *Striga hermonthica* (Singh, 2002). In some cases,

intercropping with sorghum or millet can also protect cowpea from its hemiparasite, *S. gesnerioides* (Rada *et al.*, 2005). Conserving and developing traits that contribute to cowpea's intercropping performance are an important priority for both farmers and collaborative crop research programs.

Most cowpea grown in Africa is intercropped with sorghum (*Sorghum bicolor* L. Moench), pearl millet (*Pennisetum glaucum* L. R. Br.), maize (*Zea mays* L.), cassava (*Manihot esculenta* Crantz) or cotton (*Gossypium barbadense* L.) (Blade *et al.*, 1997). Sole-crops are becoming important as cowpea production is commercialized to meet the demands of a rapidly increasing urban population. 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. Animal-draft cultivation is also used to control weeds. In Asia and Brazil, both sole-cropping and intercropping are practiced Pandey and Ngarm (1985), while in the US sole-crops predominate, although cowpeas are sometimes planted in orchards between rows of young fruit or nut trees. Cowpea can be a valuable component of crop rotations due to the ability of resistant cultivars to suppress root-knot nematode (*Meloidogyne* species) reproduction.

Intercropping is an important agricultural technique that improves diversification of food supply (Francis, 1985). It also suppresses weeds particularly when short stature, bushy cowpea varieties are used (Zimdahl, 1999). These varieties have the potential to intercept incident radiation reaching the soil surface (Liebman, 1988). Cowpea cultivars with a prostrate and dense crop canopy also act as live mulch, suppressing weed germination and growth (Mashingaidze, 2004).

2.5. Environmental Requirements

2.5.1. Climatic requirements

Temperature

Cowpeas grow best during summer. The base temperature for germination is 8.5 °C and for leaf growth 20 °C. Cowpea is a heat-loving and drought-tolerant crop. The optimum temperature for growth and development is around 30 °C (FAO, 1984). Varieties differ in

their response to day length, some being insensitive and flowering within 30 days after sowing when grown at a temperature around 30 °C. The time of flowering of photosensitive varieties is dependent on time and location of sowing and may be more than 100 days (Timko and Singh, 2008). Even in early flowering varieties, the flowering period can be extended by warm and moist conditions, leading to asynchronous maturity. The optimum sowing times are December to January. Early-sown crops tend to have elongated internodes, are less erect, more vegetative and have a lower yield than those sown at the optimum time (DAFFS, 2011).

Rainfall

Cowpea is a higher drought-tolerant crop than many other crops. It can grow under rainfall ranging from 400 to 700 mm per annum (Wastphal, 1974). Cowpeas are also having a great tolerance to water logging. Well-distributed rainfall is important for normal growth and development of cowpeas. The frequency and unreliability of rainfall pose problems to cowpea growth in South Africa. In some areas, the frequency of rain is too high, resulting in flooding, while in some other areas it is so unreliable that moisture conservation remains vitally important for crop production. Cowpeas utilize soil moisture efficiently and are more drought-tolerant than groundnuts, soya-beans and sunflowers. Adequate rainfall is important during the flowering stage. Cowpeas react to serious moisture stress by limiting growth (especially leaf growth) and reducing leaf area by changing leaf orientation and closing the stomata. Flower and pod abscission during severe moisture stress also serves as a growth-restricting mechanism (Wastphal, 1974).

2.5.2. Soil requirements

Cowpeas are grown on a wide range of soils but the crop shows a preference for sandy soils, which tend to be less restrictive on root growth. It is more tolerant to infertile and acid soils than many other crops. This adaptation to lighter soils is coupled with drought tolerance through reduced leaf growth, less water loss through stomata, and leaf movement to reduce light and heat load under stress. Cowpeas are much less tolerant to cold soils than common beans and show a poor tolerance to water logging. Cowpeas thrive in well-drained soil and less on heavy soils. It requires a soil pH of between 5.6 and 6.0 (DAFFS, 2011).

Cowpeas can be grown under a wide range of conditions. They are sensitive to cold and are killed by night frost, but tolerate heat and relatively dry conditions but suffer from heavy drought and can be grown with less rainfall and under more adverse conditions than *Phaseolus vulgaris* and *Phaseolus lunatus*. Cowpea is adapted to a different types of soils, provided they are well-drained. They are sometimes grown on very poor acid soils as a soil improver (Wastphal, 1974).

2.6. Cowpea Production in the World

Cowpea grain production estimates by Singh *et al.* (2002), was worldwide production of 4.5 million tons on 12 to 14 million ha. About 70% of this production occurs in the drier Savanna and Sahelian zones of West and Central Africa. Other important production areas include lower elevation areas of eastern and southern Africa and in South America (particularly in northeastern Brazil and in Peru), parts of India, and the southeastern and southwestern regions of North America. And also in 2010 the world annual production is estimated at 5,249,571 tons of dried grains of which over 64% are produced in Africa of which Nigeria produces about 850,000 tones by which Nigeria is supposed to be the highest producer of cowpea in the world (Ogbemudia *et al.*, 2010). Another author write was Nigerian's production and consumption of cowpea grain, with ,about 5 million ha and over 2 million tons production annually, followed by Niger (650,000 mt) and Brazil (490,000 mt)(Singh *et al.*, 2002).

In Ethiopia higher average mean grain yield 6.91 Quintal/ha was obtained from Forage Agronomy Research in Adami Tulu Agricultural research center in Ethiopia at research station bases on different accession (Ayana Etana *et al.*, 2013).The average grain yield for the seven cowpea varieties was 22.2 q/ha and this value was significantly varied among varieties. Highest grain yield was recorded from *Black eyed bean* (commercial cultivar of cowpea) 28.9 q/ha while the yield of other one variety was lower than all the varieties with 11.7 q/ha grain yield was reported under research environment at Ethiopian Agricultural Research Center, Pawi (Mandura) research station (Bilatu Agza *et al.*, 2012)

2.7. Social-Economic Importance of Cowpea

Cowpea is of major importance to the nutrition and livelihoods of millions of people in less-developed countries of the tropics. Cowpea is consumed in many forms. Young leaves, green pods and green seeds are used as vegetables whereas dry seeds are used in a variety of food preparations (Nielsen *et al.*, 1997). Trading of fresh produce and processed cowpea foods and snacks provides rural and urban women with an opportunity for earning cash income. Cowpea is also a major source of protein, minerals and vitamins (Bressani, 1985). The addition of even a small amount of cowpea improves the nutritional balance of the diet, and enhances protein quality by the synergistic effect of high protein and lysine from cowpea and the energy from starchy foods.

Cowpea is valued by agrarian societies across the semi-arid tropics for its taste, its performance in intercropping systems (Blade *et al.*, 1997), and its high performance under marginal growing conditions (Singh *et al.*, 2003). Its role in various grain and tuber intercropping systems is multi-functional. In addition to fixing nitrogen, farmers commonly grow cowpea types that mature quickly and create an understory that cools the soil, prevents soil loss, and minimizes weed pressure (Zuofa *et al.*, 1992). Cowpea grows better in marginal soils than many other legumes; it is highly drought tolerant and tolerates a wide range of soil pH for a legume, as well as low P and organic matter levels; it forms effective symbioses with mycorrhizal fungi and has a high N fixation ability (Kolawole *et al.*, 2000) .

The cowpea has high nutritive value for both people and livestock (Bressani 1985; Singh *et al.*, 2003; Tarawali *et al.*, 1997) and makes essential contributions to the starch heavy diets typical of people in sub-Saharan Africa. Cowpea grain has high protein content (23-32% of seed weight), is rich in vitamins and minerals and has one of the highest contents of folic acid among plants (Timko and Singh, 2008). Cowpea is sometimes called “poor man’s meat” or “vegetable meat” by researchers due to its high protein content. Cowpea grain contains 23.4% protein, 1.8% fat and 60.3% carbohydrates and also a good source of vitamins and phosphorus (Adeyemi, *et al.*, 2012). The protein content of cowpea leaves

ranges from 29-43% on a dry weight basis; leaves are also a good source of phosphorus, zinc, iron and vitamins (ascorbic acid, B-carotene and folic acid (Neilsen *et al.*, 1997).

2.8. Cowpea Pests and Storage Challenges

Cowpea seed pods and leaves are consumed in fresh form as green vegetables in some African countries (Ghaly and Alkoaik, 2010), while the rest of the cowpea plant after the pods have been harvested serves as a nutritious fodder for livestock (Girma Abebe *et al.*, 2005) and also a source of cash income when sold to farmers who use them as livestock feed. (Dugje *et al.*, 2009).

However, the production and storage of this important food crop has faced so many constraints, such as diseases and the limited use of fertilizers and irrigation input but insect storage pest is one of the major constraints. The major storage pest of cowpea weevil is *Callosobruchus maculatus* (Brisibe *et al.*, 2011). It infests cowpea before harvest, the higher the infestation levels before harvest, the greater the damage to the seeds in storage. This will result in higher weevil emergence causing a greater weight loss, larger number of holes and consequently loss of economic value (Baidoo *et al.*, 2010). Infestations on stored grains may reach 50% within 3-4 months of storage (Dugje *et al.*, 2009). If cowpea seeds are to be stored for longer periods, then it is advisable to treat the seeds with recommended insecticides (Asare *et al.*, 2011).

Insect pests belong to the major biotic stresses in cowpea growing regions in both developing and developed countries (Dauost *et al.*, 1985). The major insect pests in East Africa are Cowpea aphid, (*Aphis craccivora* Koch), flower thrips (*Sericothrips occipitalis* and *Megalurothrips sjostedti* (Thripidae), cowpea weevil [*Collosobruchus maculatus* Fabricius (*Coleoptera Bruchidae*)] and a multiple of sucking bugs and leaf eating beetles. In Tanzania, aphids are the major causing factor for significant yield losses. Early infestation, especially during seedling stage, often results in total crop failure. Also due to thrips infestation, a tremendous yield losses have been reported in Tanzania, Ghana, Cameroon and Nigeria (Omo-Ikerodah *et al.*, 2009) reported that yield loss due to thrips infestation ranged between 20 to 80%. Under severe infestation, a 100% yield loss has been observed (Singh and Allen 1980). Abdelbagi and Anthony (1999), found up to 50%

weight losses within a period of 3 months of storage due to weevil damage. Pest control in cowpea is best achieved through an integrated approach combined the use of insect resistant cultivars and appropriate cultural practices with minimum insecticide application (Singh and Allen, 1978).

The parasitic weed (Striga) also poses a major threat to cowpea production in Africa. Two striga species and its distribution in Africa have been reported. *Striga gesneriodes* is mostly found in Sudan and West Africa, while *Alectra vogelii* is found in Guinea, Sudan, West and Central Africa and part of Eastern and Southern Africa (Timko and Singh, 2008). *Alectra vogelii* is more widely distributed than *Striga gesneriodes*. *Striga gesnerioides*, commonly called witch-weed, is also a major constraint to growth and productivity of cowpea (*Vigna unguiculata*) throughout West Africa (Asare *et al.*, 2011).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Description of Study Area

3.1.1. Geographical location of the study area

The study area is widely distributed in southern Ethiopia in parts of four regions and comprise of 20 weredas as given in table 1 and the geographical map shown in figure 1.

Table 1:- Study sites geographical information

Region	Zone	Wereda	Altitude (m.a.s.l)	Latitude	Longitude	Distance from A.A(km)	Study locality
Gambella	Anywaa	Abobo	475	07 ⁰ 53' 50.2''	034 ⁰ 32' 38.2''	815	Chobo Kere kebele
		Itang	428	08 ⁰ 11' 29.5''	034 ⁰ 15' 54.5''	810	Itang Village
		Gambella Zuriya	450	08 ⁰ 15' 14.2''	034 ⁰ 35' 22.2''	775	Around Gambella Town
Oromia	East Shewa	Ada	1892	08 ⁰ 44' 55.4''	038 ⁰ 59' 34.1''	45	Godino Kebele
		Boset	1455	08 ⁰ 39' 36.0''	039 ⁰ 25' 52.0''	125	Welenchiti Dengoro Kebele
	West Harerge	Measo	1325	09 ⁰ 13' 59.4''	040 ⁰ 45' 16.7''	314	Measo town
		Chiro	1730	09 ⁰ 05' 16.3''	040 ⁰ 51' 59.9''	330	Chiro Market
		Oda Bultum	1692	08 ⁰ 54' 08.2''	040 ⁰ 46' 44.8''	365	Kara Kurkura Village (Badessa)
		Habero	1761	08 ⁰ 48' 27.9''	040 ⁰ 31' 32.6''	390	Around Gelemso
	East Harerge	Gerawa	2439	09 ⁰ 08' 18.6''	041 ⁰ 50' 07.4''	562	Gerawa Market
		Kurfa Cheli	2128	09 ⁰ 14' 14.1''	041 ⁰ 49' 07.1''	535	Kurfa Cheli Town
		Babile	1661	09 ⁰ 14' 07.8''	042 ⁰ 19' 14.3''	540	Ifa Kebele
		Gursum	1815	09 ⁰ 17' 22.3''	042 ⁰ 26' 30.4''	575	Awdel Kebele
Dire Dawa	Biya Awale	Belewa Kebele	1658	09 ⁰ 33' 58.5''	042 ⁰ 06' 02.0''	565	Belewa Village
SNNPR	South Omo	South Ari	1476	05 ⁰ 51' 21.1''	036 ⁰ 33' 02.2''	733	Aykamer and Geza Kebele
		Konso	1196	05 ⁰ 17' 06.6''	037 ⁰ 29' 03.2''	615	Nalya segen Kebele
	Gamo Gofa	Arba Minch	1225	06 ⁰ 02' 19.7''	037 ⁰ 33' 25.2''	505	Sheli Kebele
		Merab Abaya	1231	06 ⁰ 27' 10.1''	037 ⁰ 44' 39.2''	460	Around Birbire Town
	Wolaita	Humbo	1380	06 ⁰ 39' 13.0''	037 ⁰ 48' 48.4''	405	Abol Sipa Kebele
		Sodo Zurya	1810	06 ⁰ 46' 40.6''	037 ⁰ 46' 14.0''	380	Larena Kebele

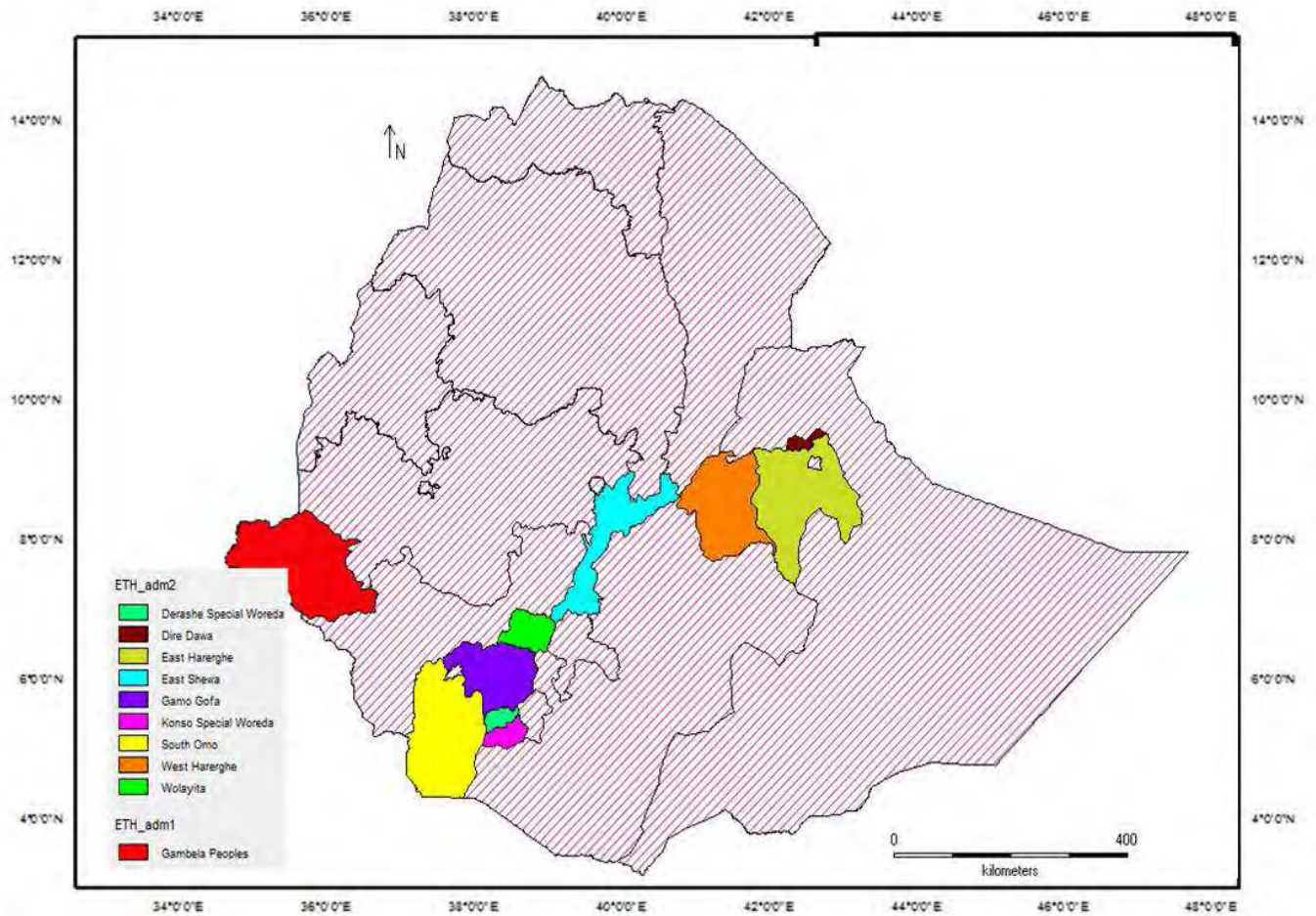


Figure 1:- Map of Ethiopia; showing Regional States and the study zones in three regions (Gambella, Oromia and SNNPR)

3.1.2. Climate

Based on the data gathered from National Meteorology Service Agency, long term rainfall records show a unimodal pattern with the annual average rainfall of 1175.9 mm for in Abobo, Itang and Gambella stations. The rainy season starts at the early April and lasts in October with maximum rainfall in July. The mean annual maximum and minimum temperatures are 35.8°C and 18.7 °C, respectively. The Bimodal pattern of rainfall areas are Arba Minch, Asebe Teferi, Badessa, Dire Dawa, Gelemso, Gursum, Jinka, Konso and Debre zeit stations recorded with the annual average rainfall of 943.9 mm. The short rainy season was from March to May with annual average rainfall 1175.9 mm. Figure 2 show that the twelve nearest climatic stations in the study areas.

The main long rainy season starts from July to October with the annual average rainfall could be 933.4 mm. The mean annual maximum and minimum temperatures of which have the bi-modal pattern season are 32.3°C and 10.6°C, respectively.

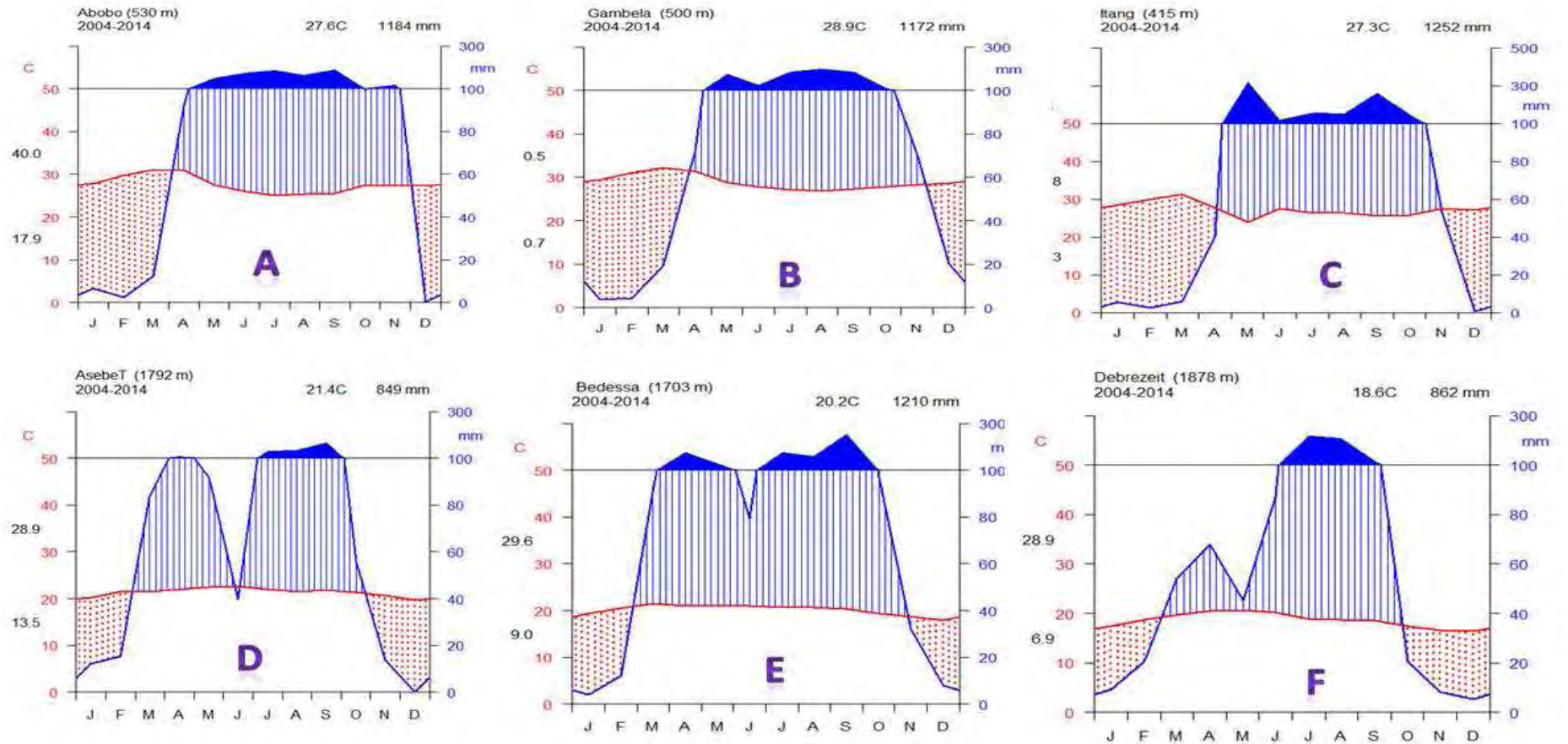


Figure 2:- Climadiagram of the study weredas (A - C Gambella, D - I Oromia , J - L SNNPR)

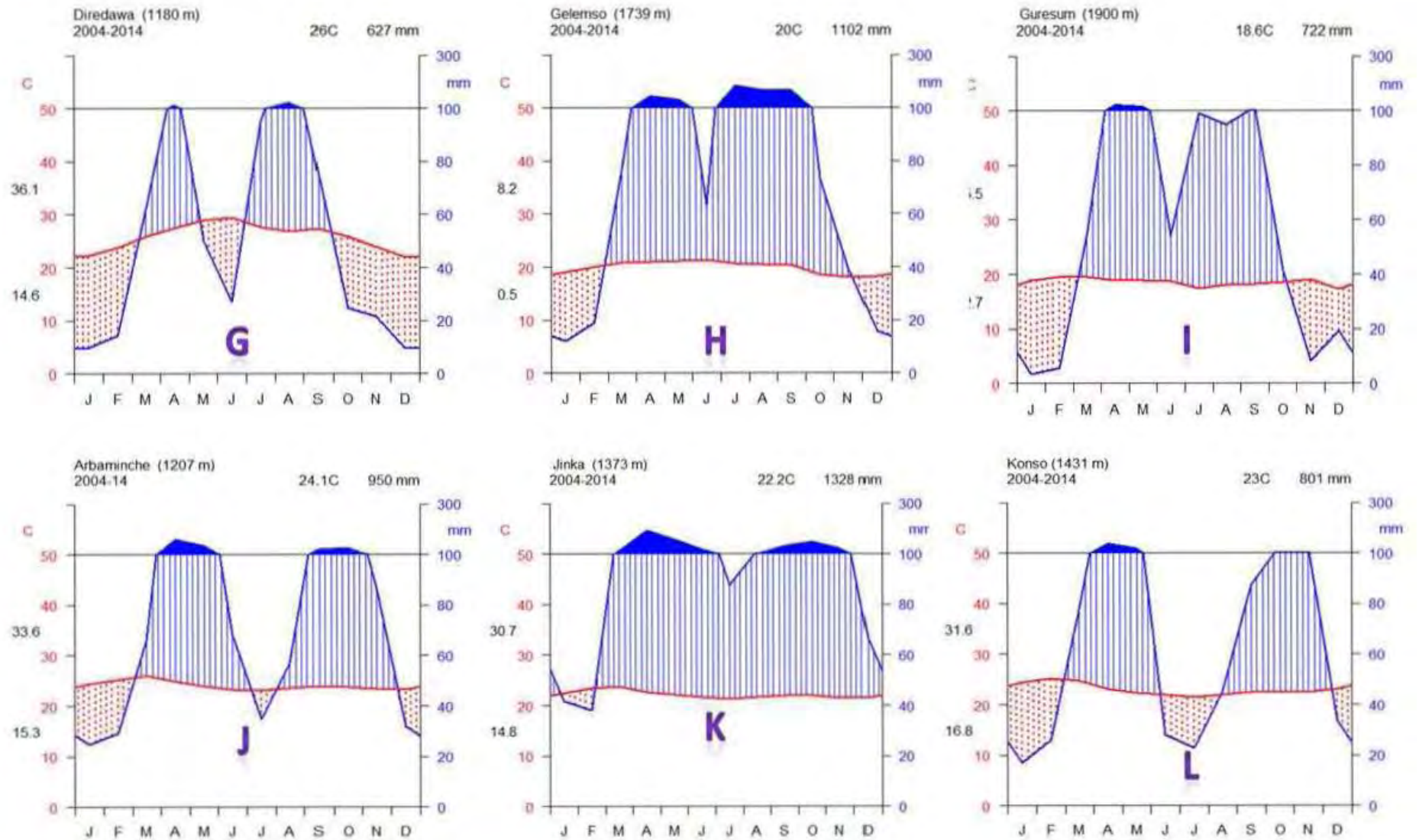


Figure 2: Climadiagrams continued....

3.1.2. Soil characteristics of the study area

The study sites were categorized under three types of parent rock such as: (a) the granites of the crystalline basement which tend to form shallow, sandy soils; (b) the volcanic rocks, such as basalts, which tend to produce fertile loams, generally red in colour, but sometimes black; and (c) the limestone and sandstones which form shallow, poor, sandy soils (Last, 1962). As described by Yacob Alemayehu *et al.* (2014), Soil types of the South west Gambella Lowlands are Vertisols and Entisols. Oromia Region, the Awash River valley is an exceptional area in the Rift valley with a large plain of alluvial soils (with Entisols) near Nazret where sugarcane is grown. Bale, Arsi and Hararge area with elevation 1800 m and higher are characterized with Alfisols and Inceptisols soil type. Gamu Gofa as far south as Lake Chamo; it lies above 1200 m and the Rift valley north of Lake Shala and south of Lake Abaya receives less rainfall and has higher temperatures. The predominant soils are Inceptisols and Mollisols up to Wolayita Sodo town. (Westphal, 1974)

3.2. Data Collection Methods

3.2.1. Field data collection

Based on the ecological requirement of cowpea, FAO (1984) with indication of suitability map and the help of agricultural extension experts a total of three regions Gambella (Anywaa Zone), Oromia (East Shewa, East and West Harerge zones) and SNNPR (South Omo, Gamo Gofa and Wolayta zones) comprising 20 weredas were purposively selected for this study. Botanical data and ethnobotanical information on cowpea were acquired using primary and secondary data sources. Data were collected from selected zones by asking agronomy officials to identify which wereda produce cowpea landrace crops and list major weredas, then selected major producing kebeles from one wereda then visit these kebele agricultural offices to select five farmers that produce cowpea crops in his farm. Twenty key informants were used to select at most knowledgeable farmers in each collection region (total 60 informants for this study) and interview informant consensus was check by reliability analysis. The interviews mainly focused on issues related to the effects of the traditional farmers' knowledge in agricultural practice and biodiversity management.

3.2.2. Informants selection

A total of 60 informants (38 males and 22 females) aged 28 to 78 were selected using simple random sampling techniques. Twenty individuals from each region were used for interview. Additional information regarding the knowledge of local farmers was gathered with the help of local guide and local agricultural extension experts.

3.2.3. Ethnobotanical data collection

Ethnobotanical data were collected in September and December 2014, following the method by Martin (1995) and Cotton (1996). Accordingly, semi-structured interview, field observation and market survey with informants were applied to obtain information about cowpea production, utilization and management. All of the interviews were held based on check list of questions (Appendix 2) prepared before hand in English language and translated into Amharic. Primary data were obtained from the farmers' fields (on-farm data collection), threshing ground, home gardens, store and market places. Information on each landrace was sourced from farmers as informants and researchers. Secondary data were collected both from governmental and non-governmental organizations.

3.2.3.1. Semi-structured interview

The main objective of questionnaire interview was to identify major factors of crop distribution and traditional management system in the area, document ethnobotanical data, the uses of the landraces in overall farming system, issues related to the effects of the traditional farmers' knowledge in agricultural practice and biodiversity management. Group discussion was conducted at the kebele administration office for the purpose of selecting cultivation localities, seed source and demands, input supply and coverage of cultivation land. Semi structured questionnaire interview was conducted with individual resource users and interviewees; impression of these local people about cowpea was recorded with the above mentioned objectives. The checklist of semi-structured questions (Appendix 2) was employed for discussion and interviewing informants to record and collect information. The methods and techniques followed were those recommended by Alexiades in 1996. After questionnaire

interview the researcher asked farmers and collected cowpea plant specimens and seed sample for further identification and conservation.

3.2.3.2. Field observation/ guided field walk

During guided field walk, the interview was conducted, while walking through the study sites to collect the data on cowpea. Accordingly, a number of field observations were performed with the help of guidance and interviewed informants to collect voucher specimens. Voucher specimens from farmers' field with important botanical information, passport data using GPS and morphological description of landraces were collected.

3.2.4. Market survey

During the study, market survey was made to collect different cowpea landraces that were sold in the market and information on market coverage of cowpea was gathered. This is especially a good method to generate information used to conserve a given landraces of cowpea that has high economic value. Therefore, local markets in the study areas were visited and collect remarkable amount of sample seeds were collected in all study area markets.



Figure 3:- Market survey: A- Babile(Oromia), B- Badessa(Oromia) and C- Konso(SNNPR)

3.2.5. Plant specimen determination and data analysis

3.2.5.1. Plant Voucher Specimens Identification

The voucher specimens of collected cowpea landraces was labeled by local names and then pressed, dried and brought to the National Herbarium (ETH), AAU, for the purpose of identification and confirmation. The landraces found on farmer's field the descriptor check list was recorded of cowpea by IBPGR (1983), descriptor list. Identification and confirmation was carried out in the National Herbarium using

taxonomic keys in the Flora of Ethiopia and Eritrea and by comparison with already identified herbarium specimens. Finally, the identified specimens were information labeled, mounted and stored at Ethiopia for further educational and research purposes.

In addition, the collected landraces of selected varieties were subjected to germination testing and evaluated based on Germination Percentage (GP) parameter. The germination test conducted in Ethiopian Biodiversity Institute germination laboratory. The laboratory prepared seeds were direct sown on Petridish with four replications. Germination incubators were used for this test and the temperature was controlled at 30 °C. The germination result were recorded for two weeks after the second day of sowing.

3.2.5.2. Data Analysis

Descriptive statistics and informant consensus tools were used for analyzing ethnobotanical data summarized in tables and figures and summarized using descriptive statistics analyzed using both qualitative and quantitative methods as recommended by Martin (1995), Cotton (1996) to identify the most common cowpea landrace area and popularly used cowpea landraces. Also determine proportions of different landraces, growth forms, seed source, plant part used, and others, such as simple preference ranking and scoring methods, was employed in order to test the consistency of respondents' information and to obtain scientifically more tangible results. In addition, R Environmental and Ecological data analysis software was used to analyze climate data and Microsoft Excel sheet was used to present the result of sort data, determine proportions, draw bar graphs, charts and tables.

CHAPTER FOUR

4. RESULTS

4.1. Cowpea Landrace Diversity in Southern Ethiopia

A total of 44 cowpea landrace accessions were collected from southern part of Ethiopia (Figure 4). Among these collections, ten seed samples of local landraces called RAPO, WENU and BOHO (Anywaa language) were collected from three weredas of Gambella Region. In Oromia Region and Dire Dawa Region a total of ten weredas were surveyed and 18 seed samples with the landraces called QECHINE, ATERA BABILE and ATERA YUSUFI (Afaan Oromo) were collected. In addition, 16 seed samples were collected from SNNPR in six weredas and the local names of these landraces are different from the other surveyed regions because there are many languages used in this Region. For example, in SNNPR the landraces are locally called WOQA, OHODA, AEQA and ALITA` in Ari, Konso, Wolaita and Derashi languages respectively (Table 3).

In this study, especially in Arba Minch Zurya, Mirab Abaya and Gidole Wereda the local farmers' used their farm land primarily for *Musa x paradisiaca* plantation and cultivation of *Phaseolus* spp. instead of cowpea production. In addition, the local and agriculture office experts said that, because of the increasing population pressure, shortage of land and the increasing demand for the aforementioned cash crop species, cowpea cultivation is in a way of disappearance from the areas.



Figure 4:- Collected seed samples and morphological variations of seed and fruit of cowpea (Where seed sample A, B and P from Gambella; C, D, G, H, J, K, M and R from Oromia; E, F, L and N from Dire Dawa and I, O, Q, S and T from SNNP Region)

Table 2:- Traditional nomenclature of cowpea and corresponding meaning

Region	Source of collection wereda & (kebeles)	Local name of cowpea landrace	Meaning of local name	Local name of wild Vigna
Dire Dawa (Special Region)	Biya Awale (Belewa Kebele)	ATERA BABILE (Afaan Oromo)	Comes from Babile	None
Gambella	Abobo (Chobo Kere Kebele)	RAPO (Anywaa)	climber on stand plants	YEZINJERO BOHO (BOHO MERE AJAMO/ BIME/)
	Gambella Zurya (Abole Kebele)	BOHO (Anywaa)	climber on stand plants	YECHAKA BOHO(BOHO MERPAPE),
	Itang Village	WENU (Anywaa)	horizontal grow on land	None
Oromia	Ada (Godino Kebele), Boset (Dengoro Kebele)	QECHINE (Afaan Oromo)	thin seeded	YAYETE QECHINE
	Babile (Ifa Kebele)	ATERA YUSUFI (Afaan Oromo)	Beautiful	ATERA WERABO
	Gursum (Awdei Kebele)	ATERA YUSUFI (Afaan Oromo)	Beautiful	ATERA WERABO
	Oda Bultum (Badessa)	ATERA BABILE (Afaan Oromo)	None	DIKALA BABILE
	Habro (Gelemso)	ATERA BABILE (Afaan Oromo)	None	DIKALA BABILE
	KurfaChelie	ATERA BABILE (Afaan Oromo)	None	DIKALA BABILE
SNNPR	Arba Minch Zuria	NONE	None	None
	Derashi (Walayeti Kebele)	ALITA (Derashigna)	None	YECHAKA ALITA
	Konso (Nalya segen Kebele)	OHODA (Konso language)	None	YECHAKA OHODA
	South Ari (Aykamer Kebele)	WOQA (Ari language)	None	WOKA BEYSI
	South Ari (Geza Kebele)	WOQA (Ari language)	None	BRWOKE
	South Ari (Yetnebershe Kebele)	WOQA (Ari language)	None	TURNA
	Wolaita (Larena Kebele)	AEQA (Wolaita)	Upright seed	BERBERA

4.2. Cowpea landrace Distribution in Southern Ethiopia

The collected ten local landraces, *Vigna unguiculata* subspecies *dikendiata* was found only in Gambella Region and *V. unguiculata* subspecies *cylindrica* and *V. unguiculata* subspecies *unguiculata* were found in all the study areas. Thus, the first one is restricted in its distribution in south-western Ethiopia while the other two are widely distributed (Figure 4).

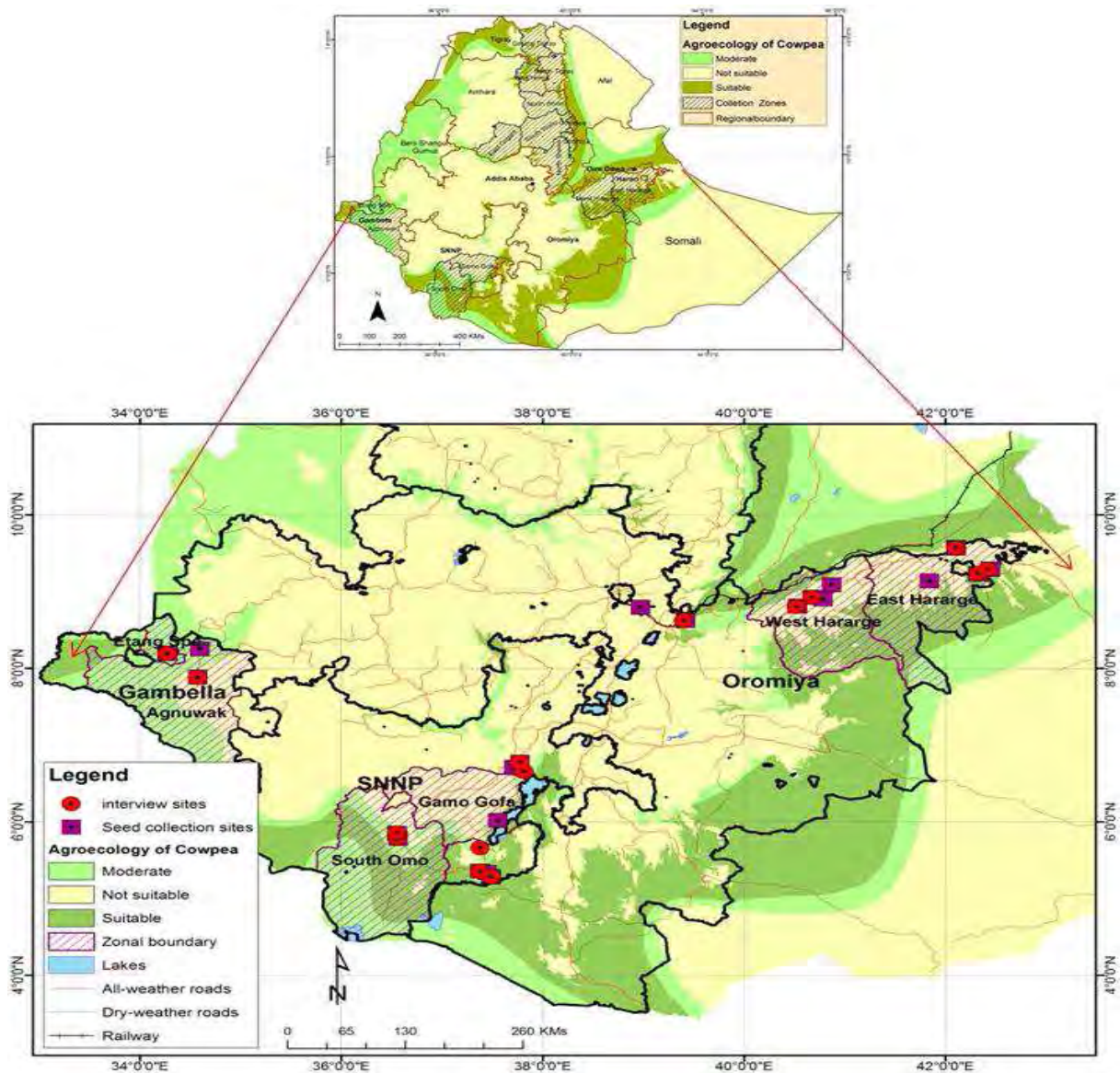


Figure 5:- Map of southern Ethiopia showing collection zones for cowpea landraces

4.3. Importance of Cowpea in Southern Ethiopia

4.3.1. Use values of cowpea

Based on farmers' perception, in southern Ethiopia cowpea is primarily used for food, fodder, and medicinal value (Table 3). A majority of farmers(53%) used fresh leaves, young shoot and grain for home consumption in the form of traditional foods and 28 respondents(47%) used the grain as food in the form of boiled grain (NIFERO), sauces (SHIRO or KIKE WET), local soup (SHORBA) and local prepared from grind seed (GENFO) (Figure 6) and livestock feed. The local framers' mostly preferred the fresh leaves of cowpea as a green vegetable for home consumption in the form of traditional stew and sauce especially in Gambella Region (Itang and Abobo) and SNNPR (Konso and South Ari). In addition, the local farmers' used cowpea for improving soil fertility by crop rotation and intercropping with cereals like sorghum and maize. In southern Ethiopia, a reasonable number of farmers (23.3%) used the leaves and seed of cowpea for medicinal purpose to cure liver disease, gastric discomfort and malarial infection. In addition, the farmers also used the crop for income generation by selling the grain and leaves in the local markets.



Figure 6:- Cowpea leaves in the local markets of Itang and Abobo weredas

Table 3:- Preference ranking for use value of cowpea

Data collection site (Wereda)	Use value ranks				
	Food	Fodder	Enhance soil fertility	Income generation	Medicinal value
Abobo	5	2	-	3	4
Babile	5	4	2	3	1
Biya Awale	5	4	2	3	-
Boset	5	4	3	2	-
Derashi	5	4	2	3	-
Gursum	5	4	2	3	-
Habro	5	4	2	3	-
Humbo	5	4	2	3	-
Itang	5	2	1	3	4
Konso	5	4	2	3	-
Oda Bultum	5	4	2	3	-
Sodo Zurya	5	4	2	3	-
South Ari	5	4	2	3	-
Total score	65	48	24	38	9
Rank	1st	2nd	4th	3rd	5th



Figure 7:- Cowpea used as boiled seed (NIFRO) in Babile and serve as leaf cabbage in Gambella

4.3.2. Farmers' seed source

A majority of local farmers (91.7%) used their own home saved seed and neighbor relatives. While respondents (8.3%) had replaced improved cultivars obtained from government agricultural offices since 3 to 17 years. And accordingly, the research showed that, 66.7% farmers prefer landraces, 10% prefer improved seed varieties and the remaining 21.7% farmers use the available seed varieties on the market.

4.3.3. Production constraint and traditional management technique

In southern Ethiopia, local farmers are facing with different constraints on production and utilization of cowpea such as storage pests, field insects, parasitic weeds and diseases. Among these problems diseases such as GUTENI (Wolaita language), MACHOLE /KESHEKESHE (Afan Oromio), SINTA (Anywaa), ROJA, JEGEDO, ATORENA (Ari language) are the most important constraints by attacking leaf, grain and pod at the overall growth stage of the crop. The most serious problem in southern Ethiopian farmers' for cowpea production is insect pests such as ALORA, JORE and AWERO (Anywaa) in Gambella Region and BAWSHA (Ari) in Southern Region recorded in this study. In addition, parasitic weeds such as AKANCHIRA(*Striga hermonthica*, other weeds including ASTENAGER (*Datura stramonium*), LEMBOCHE, *Parthenium hysterophorus*, ASHEKET (*Gallium simense*) and YEWOF ENKUR(*Commelina benghalensis*) were gathered during field interviews. To solve this problem, southern Ethiopia farmers' use different traditional techniques including hand weeding, combination of spreading ash with chemicals (Malatine) especially to prevent the severity of weeds and storage pest problem. In addition, farmers' traditionally cut the shoot part of the crop to promote lateral growth which also reduce weed invasion.

4.3.4. Cowpea cultivation and management

In southern Ethiopia, planting begins from June to September and by the end of January, all farmers' harvest cowpea from the field. The majority of farmers' (60%) produce cowpea using broadcast sowing, 18.3% use row sowing with intercropping of maize and sorghum, 11.7% use only hoeing and 10% use row and broadcast sowing then weeding and hoeing. The farmers grow cowpea via sole cropping (53.4%) and intercropping (30.7%)(Figure 8). Intercropping is mainly for maize (60%) and sorghum (40%) (Figure 9). Farmers' also used hand weeding and sometimes hoeing to manage the severe weeds. In addition, local farmers' used crop rotation system in order to harvest diverse products, reduce weed infestation, and improving soil fertility.

The majority of respondents' (90%) could not use any fertilizer to increase productivity of the crop. The remaining 10% of respondents' used organic fertilizer (compost and manure). In

addition, local farmers also use intercropping with other cereals to increase the fertility via nitrogen fixation in order to increase productivity.

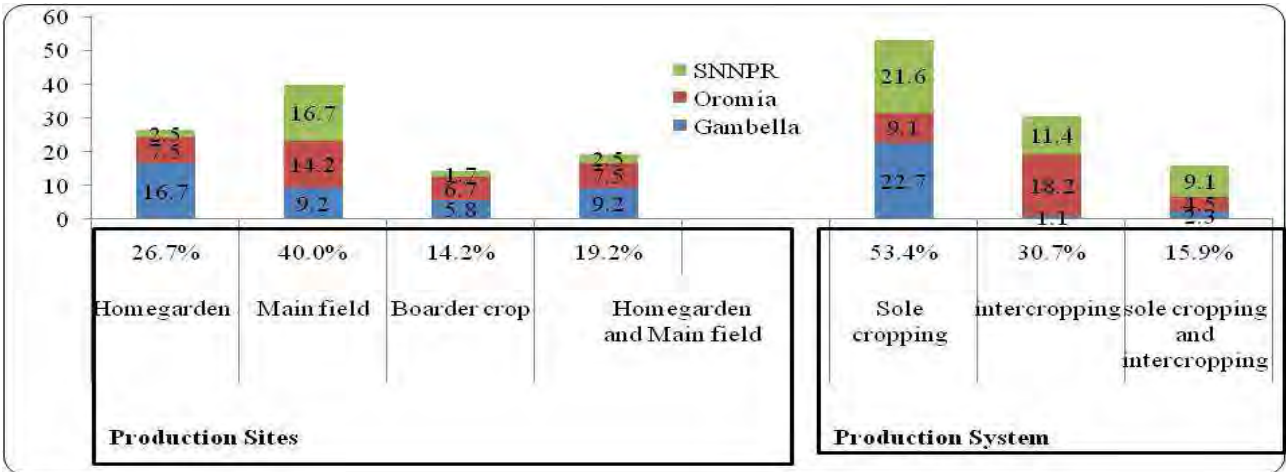


Figure 8:- Farmers’ cultivation practices

Most farmers grow cowpea for household consumption. Native/landrace/ cowpea seed when intercropped with other similar crop species flower early in the morning time. Landrace cowpea which has thin seed is soaked in water for one day before sowing. Once cowpea is cultivated on the main field it grows by itself annually because it disperses naturally on the field. The seeds grow most of the time in upright direction. Farmers cultivate this crop on the degraded land without caring for weeding task which helps in recovering the land for next production season. White seed landrace cowpea is most of the time sown in sole cropping method and mature in short period or produce twice a year; but red and black landrace cowpea seeds are sowed with intercropping method and maturity period is long and also climbing in sorghum and maize species.

Women’s contribution

Farmers seed selection parameter for better cowpea landraces was 66.7% farmers have not use any criteria just use available seed after trashing the seed but in contrast 33.3% male farmers select the big seed and pod size and women select seed from the field with big leaf size, big seed and pod size and seed coat color. Especially black seed color most of the time not

selected by women because if it is prepared boiled seed with other types of crops maize and wheat the color changes to black.

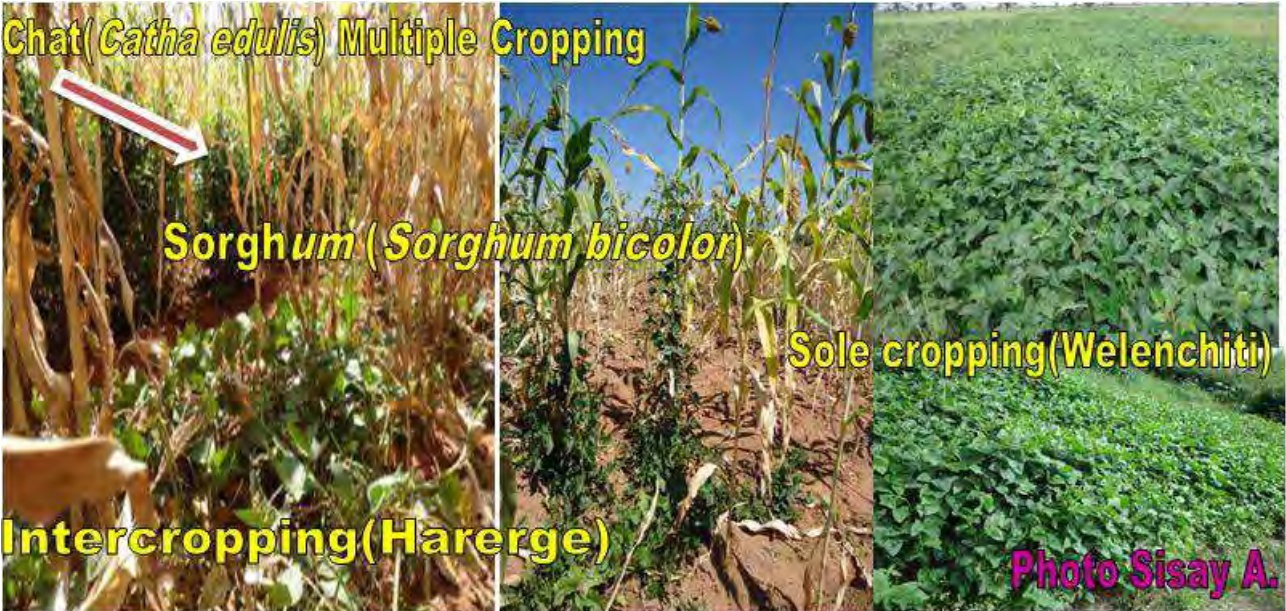


Figure 9: Cowpea intercropping with Chat and Sorghum and sole cropping

4.3.5. Farmers' knowledge and perceptions

From the farmers' point of view, cultivation of cowpea in southern Ethiopia has decreased due to preferences of farmers' for other legumes. About 28% of the respondents said that, the varieties have better performance than other crops under difficult conditions and are well adapted to drought and extreme heat conditions, 17% responded that, they have better performance in poor soil fertility and better resistance to grow in unusual rainfall pattern, 15% said local varieties have better adaptation to unusual timing of rainfall (early or late), 17% of the respondents mentioned that, have better growth in poor soil fertility, 6.7% responded that, grow better in hailstone area, 8.3% said that, better tolerate all the above conditions and the remaining 8.3% mentioned that, there is no better performance compared to other crops. Farmers evaluate cowpea landraces other particular advantages that are observed in their locality is listed in Figure 10.

In terms of insect pest and diseases, 78.3% of the respondents said that, these landraces are tolerant to parasitic weeds and, 16.4% mentioned that, They tolerant to parasitic insect pests that attack the foliage (i.e. evidence of rapid regrowth after attack) and 5.3% responded that, they are tolerant to disease resistance.

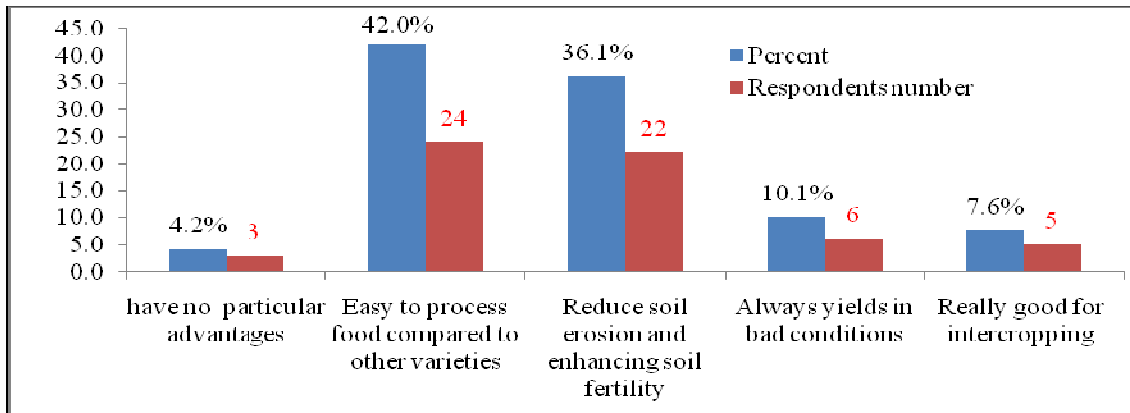


Figure 10:- Cowpea landrace and observed advantages

In the study areas, farmers listed out the general limitations on cultivation and utilization of cowpea in their locality. Among these the major ones are: disease prevalence, extreme and frequent drought and shortage of rainfall, pest infestation, shortage of land, low production and low market demand, demand for frequent weeding, problem of wild grazing animals and in some areas, because of the increased use of the leaf part as a vegetables, there is a limited amount of seed production.

In order to overcome the limitations, farmers in cowpea production areas utilize disease preventing chemicals, pest- and herbicides, develop irrigation systems, and the culture of frequent weeding, protect crops from wild grazing animals, develop access to markets and raise awareness of urban dwellers to consume cowpea and its varieties.

Farmers in the study areas mentioned additional characteristics of cowpea:- Cowpea climb on other plants or grow on the ground but do not mature at one time. Cowpea production needs frequent weeding more than other crops so farmers are not motivated to grow the crop. Early flowering seed is dispersed before harvesting time, in that frequent seed collection is needed when the seed matures and if the young shoot is removed the cowpea plant grows laterally and

has more production. If it gets much rain the plant needs more time to produce seed. The native species do not grow in short rainy season but as the main rain season sets the plant immediately grows, and if the young shoot is not removed on time, the cowpea plant starts climbing on nearby plants, otherwise, it grows as semi erect plant.

4.4. Cowpea Seed Samples Germination Performance

The seed sample germination test was carried out in EBI germination laboratory. Initially ten seed samples were selected from all regions based on seed size and color, (i.e. small, medium and big seed size and seed color was red, white, cream and light violet (see seed color and size in Appendix 1)) which was representative for all collected samples. The average germination capacity was 73.1% (Table 4). In general, there is no germination problem but samples Dass 09(QECHINE), Dass 015(BOHO), Dass 028(ATERA BABILE) are all small size seeds, with relatively low germination rate. Similarly, during the field data collection period some farmers in Dire Dawa and Konso area described that before sowing farmers use one day soaking of cowpea seed in cold water to initiate germination.

Table 4:- Germination capacity of sample cowpea accessions

N o	Seed Sample code	Collection locality	Germination percentage
1.	Dass 028	Dire Dawa (Belewa)	55.5
2.	Dass 015	Gambella (Abobo)	62.5
3.	Dass 05	Gambella (Itang)	90.0
4.	Dass 035	Oromia (Babile)	67.5
5.	Dass 026	Oromia (Badessa)	97.5
6.	Dass 037	Oromia (Gursum)	90.0
7.	Dass 09	Oromia (Welenchiti)	45.5
8.	Dass 016	SNNPR (Konso)	65.0
9.	Dass 017	SNNPR (Konso)	82.5
10.	Dass 012	SNNPR (South Ari)	75.0
Average			73.1

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Discussion

5.1.1. Landrace diversity and distribution

In this study findings ten farmers' landraces are grouped in three botanical identified species. Landrace RAPO scientifically *Vigna unguiculata* subspecies *dikendiata* found only in Gambella Region. Landrace ATERA BABILE, BOHO, OHODA, QECHINE and WOQA (Figure 10) scientifically identified *Vigna unguiculata* subspecies *cylindrica* and landrace AEQA, ALITA ATERA YUSUFI and WENU known as *Vigna unguiculata* subspecies *unguiculata* are found in three of the study regions. Similarly, the landrace diversity at the field level is greater for farmers who apply more selection criteria to define their diverse needs and requirements. Both natural factors and farmers' selection criteria shape crop genetic diversity at the field and landscape levels (Awegechew Teshome *et al.*, 2007).

As indicated in the cowpea suitability area in distribution map (Figure 4) cowpea may grow in many parts of the study area but low market demand and low production forced by low cultivation management and production system (i.e. cultivate on border cropping as a buffer of main crops from livestock's) limited the existence of cowpea landrace along such area. Environmental factors, e.g., degradation of soil fertility and extreme droughts were main factors for the loss of diversity. Other causes of diversity loss in the study area are various. In the last three decades, agricultural research and extension services favored improved varieties. But mitigation or preservation methods suggested by Firdissa Eticha *et al.*, (2010), reported as landraces conservation is influenced by their end-use, market demand and price.

5.1.2. Use values of cowpea landrace varieties

Young cowpea leaves are eaten as a pot herb and enjoyed in many parts of Africa. The freshly harvested leaves are sold in local markets in many parts of Ghana, Mali, Benin, Cameroon, Ethiopia, Uganda, Kenya, Tanzania and Malawi. And also cowpea shoots and leaves are rich sources of calcium, phosphorous and Vitamin B (Barrett, 1987). The young leaves are

especially important in drought-prone regions of Sub-Saharan Africa to tide local populations over during the “hungry period” which occurs after planting but before the main harvest of fresh pods and dry grains. Similarly this research showed that, local landraces like RAPO, BOHO and WENU in Gambella and OHODA in Konso wereda mainly used the leaf and young shoot as a leafy vegetable for home consumption. In addition, in Gamo Gofa and Wolaita zones and Oromia Region, farmers’ used the seeds of cowpea for food and leaves as a fodder for their livestock. Prepared food types from cowpea were mostly as boiled grain locally known as NIFERO and KIKE WET in all study sites. In particular people in areas of Dire Dawa, east and west Harerge weredas landrace ATERA BABILE prepared as sauce. Landrace WOQA in South Ari was used by local community as cultural food so called AYEBZA and ZEGOLA. Similarly landrace OHODA in konso, landrace ALITA in Derashe, landrace AEQA, in Wolaita are used as local food CHANGA, KURKUFA, and POLANDO (POCHE/HOCHE), respectively.

Landraces BOHO and ATERA BABILE served for medicinal purpose by 23.3% or 14 farmer respondents. Among those which were used for medicinal purpose, 70% of farmers in Gambella Region used cowpea leaf for treating human liver pain and 30% farmers in Oromia Region especially Dire Dawa Special Region and Babile Wereda used cowpea seed to treat Malaria pain and Gastric discomforts.

5.1.3. Production constraint and traditional management technique

In SNNP Region, leaf and seed disease locally known as GUTENI and SINTA/Wolaita and South Ari/ respectively, seed disease ROJA, JEGEDO, ATORENA in South Ari were recorded and similarly in Oromia Region leaf and seed disease so called MACHOLE and KESHEKESHE existed. Common insect pests found in Gambella Region are known as ALORA, AWERO and JORE /Anywaa language/, Insect pests in SNNP Region are BAWSHA and wild nocturnal grazing animals and also in Oromia Region there are pests that attack cowpea plants. Similar results were reported by Singh and Allen (1982) in that the author listed cowpea plant diseases such as fungal diseases seedling mortality disease, stem, root and foot rots(*Anthracnose*) disease, *Phthium* and *Sclerotium* stem rot, Wilts (*Fusarium wilts*), leaf diseases; like *Cercospora* leaf spot Target spot, *Septoria* leaf spot, *Dactuliophora* leaf spot, Broun rust, Pink rust, False rust or Yellow

blister, Black spot or leaf smut and Powdery mildew, Pod diseases; Lamb's tail pod rot, *Colletotrichum* brown blotch and Scab; Bacterial diseases, for instance Bacterial blight or canker and Bacterial pustule or spot, Virus diseases; for example cowpea (severe) mosaic, cowpea (yellow) mosaic, cowpea aphid-borne mosaic and cowpea golden mosaic diseases (Singh and Allen, 1982).

In Africa, *Striga gesneriodes* and *Alectra vogelii* are the most known weed species which affect cowpea production (Timko and Singh, 2008). In all regions of southern Ethiopia, there are some climber species and grass species which affect the production of cowpea. The use of storage chemicals for controlling storage pests is known to be costly and environmentally hazardous even for human, hence research on use of locally available plant materials for storage of grains have been very successful (Dudu, 1996). Ethiopian women contributed on conservation of germplasm through different conservation techniques. These methods used include dried big seed mixed with ash, salt, tobacco (*Nicotiana tabacum*) powder and BERBERE /*Capsicum annuum*/ powder. After some periodical exposure on sun to remove infested pest and put the seed closed stone pots, tans or plastic bottles seeds were mixed with DDT and some preservative chemicals supplied from agricultural input suppliers to prevent post-harvest pests. According to Duruigbo (2010), Neem Seed powder (*Azadiracta indica*), Black pepper powder (*Piper guinensis*), pepper fruit seed (*Denittia tripetata*), Soyabean oil (*Glycine max*) and Palm oil (*Eleais guinensis*) dried seed were milled separately mixed to dry maize and cowpea seed with the dosage rate of 10g/kg of grain as a treatment to store for 12 weeks. The use of Neem seed powder (*Azadiracta indica*) (i.e. Neem contains Azadiractin which has been found to be insecticidal in action (Dudu, 1996)), and pepper fruit seed powder *Dennittia tripetata* as well as black pepper (*Piper guinensis*) has a positive influence on protecting maize and cowpea seeds from storage pests and without any adverse effects on the viability of the seeds.

5.1.4. Cowpea cultivation and management

Cultivation management such as crop rotation and production systems are practices in the study area. Gambella Region and eastern Oromia, (West Harerge Zone) farmers do not use any crop rotation system. In contrast, all SNNP Region farmers and East Shewa and East Harerege zone

farmers used crop rotation system for the purpose of enhancing or improving soil fertility, reducing weed infestation and produce diverse production.

SNNP Region, South Omo and Wolaita zones and all Gambella Region farmers used broadcast sowing method and hand weeding to manage cowpea farm land. Whereas, in West and East Harerge zones farmers used row planting method via intercropping with sorghum and maize. East Shewa Zone, Boset Wereda farmers used broadcast sowing and hoeing management. And SNNPR Region, Segen People's Zone, Konso and Gidole Wereda farmers used combination of row and broadcast sowing followed by weeding and hoeing task. Cowpea intercropping with sorghum has been conducted in Cameroon to show the effects on suppression of parasitic weeds (Carsky *et al.*, 1994). The result indicated that the ground cover ranged from 20 to 80% and the density of mature capsule-bearing *Striga hermonthica* plants was low when the cowpea ground cover was high. This suggested that any spatial arrangement that increases cowpea ground cover at the base of the sorghum can reduce the density of mature *Striga hermonthica* (Carsky *et al.*, 1994).

Sole-crops are becoming important as cowpea production is commercialized to meet the demands of a rapidly increasing urban population. In Senegal, most cowpea is sole-cropped (Thiaw *et al.*, 1993). Intercropping is an important agricultural technique that improves diversification of food supply and ensures high economic returns. It also suppresses weeds particularly when short stature, bushy cowpea varieties are used (Zimdahl, 1999). In this research results showed that, in SNNPR Welayeta zone and Gambella Region all farmers grow cowpea crop as sole-cropping method with some intercropping in Konso and South Ari wereda. But in Oromia Region except Boset wereda, all farmers produced cowpea via intercropping with sorghum and maize (figure 11).

Women's contribution

It should be noted that in Ethiopia women are the one and only members of the households who are fully responsible for the processing of food and drinks. Women's contribution in agriculture and their decisions about the utilization of biological resources to satisfy the needs of rural households are often ignored (Firdissa Eticha *et al.*, 2010). In this study (22, 36.7%)

respondents are women farmers and better ability to describe the landraces in regard to their grain flavor, flour taste, cooking, cultural food and beverage-making quality, while men had better knowledge about agronomic traits such as plant height, maturity, disease tolerance, thresh ability, yield performance and straw quality. In rural societies in Gambella and SNNPR Regions women do also the bulk of farm labor more than men farmers including weeding, hoeing and harvesting grain. And also they grew cowpea crop in homestead area to easily utilize leaves and the grain used as a spice for many cultural food preparations.

5.1.5. Farmers' knowledge and perceptions

Cowpea Limiting factors

Cowpea has faced so many constraints, such as diseases and the limited use of fertilizers and irrigation input as mentioned by Brisibe *et al.* (2011); insect pests are one of the major constraints for cowpea production. Cultural management techniques of local farmers on disease, insect and weeds are less emphasized by wereda agricultural office experts on field protection of this crop. Farmers' believed that cowpea is a fodder plant so there was less management of crop protection as reported by the majority of respondent (68.3%). About 16.7% farmers used chemical pesticides; 8.3% of only Gambella farmers use ash spray on the ground of cowpea plant to prevent disease and pest and 6.7% farmers believed that cowpea plant by itself prevent weeds because of its climbing nature so that in all regions farmers give less emphasis for cowpea crop protection against weed, disease and pest and hence the grain production could be very low.

Cowpea cultivation Advantages

Cowpea cultivars which are prostrate and having dense crop canopy also act as live mulch, suppressing weed germination and growth (Mashingaidze, 2004). Thus, reducing the frequency of weeding the maize crop and the labour costs involved, high performance under marginal growing conditions (Singh *et al.*, 2003), create an understory that cools the soil, prevents soil loss, and minimizes weed pressure (Zuofa *et al.*, 2000) and it is highly drought tolerant and tolerates a wide range of soil pH for a legume (Kolawole *et al.*, 2000). This research result also

showed that cowpea landraces which can tolerate pests, diseases and parasitic weeds, easily rapid coverage of foliage leaves and primarily used for household consumption were produced in Gambella. Cowpea crop has better performance than other crops under difficult condition such as adaptation of drought and extreme heat occurrence; grow in poor soil fertility areas, grow in unusual rain fall pattern and in hailstone areas (Dire Dawa, Gambella and Konso area are a typical example landraces).

In general farmers describe the cowpea production unique features they observed during agricultural practices:-① Farmers assumption of cowpea weed suppression nature leads to neglect necessary weeding task on farm plot and hence the production decrease,

② The Konso and Wolaita farmers described that if this crop gets much rain the plant needs more time to produce seed and if it grows mixed with other crops like MASHO Mungbean (*Vigna radiata*) or other *Phaseolus* species the cowpea flower open early in the morning preventing cross breeding,

③ The landraces that has thin seeds which are easily dispersed and the seeds are soaked before sowing at least for 24 hours as a sowing pretreatment,

④ The South Omo zone farmers use the cowpea plant young shoot as leaf vegetable which results in erect or semi erect plant behavior that produces more fruit.

5.2. Conclusion

In southern Ethiopia, cowpea is a multipurpose crop by which green leaves are primarily used as cooked vegetables and the crop also has medicinal purpose. In addition, the majority of local farmers' used the grain of cowpea for home consumption purpose and for livestock feed. *Vigna unguiculata* subspecies *unguiculata* farmers' variety ATERA BABILE is preferred by a majority of farmers' because of spreading nature of the crop, ability to produce more leaf than other varieties, improving soil fertility and ability to supersede weeds via ground covering.

This study revealed that, in southern Ethiopia there is a moderate existence of important diversified cowpea landraces but their production coverage has decreased. Local farmers

mainly grew cowpea in marginal land and crop protection mechanism of cowpea is too low. The decrease in production is due to limited use of improved inputs, small fragmented plots, sowing in marginal soils and inadequate farm management practices and also the agricultural office experts' opinion on cowpea believed that it is forage crop so that the extension workers do not incorporate into extension packages for this crop.

The main cultivation practices in the study areas (Gambella, SNNPR and central Oromia Region) were sole-cropping and in Oromia Region (East and West Harerge zones) local farmers' used only intercropping with sorghum and maize for the sake of improving soil fertility, to produce diverse product and to use as a supporting mechanism for cowpea.

5.3. Recommendations

Core interventions and actions can be applied for optimal production and conserving landraces to supply domestic markets. These recommendations are complementary and intended to accelerate the impact of current governmental organizations, research institutions and development partner strategies:-

- ✓ 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.
- ✓ Awareness raising on cowpea use, nutritional value and trade linkage on farmers and merchants needed.
- ✓ The extension system should incorporate cowpea crop production like other pulses into their operational schedules, including module development for farmers that explain best practices of cowpea production and makes the case for fertilizer and pre and post harvest management techniques.
- ✓ Further research should be conducted on environmental capability and genetic aspect of cowpea in Ethiopia.
- ✓ Further in-depth research should be also conducted on the diversity of wild relatives of cowpea.

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Appendices








Appendix 1:- Samples collected germplasm accessions and locality

Seed collection code	Locality		Seed sample	Seed collection code	Locality		Seed sample
	Latitude (N)	Longitude (E)			Latitude (N)	Longitude (E)	
Dass 001	08 ⁰	034 ⁰		Dass 010	08 ⁰	038 ⁰	
	11'	15'			47'	58'	
	24.8"	50.2"			32.6"	03.4"	
Dass 002	08 ⁰	034 ⁰		Dass 011	08 ⁰	039 ⁰	
	11'	15'			37'	24'	
	32.4"	50.2"			19.8"	53.1"	
Dass 004	08 ⁰	034 ⁰		Dass 012	05 ⁰	036 ⁰	
	11'	16'			50'	32'	
	47.2"	00.4"			42.3"	56.2"	
Dass 005	08 ⁰	034 ⁰		Dass 013	05 ⁰	036 ⁰	
	11'	16'			51'	32'	
	47.7"	07.2"			12.6"	46.3"	
Dass 006	08 ⁰	034 ⁰		Dass 014	05 ⁰	037 ⁰	
	15'	35'			17'	29'	
	14.2"	22.2"			01.0"	07.0"	
Dass 007	08 ⁰	034 ⁰		Dass 015	08 ⁰	039 ⁰	
	15'	35'			38'	24'	
	14.2"	22.2"			17.7"	48.8"	
Dass 008	07 ⁰	034 ⁰		Dass 016	05 ⁰	037 ⁰	
	53'	34'			17'	28'	
	01.1"	03.4"			15.6"	55.8"	
Dass 009	08 ⁰	039 ⁰					
	38'	24'					
	17.7"	48.8"					

Annex 1. Continued...

Seed collection code	Locality		Seed sample	Seed collection code	Locality		Seed sample
	Latitude (N)	Latitude (S)			Latitude (N)	Latitude (S)	
Dass 017	05° 21' 26.2"	037° 22' 17.3"		Dass 024	08° 55' 21.9"	040° 40' 19.9"	
Dass 018	05° 20' 29.8"	037° 26' 29.1"		Dass 025	08° 48' 27.9"	040° 31' 32.6"	
Dass 019	06° 01' 02.4"	037° 32' 53.5"		Dass 026	08° 54' 08.2"	040° 46' 44.8"	
Dass 020	06° 42' 25.3"	037° 42' 26.1"		Dass 027	09° 05' 16.3"	040° 51' 59.9"	
Dass 021	06° 42' 06.1"	037° 46' 14.1"		Dass 028	09° 34' 19.4"	042° 06' 11.8"	
Dass 022	06° 42' 06.1"	037° 46' 14.1"		Dass 029	09° 34' 06.3"	042° 06' 04.8"	
Dass 023	06° 46' 40.6"	037° 46' 14.8"		Dass 030	09° 33' 58.5"	042° 06' 02.0"	

Annex 1. Continued...

Seed collection code	Locality		Seed sample
	Latitude (N)	Latitude (S)	
Dass 031	09 ⁰ 33' 47.2"	042° 06' 11.3"	
Dass 032	09 ⁰ 08' 18.6"	041° 50' 07.4"	
Dass 033	09 ⁰ 14' 07.8"	042° 19' 14.3"	
Dass 034	09 ⁰ 13' 31.5"	042° 18' 56.8"	
Dass 035	09 ⁰ 12' 35.6"	042° 18' 57.6"	
Dass 036	09 ⁰ 17' 22.5"	042° 26' 30.4"	
Dass 037	09 ⁰ 17' 33.5"	042° 26' 43.3"	

Appendix 2:- Data Interview Collection Format

Data Interview Collection Format

1. General Information

Informant's Name _____ Age _____ Sex _____

Location: Region _____ Zone _____ Wereda _____ Kebele _____

Local name of the crop _____ language _____ Soil type _____

Altitude _____ Latitude _____ Longitude _____

Meaning of the local variety name Language _____

Cropping season (Meher/ Belg/ or others)

Folk Taxonomy (characters used by the farmer for identification of the crop variety)

Quality, Diseases & pests identified by the farmer and Economic use of the crop

2. Ethnobotanical Information

1. Is it improved or farmers' variety? _____ If it is farmer variety what is the name of the variety? _____ Meaning of name _____.

2. How do you use this crop? A. food B. fodder C. others _____ specify _____

3. What parts of cowpea are used for food? -----
for animal feed? _____

4. Uses and values of the Crop other than food. A. Income generation, B. Soil fertility
C. Forage D. Alcoholic beverage (specify) E. Medicinal F. Ritual G. Myths and beliefs associated with the crop H. Any sayings, songs and poems

5. What is the most commonly used cowpea (*Vigna unguiculata*) landrace varieties in the your area? _____, (list most important first)

Is there any wild relative? _____ What is it called? _____ How is it used? _____

6. How do member of local community cultivate and manage to improve productivity of the crop? _____

7. If it has medicinal values describe the medicinal value (kind of disease and method of application)._____
8. Which varieties of the crop are said to have medicinal value?
1. _____ Purpose_____
 2. _____ Purpose_____
- 8.1 What is the local name of the variety used as a medicine in your area?
- 8.2 What part/parts of the crop are used for medicinal purpose?
- 8.3 What are the common diseases that can be treated by this crop?
- 8.4 What are the common insect pest affecting this crop?
- 8.5 What are the common weeds attacked this crop?
- 8.6 What are the common environmental factor (drought, heat) that affects this crops?
- 8.7 What are the methods of preparation to use as a medicinal plant?
- a. Preparation form: crushed, powder, chewed etc.
 - b. Used alone, mixed with water or other etc.
 - c. Condition: dried, fresh, both.
- 8.8 Could you tell me the amount or dosages that are used for disease treatment?
9. Suitable soil types for the crop to grow_____
10. Cultivation time?_____
11. Do you use cowpea in your crop rotation system? -----, If yes sequence of the crop types_____
12. Use in crop rotation sequence_____
- i To eliminate pest infestation
 - ii. To eradicate problem of weed
 - iii. To replenish soil fertility
 - iv. Others_____
13. Where do you grow this crop? Home garden _____ main field _____ boarder crops_____.
14. How do you grow this crop? Monoculture _____ Multiple cropping /intercropping--

15. Do farmers use intercropping? Why? -----

16. If intercropping, which crops do you grow in association with cowpea? _____

Crops grown in association	Farm land (main land or homestead)	Give reasons or uses of intercropping

17. If Multiple cropping, which crops do you grow in association with cowpea? _____

18. What do you think about the area of production in terms of coverage? _____ Production per ha _____.

Increasing	Decreasing	No change	Factors /reason/

19. How do farmers maintain the fertility of their farmland? Do they use artificial or natural fertilizer?

20. In case of seed shortage; where does a farmer obtain seed? Are there seed exchange mechanisms?

21. Are there any traditional varieties that are no longer cultivated? _____ Why not cultivated? _____

22. Do you think improved varieties have replaced the landrace? Yes/No----- . If yes, how many landraces has been replaced so far? _____

23. How long hasn't seen since the landrace has been replaced in the area? _____

24. Does the community prefer landrace or released ones? -----Why? _____

25. How do farmers culturally manage disease /insectpest/ weeds? _____

26. What are the main threats to the traditional variety in your area? _____

27. What measures should be taken to overcome the problems? _____

28. Do you grow any landraces here on your farm that perform noticeably better than others under difficult conditions(discuss each condition in turn) such as Drought, Extreme heat, Poor soil fertility Others?

29. Are certain varieties you grow here on your farm notably more tolerant to important pest and disease problems (show pictures of the primary p & d for the crop) examples Tolerance to parasitic weeds, Tolerance to seedling establishment problem, Pests that attack the foliage, Not as attractive to insects, evidence of rapid regrowth after attack Others?

30. Do you grow any varieties here that have a particular advantage, such as Easy to process compared to other varieties Soil fertility enhancing, Reduce soil erosion, Really good for intercropping and Other advantages?

3. Socio- Cultural Significance of Crops

31. If cowpea used as food and fodder which variety do you use and for what purpose?

Variety of the crop purpose

32. Which varieties of these crops are said to have better nutritional value?

1. _____ 2. _____

33. What special tasks do women contribute to maintain genetic diversity?

34. What are your parameters of selection for better varieties of the crop?

Men

women

4. Economic significance of crop varieties

35. Which varieties of the crop are more preferred for its better production? _____

36. Which varieties of the crop are used for consumption? _____

37. Which varieties of the crop are used for market? _____

38. Are there special landrace varieties of cowpea which are marketable in your area? _____

39. Are there limitations in the cultivation and utilization of cowpea in the locality? _____

40. What are the solutions to constraints for cowpea species? _____

41. Could you kindly list crop species that are cultivating in your area? _____

42. Do you have anything else to tell me? _____

Thank you for your willingness!!!

Appendix 3:-Selected morphological character and key construction of *Vigna unguiculata* spp.

Characteristics	Subspecies A (<i>dikendiata</i>)	Subspecies B (<i>cylindrica</i>)	Subspecies C (<i>unguiculata</i>)
Growth habit	Climber	Erect	Semi- prostrate
Twinning tendency	Pronounced	None	Intermediate
Leaflet shape/Terminal	Hastate	Sub-Hastate	sub-globose
Pod curvature	Straight	Straight	Slightly curved
Pod length	12	10.5	18.2cm
Number of locules per pod	15	14	17
Seed shape	Rhomboid	Rhomboid	Ovoid
Leaf colour	Dark green	Intermediate green	Intermediate green
Terminal leaflet length [mm]	6cm	8.5cm/85mm/	10cm (100mm)
Terminal leaflet width [mm]	5cm/50mm/	5cm/50mm/	5.9cm (59mm)
Plant vigour	Intermediate	Non-vigorous	Non-vigorous
Pod width [cm]	0.5cm	0.4cm	0.85cm
Pod wall thickness	Intermediate	Thin	Thick
Pod colour	Dark tan	Pale tan (straw)	Pale tan (straw)
Seed length [mm]	55mm	6mm	8mm
Seed width [mm]	4.5mm	4mm	5.5mm
Seed size	Small	Medium	large
Seed color	Cream	Different types	Different types

Key for *Vigna unguiculata* subspecies collected from southern and eastern Ethiopia.

1. Climber; intermediate plant vigour, terminal leaflet hastate, 7cm long, dark green; pods 12 cm x 0.5cm, dark tan in colour; seed 5.5 mm wide

.....*Vigna unguiculata* subspp *dikindtiana*

Erect or semi prostrate, non-vigour plant; terminal leaf sub-hastate and sub-globose, 8.5cm- or 10cm long, intermediate green colour; pod 10.5- or 18.2cm long, 0.4cm- or 0.85cm wide, Pale tan (straw); seed 6mm- or 8mm wide2

2. Erect; terminal leaflet 8.5x 5 cm; pods with straight curvature, 10.5 x 0.4 cm, 14 loculed; seed rhomboid, length 6mm long, 4mm wide, cream.

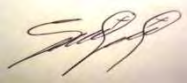
.....*Vigna unguiculata* subspp *cylindrica*

Semi –prostrate; terminal leaflet 10.5 x 5.9 cm; pod slightly curved, 18.2 x 0.85 cm, 17 loculed; seed ovoid, 8 x 5.5 mm, violate colour.

..... *Vigna unguiculata* subspp *unguiculata*

DECLARATION

I, Sisay Alemu, author of this thesis titled “Cowpea (*Vigna unguiculata* (L.) Walp.) Landrace Diversity in Southern Ethiopia”, do hereby declare that apart from the references of other people’s work which has been duly and appropriately acknowledged. The research work presented in this thesis was done entirely by me in Addis Ababa University, Graduate Programs, College of Natural Sciences, Department of Plant Biology and Biodiversity Management (PBBM) from September 2013 to June 2015. This thesis is my original work and it has never been presented and submitted in other universities, colleges, institutes or elsewhere for a degree or other purpose.

Name: Sisay Alemu Dersesse Signature:  Date: June 17, 2015

This work has been done under my supervision.

Name: _____ Signature: _____ Date: _____

_____ Signature: _____ Date: _____

_____ Signature: _____ Date: _____

_____ Signature: _____ Date: _____