Access to Seed and Variety Adoption of Farmers in Ethiopia:

A Case of Open Pollinated Maize in Drought-Prone Central Rift Valley

By

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ABBREVIATIONS

ADLI	Agricultural Development Led-Industrialization
ATJK	Adami-Tulu-Jido-Kombolcha
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CRV	Central Rift Valley
CSA	Central Statistics Agency
EIAR	Ethiopian Institute of Agricultural Research
ESE	Ethiopian Seed Enterprise
FAO	Food and Agricultural Organization of the United Nations
FRG	Farmer Research Group
GTP	Growth and Transformation Plan
ISM	Informal Seed Markets
MARC	Melkassa Agricultural Research Center
MoARD	Ministry of Agriculture and Rural Development
OPV	Open-Pollinated Variety
PASDEP	Accelerated and Sustainable Development to End Poverty
PVS	Participatory Variety Selection
SG 2000	Sasakawa Global 2000
SSA	Sub-Saharan Africa
UNDP	United Nations Development Program
WANA	West Asia and North Africa Program

CHAPTER 1

INTRODUCTION

1.1 Background

Seed is a fundamental input in crop farming. It has played a critical role in agricultural development since humans domesticated the first crop around 11,000 years ago. It is a carrier of genetic information that controls the maximum crop productivity, resistance to disease, and tolerance to environmental stresses such as drought (Cavatassi *et al.*, 2010; Bishaw, 2004). Seed is an essential agricultural input and access to quality seed is of crucial in improving farm household food security in agrarian nations particularly in Sub-Saharan Africa (SSA) and elsewhere.

Agriculture provides food, and jobs for about two-thirds of SSA and contributes about 32% of Gross Domestic Product (GDP) (The World Bank, 2008). Agriculture led growth in SSA is the most effective and a pro-poor growth strategy than those in the non-agricultural sector (The World Bank, 2005). In Ethiopia, for instance, a unit increase in GDP derived from agriculture has a potential of reducing poverty annually by 1.66% as compared to 0.73% poverty reduction expected from non-agricultural sector (Diao *et al.*, 2007). Agriculture, particularly crop farming, has a greater effect on both the rural and the urban poor who spend more than a half of their incomes on food (The World Bank, 2008).

The bulk of human food comes from crops produced from seed. Three dominant cereal crops wheat, rice and maize provide 50% of human food calories (Fischer and Edmeades, 2010). Seed has unique features as a medium for germplasm exchange among farmers and among farmers and researchers. In short, seed is a medium though which a new crop technology is transferred to farmers. It is the carrier of genetic message for different characteristics embodied in a variety[1]. A seed of particular characteristic represents a variety. Farmers seek particularly seed from off-farm source for numerous reasons. The common reasons are to get a variety of high yielding potential, drought tolerance, disease resistance, a preferred taste, etc. when food crop is considered. When there are different seed sources available and farmers get access to them there is high probability of adoption of improved varieties (Alene *et al.*, 2000). An enhanced seed availability though formal or informal or both sources will improve smallholder farmers access to seed and enhance improved variety adoption. In practice, whenever a farmer is talking about getting a new seed it implies that she or he is deciding to adopt a new variety. The ultimate goal of a farm household in a risk prone agro-ecology is to obtain seed with characteristics suitable to farmers' agro-ecological and socio-economic condition. A suitable variety generation and dissemination requires for formal and informal the seed system that is discussed in Section 1.2. In this study, crucial components of a seed system are discussed in Chapters 4, 5 and 6. Chapter 4 deals with access Chapter 5 adoption issues and Chapter 6 addresses seed provision in improvising seed availability taking the case in point of open-pollinated maize varieties. In the first two analytical Chapters 4 and 5, the discussion is approached from famers' as improved seed users. Chapter 6 discusses as farmers as potential improved seed provider to look at both sides of farmer improved seed need and local supply.

Similarly, seed is pivotal in the improvement of food security and farm household livelihood (McGuire and Sperling, 2011). Therefore, farmers' access to quality seed, as well as the introduction and adoption of improved varieties is of crucial to smallholder farmers in SSA and elsewhere.

[1] A plant grouping with a botanical taxon, which can be defined by the expression of characteristics resulting from a given genotype or combination of genotypes. It is sufficiently homogenous to be distinguished from other such groupings by expression of at least one characteristic (Almekinders and Louwaars, 1999).

Crop productivity is low in SSA including Ethiopia (Central Statistical Agency, 2011; Langyintuo *et al.*, 2010). Governments have been pursuing strategies for improving food crop productivity by using improved varieties and application of accompanied agronomic practices, inputs through parastatal agencies seed production and supply (Government of Ethiopia (GoE), 2001). Considerable resources have been devoted to the development and release of improved varieties though their adoption has been remained low (Spielman *et al.*, 2011).

For enhanced improved seed supply a well functioning[2] seed system is deemed crucial (Maredia *et al.*, 1999). In that aspect, a formal seed system that functions adequately feeds informal seed system and they are noted to be complementary (Almekinders *et al.*, 1994). Before turning to the objectives, research questions and methodology of the study, a highlight is given about seed systems and seed development policies in Ethiopia.

1.2 Formal and informal seed systems: Definitions and functions

Seed system is as a network of actors involved in variety development, seed production, regulation, storage, transport, marketing, and use. The literature often refers to the structured formal or commercial sector in defining the seed system (Jaffee and Srivastava, 1992; Venkatesan, 1994; Loch and Boyce, 2003). There is a growing practice of looking beyond the formal one in defining seed system by including the informal seed system and categorizing a country's or region's seed system as formal or informal (Almekinders and Louwaars, 1999; Bishaw, 2004). The formal seed system operates within the legal framework and comprises modern formal institutions such as parastatal seed agencies, research centers, seed certification organization. The informal seed system refers to the farmer selected and saved

[2] A well-functioning seed system is defined as one that uses the appropriate combination of formal, informal, market and non-market channels to stimulate and efficiently meet farmers' evolving demand for quality seeds (Maredia *et al.*, 1999).

seed, farmer managed seed production such as community or farmer group based seed production and dissemination operating without the legal framework (Bishaw, 2004).

In the modern plant breeding, researchers create genetic variability, select better-performing varieties, and release them for grain production. Released varieties seeds are expected to be multiplied and then channeled to farmers by the public seed supply enterprise or commercial seed enterprise or both depending on the stage[3] of seed system development of a country (Maredia *et al.*, 1999). For a continuous supply of certified seed for grain production, specified amount of breeder seed[4] is maintained by the institutions released the variety for basic and certified seed production. In developing countries, where seed system is at early stage of development, public seed enterprises and research centers multiply certified seeds from basic seeds then supply them to the farming community.

However, formal seed enterprises could serve only a small portion (not more than ten percent) of the farming community. Consequently, the dissemination and adoption of improved varieties has been slow or absent in SSA, such as Ethiopia. For instance, Mekbib (1997) documented that only ten percent out of 122 released varieties of cereals, legumes, oil crops and vegetables were adopted in Ethiopia. A recent study in common bean also showed a similar trend in which only 6 out of 19 varieties released for the Central Rift Valley (CRV) of Ethiopia were found to be under production (Beshir and Nishikawa, 2012).

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[3]Stage 1, the informal seed system predominates; most farmers save their own seed or obtain seed from nearby farmers and the rate of new varietal development and adoption is low. Stage 2, seeds of improved varieties developed by publicly financed research begin to replace local varieties, use of complementary inputs is limited, and private sector is emerging and they involve in the multiplication and distribution of public varieties. Stage 3, the private sector begins to play an active role in research and development of hybrids and seeds for specialized cash crops. Seed distribution systems become more organizationally varied and decentralized. During stage 4, the seed system and the agricultural sector as a whole are well developed. Commercial seed production and marketing are common, effective seed laws and regulations are in place, linkages with actors outside the seed sector are well established, and the use of improved seed is widespread (Maredia, 1999:14).

[4] Breeder seed is specified amount of seed maintained by a breeder or institution released the variety. It has the maximum varietal and genetic purity while basic seed is the seed produced from breeder seed. The seed class produced from basic seed for grain production is kwon as certified seed (National Seed Indutry Agency, 2001).

The provision of certified seeds constrained by high cost of seed production due labor costs, expensive infrastructure, certification, processing and distribution logistics which inflate seed prices (Sahlu *et al.*, 2008). Moreover, seed quality, at times, deteriorate due to poor storage conditions and delayed supply through extended chain [5] of seed requests and an inadequate delivery system (Almekinders *et al.*, 2007; Spielman *et al.*, 2010; Alemu *et al.*, 2008). Similarly, Venkatesan (1994) noted that a high level of unpredictability in seed demand for self-pollinated and open-pollinated crop varieties when certified seed supply is concerned.

On the other hand, there exists an informal seed system. In the informal seed system, the production and exchange of seed are largely integrated into the farmers' crop production and their socio-economic processes of farming (Tripp, 1997; Almekinders and Louwaars, 1999). Farmers select, save, use and exchange seeds through the local networks developed over generations. The informal seed system is also known under different names, such as traditional seed system (Cromwell *et al.*, 1992), local seed system (Almekinders *et al.*, 1994) or farmer seed system (Almekinders and Louwaars, 1999). The informal seed system is the predominant one in developing countries where the bulk of the seed is obtained (McGuire, 2005; Almekinders and Louwaars, 1999). The informal seed system includes farmers managed improved variety seed production that meant to improve availability and quality of seed by farmers such as farmer research group (FRG) based seed production and dissemination.

[5] Certified seed demand in Ethiopia passes through numerous steps. The request collection within the lowest administrative unit (*Kebele*) itself has three levels (i.e., a group of six farmers that is a subset to a group of 20 to 30 farmers. Then the groups of the 20 to 30 farmers form 'zone', which constitute one third of a *Kebele*). Then the *Kebele* agricultural development agents compile the request in consultation with the *Kebele* administration and submit it to the district Agricultural and Rural Development Office. The request processed through the higher administrative tiers zone and regional agricultural development offices up to the Ministry. The delivery is made through farmers' cooperative unions. The process goes through about seven to eight stages (see Fig 2-4).

The formal and informal seed systems have been predominantly operating independently though there were efforts to link them through certain arrangements such as contractual based seed farmer seed production and marketing (Sahlu *et al.*, 2008) and farmer participatory variety selection (Cavatassi *et al.*, 2010). Almekinders *et al.*(1994) noted the complementary relationship of informal and formal seed systems. However, the modality of developing complementary functions between the two systems largely remains a point of discussion. One reason is that there are differences in seed systems from crop to crop, from one agro-ecology to another where the situation is particularly complex, diverse and risk prone for farming, such as in drought-prone areas. A close understanding of the functioning of seed systems, for that matter farmers' access to seed and the quality of seed of informal seed sources farmers' adoption behavior and farmer participatory such as farmer research group based seed production and dissemination would provide an in-depth evidence helpful for suggesting complementary integration or reform. I will consider this point in detail later in Chapters 3 in the literature review, since it has strong implications for seed supply and dissemination.

The concept seed system is utilized to adhere to the original words used in the literature referred. Otherwise, more applicable concept seed source is used since this dissertation focuses on with seed sources accessed by smallholder farmers that represent the function of the seed system in context of the study area.

1.3 Agriculture in the Ethiopian economy and related policies

Ethiopia is the second most populous African nation (population estimated to be 84 million[6]) occupying 1.12 million square km (Central Statistical Agency, 2011). The county's economy relies heavily on agriculture. The sector contributes about 41% of the GDP and employs 83% of the economically active population (National Bank of Ethiopia, 2011). The major cereal crops cultivated in the country are tef (2,761,190 ha), maize (1,963,179 ha), sorghum (1,897,733 ha), wheat (1,553, 240 ha), and barley (1,046,555 ha). Pulses are important grain crops for cash earning as well as for food production (Central Statistical Agency, 2011). Although farming is the foundation of the country's economy, crop productivity has remained low. For instance, the average national yield of important food crops such as tef, maize, sorghum and wheat were 1.26, 2.54, 2.08 and 1.84 tons per hectare respectively (Central Statistical Agency, 2011) while the potential of those crops is two to three times higher (MoARD, 2008). Food insecurity has been a persistent issue in the country where the recurrent drought considerably affects crop production of its numerous villages[7] (Dercon *et al.*, 2005). Growing drought tolerance varieties is a promising means of increasing food production particularly in drought-prone areas.

Low crop productivity in SSA including Ethiopia is due to a limited use of seeds improved varieties by smallholder farmers. The supply of certified seeds of grain crops in Ethiopia is estimated to be about 10% of the annual seed planted (Spielman *et al.*, 2010). Seed is a divisible and scale-neutral technology that can be adopted by different categories of farmers - from resource poor to resource rich. Farmers' access to seeds of adapted varieties of modern or landrace to their agro-ecologies is critical in increasing food production (Feder *et al.*, 1985). However, deficiencies have been observed in improved seed supply due to

[6] The population of Ethiopia was 73.9 million in 2007 census growing at 2.6% per year (Population Census commission, 2008). Thus, it is estimated to be 84 million in 2012.
[7] In Ethiopia, 262 districts out of 768 suffer from unreliable rainfall (Alemu, 2012).

inadequacies in seed varieties demanded and quantity required, prices, and untimely seed delivery (Sahlu *et al.*, 2008).

The capacity of seed supply and seed dissemination is highly influenced by a country's seed system development stage (Maredia *et al.*, 1999). The transition from one stage to another stage, however, is not linear but dictated by economic, agricultural development and seed system development stage of a particular country and crop. For instance, some crops attract commercial enterprise while others do not; hence, seed system development requires policy intervention (Tripp and Louwaars, 1998).

Ethiopian agricultural development policy

The issue of seed is an important element in agricultural development policy in Ethiopia. The government has established development policies emphasizing agriculture as an engine for economic growth. In this respect, the Agricultural Development Led-Industrialization (ADLI) has been an umbrella strategy[8] since 1994 and has had the ongoing influence in providing a framework for long-term economic growth. Agriculture has been envisaged as a base for enhancing structural transformation in economic growth because the largest human and land resources are located in rural areas where farming is predominantly practiced. Within agricultural sector, the focus has been placed on the improvement of smallholder farmers' crop productivity (Rahmato, 2008). The provision of improved agricultural technologies smallholder primarily seeds of improved varieties and agro-chemicals were envisaged to be the most important inputs (Government of Ethiopia (GoE), 2001).

[8] There are differences regarding the meaning of policy and strategy and the link between them. It is suffice to say that policy is taken to mean broad framework defining fundamental assumptions, principles, objectives and priorities while strategy represents long-term measures planned and undertaken to achieve the objectives of the policy.

Another important national development program, Accelerated and Sustainable Development to End Poverty (PASDEP) of 2004/5 to 2009/10, was also built on the experience of implementing ADLI. The novel approach of the PASDEP was its recognition of the need to tailor agricultural interventions according to specific economic and agro-ecological conditions. PASDEP emphasized food insecurity reduction in drought-prone areas through diversification away from reliance on food crop production by increasing off-farm income opportunities (Teshome, 2006). However, given that the mass of the population living in drought-prone area is agrarian, the envisaged shift from food crop production to off-farm activities did not have a clear impact.

The country's current development plan, the Growth and Transformation Plan (GTP), is based on the experiences that have been drawn from implementing development policies and strategies of the previous years. During the GTP (2010 to 2015), agricultural has been stipulated to continue playing its key roles as an economic growth source. For this purpose, the application of improved variety seeds has been emphasized with the assumption that the formal seed enterprises will deliver the required seed in quality and amount.

The GTP and agricultural and rural development policies of the country place crop production and productivity enhancement at the heart of agricultural growth where seed is given high emphasis. The GTP reiterates,

> "Since technology multiplication, supply and distribution system is crucial to increase crop production and productivity. This system will be strengthened to make it effective. In the coming five years [2010 to 2015] the required fertilizer, improved seeds, and small farm machineries will be made available with the requisite quality and quantity" (MoFED, 2010: 22).

Seeds of improved varieties are regarded as effective tools in enhancing crop productivity since it dramatically changed the productivity of crops during the Green Revolution of the1960s to 1980s. Such productivity increase did not happen yet in SSAs such as Ethiopia where the agro-ecology is diverse and farming is a risky enterprise particularly in drought-prone areas (Spielman *et al.*, 2010; Alemu *et al.*, 2008). Adoption of improved varieties of widely grown crops such as tef, maize, sorghum and common beans is low (Spielman *et al.*, 2010).

Likewise, the aggregate cereal adoption such as improved maize variety in many SSA including in Ethiopia is low (Table 1-1) (Langyintuo *et al.*, 2010). Technical and policy bottlenecks are identified[9] as the causes for such differences in the adoption of improved varieties across countries.

[9] Different bottlenecks were identified that affect the entire maize seed system in major maize producing parts in Africa. These are time taking varietal release process, high investment cost, lack of manpower, and lack of operational credit); lack of access to germplasm, lack of production credit, and expensive production equipment, retail contractual problems, and poor rural road and low adoption rates, poor extension services and difficulty in estimating demand (Langyintuo *et al.* 2010: 325*)*.

Table 1-1 Improved seed supply and adoption rate of improved maize varieties in selected countries of SSA, 2006/7

Region/ Country	Maize area (1990-2007 average million ha)	Estimated seed required (10^3 t)	Maize seed sales in 2006/07 (1000 t)			Adoption rate (% of area)
			OPV	Hybrid	Total	
Eastern Africa	**6.6**	**161.8**	**11.1**	**42**	**53.1**	**36**
Ethiopia	1.7	42.4	2	6.2	8.2	19
Kenya	1.6	38.9	1.7	26.3	28	72
Tanzania	2.6	64	3.9	7.3	11.2	18
Uganda	0.7	16.5	3.5	2.2	5.7	35
Southern Africa	**5.4**	**133.4**	**12**	**38.5**	**50.5**	**38**
Angola	0.8	19.3	0.8	0.2	1	5
Malawi	1.4	35.3	5.4	2.5	7.9	22
Mozambique	1.2	30.3	3.1	0.2	3.3	11
Zambia	0.6	14.1	0.5	9.7	10.2	73
Zimbabwe	1.4	34.4	2.2	25.9	28.1	80
Regional Total/average	**12**	**295.2**	**23.1**	**80.5**	**103.6**	**37**

Source: Adapted from Langyintuo *et al.*, 2010

Ethiopian laws related to seed system development

Other than the national development policies, laws and regulations play essential roles in facilitating the development of a seed system. Almost every country has its own seed laws. Different seed laws and regulations guide the Ethiopian seed system. The seed regulations and procedures directly affect a variety release, seed production and seed dissemination are highlighted as follows.

The national seed proclamation (No. 206/2000) is one of the most important laws. It provides for creating a legal framework for the protection of the interests and control of the farmers, originators, processors, wholesalers and retailers of seeds. It also designates government agencies to support, advise and control individuals/organizations engaged in the production, processing, transporting and distribution of quality seeds; and promoting the use of certified seed. There is, however, no legal provision for farmer-based seed production and supply, which is currently play significant roles in improved varieties seed production and distribution in Ethiopia and numerous countries of SSA.

The national variety evaluation and release procedures and mechanism of 2001 provides guidelines as to what variety evaluation procedures should be pursued. The major criterion for variety release is yield performance records. The procedure restricts the number of varieties released to one during any one season for a given crop. This eliminates the option of releasing more than one variety, a high possibility during participatory variety selection. A typical example comes from farmer participatory common bean variety selection in the CRV of Ethiopia where five varieties were selected and given vernacular names by farmers (Rubyogo, nd), but reduced to just one during official variety release since variety release criteria consider average agronomic performance across different sites at national levels, overlooking local performance differences and farmers preferences. Moreover, the variety release committee is entirely composed of researchers and agricultural experts (National Seed Indutry Agency, 2001).

The other important seed law in Ethiopia is proclamation No.206/2000. It requires expensive seed processing facilities to participate in seed provision that is beyond the reach of individual farmers who wants to venture in seed supply business. Moreover, the seed quality standard in Ethiopia is repeatedly noted to has been set very high as compared to neighboring countries (Simane, 2008) and there are no other provision such as truthfully labeled system or quality declared seed (Tripp and Pal, 2001). The seed law fails to provide the emerging small-scale voluntary seed producers such as farmer based seed production that have the potential to grow into a seed business enterprises or farmer group based seed production that would increase local seed availability.

Policies guiding a country's seed system development needed to consider the exiting farmers' seed system and specific crop characteristics (Tripp, 2006). Farmers major seed sources, and adoption of improved varieties, smallholder farmers' involvement in improved variety seed provision would present empirical evidence in understanding the local seed system to develop seed policies and suggest any reforms.

1.4 Statement of the problem

Farmers' access to improved seeds has been an ongoing agricultural development issue in countries of SSA such as Ethiopia (Alemu *et al.*, 2008), Kenya Malawi, Zambia and Zimbabwe (McGuire, 2005; Chambers and Ghildyal, 1985; Tripp, 2002; Bishaw, 2004) and many others (Cavatassi *et al.*, 2010; Spielman *et al.*, 2010). International development agencies and nation states supported the formal seed system development by financing agricultural research, improved variety seed production and distribution agencies in the 1970s and 1980s. They have been, however, unable to provide improved seed to the vast majority of smallholder farmers particularly those who are residing in drought-prone areas (McGuire, 2005; Chambers and Ghildyal, 1985; Tripp, 2002; Bishaw, 2004). Likewise, the adoption of improved varieties of major crops such as maize has remained low in Ethiopia (Spielman *et* *al.*, 2010) and other SSA countries (Langyintuo *et al.*, 2010). In Ethiopia, Alemu *et al.* (2008) noted that the public seed organization dominance in improved seed supply as a major reason for a limited access by smallholder farmers to improved varieties and they suggested for more involvement of the private sector. However, neither the public nor the private seed enterprise is in a position to provide the seeds of open-pollinated and self-pollinated crop varieties [10] that are commonly grown in drought-prone areas.

The seed system in developing countries particularly those in drought-prone areas is intricate and a single seed source does not satisfy the seed needs of the farming community. Other than the formal seed system, the informal seed source prevails that has been playing key roles in seed production and dissemination. This indigenous entity, however, has been underestimated in the seed system development efforts.

Few studies have been conducted related to seed system in Ethiopia and elsewhere with much focus on the indigenous crops. For example, Bishaw (2004) conducted a research in seed system of two indigenous crops -wheat and barley- in high potential areas of Ethiopia while McGuire (2005) pursued his studies on another indigenous crop –sorghum- in Ethiopia focusing on formal breeding and local seed exchange issues. Whereas Nuijten (2005) dealt with gene flow management of millet and rice the indigenous crops in the Gambia. Numerous others dwelt on adoption of improved varieties in their studies related to the seed system of maize (Abdissa Gemeda *et al.*, 2001; Feleke and Zegeye, 2005; Alene *et al.*, 2000). The issue of farmers' behavior in access to seed and seed quality of informal sources and adoption of improved variety central issues in a seed system has been hardly captured in any of those

[10] Open pollinated variety is a variety multiplied through a random fertilization and the progeny of a single plant have variable characteristics. On the other hand, self-pollinated crop is a crop under normal conditions seeds are produced because of a self-fertilization in at least 95% of cases. In addition, hybrid exists of which the seed is produced by controlled crossing of two different parents (Almekinders and Louwaars, 1999).

related studies by using field data, employing qualitative and quantitative analysis like the one employed in this study.

Understanding and analysis of those dimensions of seed system is valuable for facilitating farmers' access to seed and enhanced adoption of improved varieties. Likewise, farmer participation in research, seed production and dissemination believed to play critical role in selecting and disseminating suitable variety. Based on this assumption different farmer participatory approach such as farmer research group (FRG) is getting popular in many parts of SSA including Ethiopia. However, the contribution of farmers' participation in improving access to seed and adoption has not been systematically studied and documented. There is limited information about farmers' seed quality and their management practices. It has been simply believed that seeds of informal sources are of low quality without sufficient evidences to suggest any improvement to be pursued.

This study tries to understand the factors influencing farmer' access to seed and improved variety adoption in drought-prone area considering farmers' resources endowment and characteristics of farm household head -the decision maker. The perennial issue of smallholder farmers' limited access to improved variety seed expected to be addressed though farmer participatory research and seed production and dissemination. Farmers' prevailing seed access and adoption behavior provides for suggesting areas of intervention in understanding improving smallholder farmers access to seed and improved variety adoption in drought-prone areas.

The main aim of this study is, therefore, to understand and explain smallholder farmers' behavior in access to seed and improved variety adoption in the drought-prone CRV of Ethiopia focusing on open-pollinated varieties of maize. A combination of data collection methods, namely field study, secondary data, group discussions and a case study were utilized.

1.5 Objectives of the study and research questions

Objectives of the study

1. To analyze and explain farmers' behavior in access to seed of maize in drought-prone areas of the CRV Ethiopia.
2. To analyze the determinants of farmers' adoption of improved open pollinated varieties (OPV) of maize in drought-prone areas of the CRV of Ethiopia.
3. To discuss the contribution of farmer-group based improved OPV maize seed production and dissemination to improved seed variety seed availability in drought-prone areas of the CRV of Ethiopia.

Research questions

The research was conducted by tackling the following research questions:

1. What factors influence farmers' access to seeds in drought-prone areas of the CRV of Ethiopia?

2. What factors influence the adoption of improved OPVs of maize in drought-prone areas of Ethiopia?

3. How does improved OPVs maize seed production and dissemination by smallholder farmers groups, such as FRG contribute to farmers' access to improved variety adoption?

1.6 Significance of the study

This study will make a considerable contribution in understanding and analyzing the factors influencing smallholder farmers' behavior in access to seed, improved variety adoption in drought-prone areas of SSA and elsewhere. Previous studies have concentrated on the formal seed system and high potential areas while the present dissertation deals with both informal and formal seed sources with focus on the informal seed of non-indigenous major food crop –maize. This study combines a range of data sources including household socio-economic data, case study, secondary data and seed sample. The data analysis utilizes the description of socio-economic data and agronomic data (seed quality analysis) that usually overlooked. This study employs the Logit Model in analyzing the factors for adoption of improved varieties including new variables of practical and theoretical importance unlike the previous studies which dealt either with adoption studies or descriptive analysis of a particular seed system. The selection of maize has a profound implication in understanding of cross-pollinated as well as self-pollinated crops in seed system understanding of smallholder farmers in drought-prone areas. Both self-pollinated and cross-pollinated crops do not attract the formal seed system since their seed can be recycled for multiples of years. Thus, the information obtained from maize is as well valid for other self-pollinated and cross-pollinated varieties grown in drought-prone areas. The study on maize is a unique that it is non-indigenous essential crop while almost all related studies focused on indigenous crops.

1.7 Organization of the dissertation

This dissertation is organized into seven chapters. While the present chapter has highlighted the background of Ethiopia's seed issues, objectives and the research questions. Chapter 2 describes agro-ecology of the CRV of Ethiopia including its related crop production constraints. The chapter point out how drought-prone area crop production is highly uncertain to plan before the planting time due to its erratic rainfall. Similarly, the chapter draws attention to getting access to appropriate types of maize varieties that can respond to the existing conditions to mitigate the major challenges of drought facing maize production.

Likewise, this chapter presents the methodology pursued in collecting and analyzing data. A range of data collection methods including farm household survey, seed sample and case studies were employed while descriptive statistics and the Logit Model were used for the data analysis. The specific methodologies utilized are highlighted in each chapter prior to presenting results. Chapter 3 explores and highlights major literature about the subject mainly dealing with seed access and seed sources, adoption of improved varieties and participatory research under the area of the broader seed system. Following Chapter 3, the subsequent three chapters bring in field study results and their discussions. Chapter 4 through 6 strives to answer the research questions presented under the dissertation objectives. That is the ongoing agricultural development issue of numerous developing countries including Ethiopia's access to seed and improved variety adoption. In Chapter 4 and 5, the analysis was made by considering seed access and improved variety adoption decision. Farmers with better access to the source seed are expected to have higher chance of adoption. Access to seed can be enhanced by improving local availability of improved seed that would usually be limited in drought-prone areas. Chapter 6 approaches the analysis from farmer point of view in improved seed supply.

Chapter 4 discusses farmers' seed access behavior to OPV maize in the CRV of Ethiopia. Farmers access seed from four major sources: their own harvest, another farmer, informal seed markets (ISM) and formal source. Dynamicity in the maize seed system has been observed which goes beyond the farmers' own harvest or formal sources where farmers approach different seed sources including ISM for different objectives such as obtaining new variety. This chapter also presents quality analysis results for the seed obtained from informal sources, an aspect usually overlooked in similar studies beyond simple claims that seeds from informal sources are poor quality. The chapter further presents comparative summary of formal and informal seed sources of maize referring to drought-prone areas of CRV of Ethiopian which can be applicable to other countries with similar agro-ecologic and socio-economic conditions in SSA and elsewhere.

Chapter 5 analyzes the factors affecting adoption of improved OPV of maize. A number of factors influencing adoption of improved OPV of maize were taken into account based on literature of adoption studies and local context. In this study, new factors and other factors not commonly covered in previous literature are included in a modified form. For instance, factors that were not captured in the previous studies like farmer participatory research in this case farmer research group (FRG) and drought encounter frequencies were included in this study due to its importance in the study area and in numerous SSA. Chapter 6 addresses the contribution of farmer-group based seed production and dissemination taking the case of FRG in OPV of maize seed production and distribution. FRG-based seed production and dissemination can be one feasible approach for seed provision to farmers in drought-prone areas. Seed provision of improved varieties in drought-prone areas has been an ongoing agricultural development issue. The availability of improved variety seed will enhance farmers' access to the seed and a new variety adoption. The issue of creating sustainable linkages between research and farmers in the development of such local seed production to local business needs to be considered to make a plausible statement about sustainable seed production. Furthermore, to what extent the client farmers appreciate the FRG, the appropriate number of FRG member for significant impact, and the communication strategy and essential characteristics of FRG in enhancing improved variety adoption remain to be dealt with in further studies. Chapter 7 provides the main findings and draws implications for policy recommendations.

CHAPTER 2

METHODOLOGY

This chapter describes the agro-ecology of East Shewa Zone focusing on the drought-prone CRV area where the study was conducted. After highlighting the agro ecologic condition, data collection and data analysis method pursued and the theoretical framework in employed in this research are explained.

2.1 Description of the study area

The field study was conducted in East Shewa Zone, CRV of Ethiopia. East Shewa Zone is one of the 18 zones of Oromia Regional State, Ethiopia. Adama, capital of the zone, located in the CRV about 100 km to the southeast of Addis Ababa. CRV of Ethiopia is the area between Yarer Fault in the western edge to Abijata Lake on the southern edge extending to Mieso, in the East. The soils of the area are volcanic parent material of low water holding capacity.

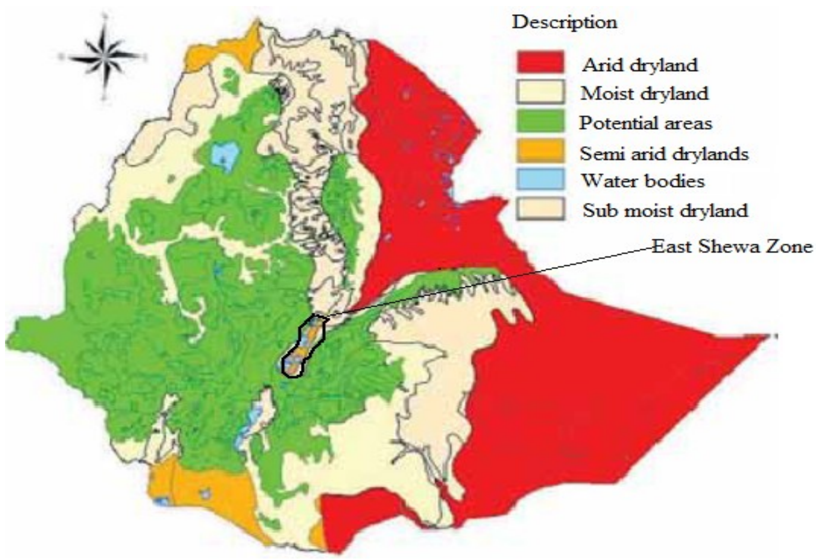


Figure 2-1 Map showing agro-ecologies of Ethiopia
Source: Adopted from Ministry of Agriculture and Rural Development

Agro-ecology

The study area is characterized by erratic and unpredictable rainfall. Drought-prone agro-ecology, where inter-annual rainfall variation is high (Table 2-1). The principal agro-ecologies of the study area constitute hot to warm semi-arid plains, semi-arid lakes and rift valley semi-arid lakes, sub-moist lakes, rift valley and tepid to cool based on the 18 major and 47- sub-agro-ecology classification on Ethiopia (Ministry of Agriculture, 2000).

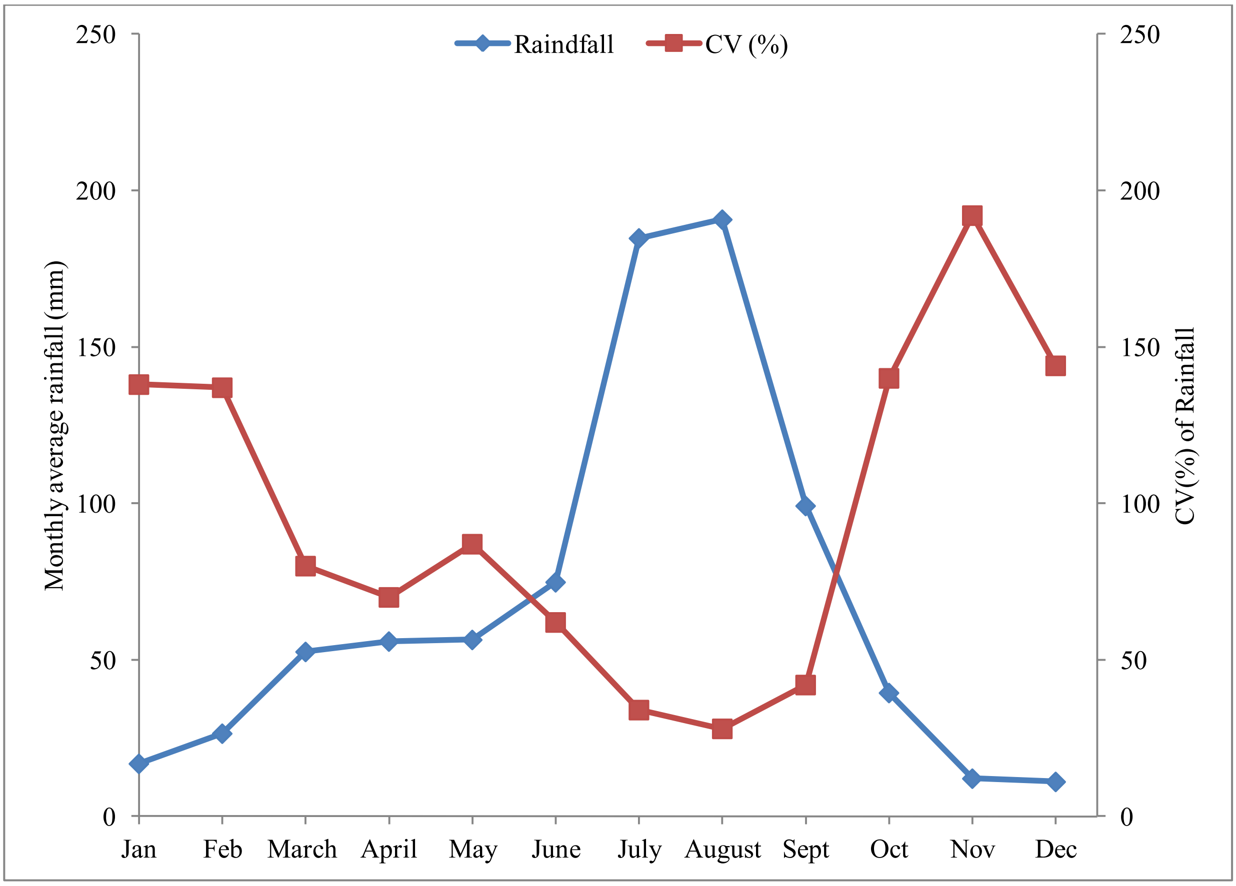
Hot to warm semi-arid plains represented by the semi-arid plains, lakes and rift valleys, mountains and plateaus. This is the area located northeast of Alem-Tena. Maize, tef, sorghum and common bean are the major food crops cultivated.

Semi-arid lakes and rift valley represent Alem-Tena, Adama and Bulbula areas that receive annual average rainfall of 650 to 700 mm and temperature 16 to 28^{O}C. In this agro-ecology, the effective length of crop growing period is 45 to 60 days. In this sub agro-ecology, mainly mixed farming of crop and livestock production is practiced. Maize, common bean and sorghum are the major crops cultivated.

The major parts of Adama, Boset and Dugda districts are included in the sub-moist lakes and rift valleys, tepid to cool sub-Agro-ecology. The crop-growing period in this agro-ecology lasts for two to four months and the precipitation of 700 to 1100 mm of. Most of the study areas lie within this agro-ecology The major farming system of this area is a mixed crop and livestock production under rainfed condition where irrigation horticulture and floriculture are practiced in the lakes and rivers basins.

Rainfall pattern

The distribution of rainfall fluctuates over space and time in the CRV. The precipitation considerably varies from year to year. Relatively reliable moisture is received for two months (July and August). The monthly rainfall data at Melkassa Agricultural Research Center (MARC), located in the heart of CRV is indicated (Figure 2.2). The onset of rainfall is important in decision making about what crop and varieties to grow by a farm households. The issue is particularly important for maize because a longer growing period is needed as compared to other major crops grown in the area and maize planting is done using the first moisture of the season. Planting of late to medium maturing variety maize starts in April if the rain starts early. If the moisture in April is not sufficient, planting is postponed. Medium and late maturing varieties are planted in May and June. Moisture availability at planting is a critical issue for decision making what type of maize variety to grow though the intermittent moisture stress is also another constraint. During the recent 35 years, 1977 to 2011, the average rainfall at MARC was 820 mm (Table 2-1). The main issue is the fluctuation of the amount of precipitation over time and space except in the two main months of the rainy seasons in July and August. In the remaining months, the amount of rainfall is small and inter-seasonal variation is high (for instance the coefficient of variation is 28% (in August) to 192% (in November). Thus, the moisture is insufficient to support crop growth in most of the months in the CRV. The reliable crop-growing period is when the line of rainfall chart is above the line of its coefficient of variation that is between June and September (Figure 2-2).



Note: Coefficient of variation (CV)

Figure 2-2 Monthly average rainfall distribution and its CV at MARC, CRV of Ethiopia, 1977 to 2011

Source: MARC Agro-meteorology Rainfall Data, 2012

Table 2-1 Average monthly rainfall distribution at MARC, CRV of Ethiopia, 1977 to 2011

Month	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
1977	98	2	64	176	76	212	129	154	100	248	53	0	1310
1978	3	143	5	49	13	53	86	178	108	13	0	35	683
1979	59	13	60	14	111	156	198	143	85	22	0	15	876
1980	20	0	7	25	26	99	189	181	71	47	4	0	669
1981	0	63	134	50	1	5	250	151	136	11	1	0	800
1982	11	20	10	40	52	29	135	228	45	69	95	7	740
1983	0	40	56	46	204	25	174	137	125	10	0	1	818
1984	0	0	14	1	81	40	153	153	99	11	0	16	568
1985	6	0	14	43	81	27	280	262	79	3	1	0	796
1986	0	56	68	56	26	107	149	90	78	11	0	3	642
1987	0	13	89	44	149	6	102	228	61	3	0	0	695
1988	35	14	2	30	26	71	189	186	132	14	0	5	704
1989	0	16	35	62	2	84	148	272	67	10	0	7	702
1990	0	103	59	81	12	7	124	222	99	13	0	0	720
1991	0	47	111	10	56	131	236	235	89	8	0	2	924
1992	6	9	0	43	11	110	149	247	98	47	6	56	781
1993	40	46	0	162	86	62	244	126	58	40	0	11	874
1994	0	0	36	30	29	105	303	88	85	21	19	23	738
1995	0	29	73	115	10	54	159	194	84	2	0	14	733
1996	27	0	152	56	71	95	125	167	140	0	5	0	837
1997	14	0	46	22	3	112	231	154	67	140	15	0	804
1998	16	57	51	49	40	22	255	326	99	132	0	0	1047
1999	8	0	21	0	3	135	239	177	82	127	0	2	793
2000	0	0	9	40	78	78	263	180	65	81	43	17	854
2001	0	7	97	27	138	128	197	162	52	0	1	12	821
2002	43	10	58	58	50	24	75	158	46	6	2	21	549
2003	18	24	128	75	6	53	189	188	161	2	3	53	899
2004	52	2	94	73	2	69	189	140	110	68	20	5	823
2005	23	2	85	100	95	82	117	232	130	5	12	0	882
2006	11	45	59	95	35	61	209	217	139	24	0	34	929
2007	49	41	75	88	100	62	171	239	228	3	10	0	1065
2008	0	0	1	74	98	46	334	211	122	93	75	0	1053
2009	53	0	0	48	53	54	150	139	34	100	1	48	679
2010	0	123	90	32	115	107	210	294	114	0	5	3	1093
2011	0	2	38	46	38	112	116	218	188	0	52	0	810
Mean	16.8	26.5	52.6	55.9	56.4	74.8	184.7	190.7	99.2	39.4	12.1	11.0	820.2
SD	23.3	36.1	42.3	38.9	49.1	46.7	62.2	54.1	41.3	55.2	23.2	15.9	156.1
CV%	138	137	80	70	87	62	34	28	42	140	192	144	19

Note: Standard deviation (SD)

Source: MARC Agro-Meteorology Rainfall Data, 2012

Data show that where the annual rainfall drops below the average roughly by more than one standard deviation crop production tends to be highly stressed[11]. This happened for ten years in 35 years that is once every three years where 1984, 2002 and 2009 presented the extremes. This in line with what farmers claimed during group discussions and later confirmed from survey data showing about 3 years droughts stress in every ten years and one major drought occurs once every 10 years (Figure 2-3).

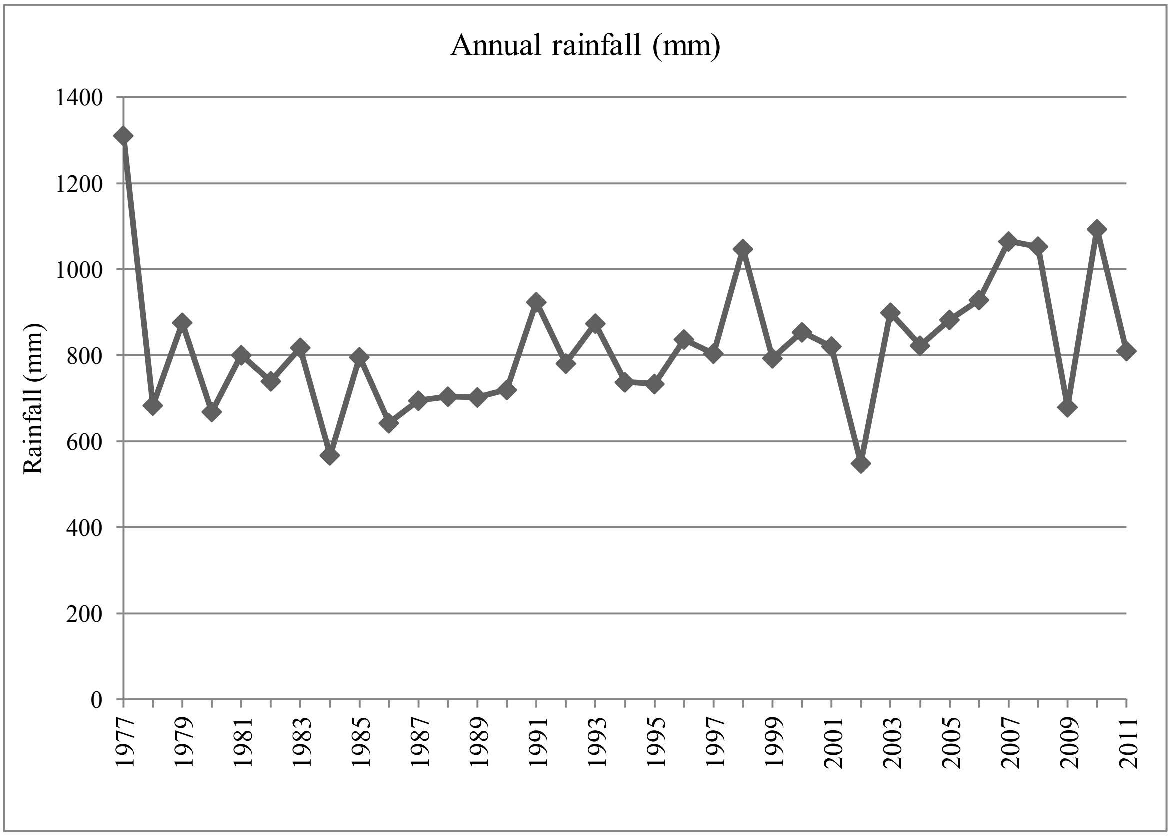


Figure 2-3 Annual average rainfall distribution at MARC, CRV of Ethiopia, 1977 to 2011

Source: MARC Agro-Meteorology Rainfall Data, 2012

[11] The average rainfall between 1977 and 2011 was 820.2 mm (standard deviation 156.1 mm). The annual rainfall below 664 mm (that is one standard deviation from the average) has strong influence on crop production. The severe drought years 1984, 1986, 2002 and 2009 were received 568 mm; 642 mm, 549 mm, and 679 mm precipitation respectively (see Table 2-1).

Crop production

The major crops produced in East Shewa Zone are tef, maize and wheat (Table 2-2). Tef is produced along the whole agro-ecologies of the zone while wheat is dominant in high moisture area. Maize and common beans are predominantly grown in low land (low and erratic) rainfall areas. Maize is the major staple crop for farm households and the urban poor. Whereas common bean is a cash crop and food crop in the drought-prone parts of the zone. Sole cropping is the predominant cropping pattern though maize and common bean intercropping is seldom practiced.

Table 2-2 Number of farm households, area of major crop cultivated and productivity of the major crops in East Shewa Zone, Ethiopia

Crop	Number of Household	Area (ha)	Productivity (t/ha)
Tef	201,234	194,027.13	1.40
Barley	54,968	10,656.54	1.25
Wheat	112,544	55,035.46	1.78
Maize	173,703	88,826.36	2.39
Sorghum	48,677	21,064.10	2.32
Faba bean	61,795	9,726.31	1.68
Field peas	14,337	2,832.19	1.69
common bean	76,389	21,460.76	1.71
Chickpea	40,723	17,271.34	1.97
Lentils	38,680	9,982.66	1.45
Grass peas	17,413	3,086.76	1.66

Source: East Shewa Zone Agricultural and Rural Development Office records of households and major crop cultivated, 2011

An over view of certified maize seed supply in Ethiopia

The supply of basic seed[12] is the mandate of public research institutes while the Ethiopian Seed Enterprise (ESE) mainly handled certified seed provision until 2008. Recently, regional government funded seed enterprises have been started operating with the purpose of bridging the gap that the national seed enterprise was unable to satisfy. Nonetheless, both the national and the regional government seed enterprises are mainly involved in hybrid seed production while OPVs maize seed production claims a tiny share (not more than 3%).

Historically, the ESE largely used to supply seed to state owned farms in the late 1970s and 1980s, under the *Dergue* regime. After the regime changed in 1991, the enterprise extended its service to smallholder farmers whose demand was triggered by the mid-1990s extension package intervention of SG2000 later widely adopted by the government (Kassa, 2003). SG2000 was conducted identification of potential varieties and undertook demonstrations on large plots of land to show the impact. Seed and other inputs were delivered to farmers on credit through government offices.

Currently the private seed companies have a considerable market share (30-40%) (Tesfaye *et al.*, 2012) in the hybrid maize seed provision whereas the OPVs are entirely provided by the public sector. Most of the private companies use publicly−bred seed and are sub-contractors to the ESE except for the Pioneer Hybrid. Both the public and the private seed enterprises deliver their seed through the public extension services to farmers' cooperative unions for distribution and marketing (Figure 2-4). The average seed production cost of private companies is lower than that of public seed enterprises (e.g. ESE), but the marketing

[12] According Organization for Economic Cooperation and Development (OECD) seed classification, basic seed class is the seed from which certified seed is produced for grain production. The equivalent terminology by Association of Official Seed Certifying Agencies (USA) is foundation seed.

and the promotion costs are prohibitively high for them (Alemu *et al.*, 2008). Moreover, OPVs are not attractive to the private seed companies because the farmers can recycle the seed for multiple years once they have obtained the seed. The public seed enterprises are expected to make profits as well as to meet the needs of the farming community. Nonetheless, they are unable to satisfy the needs of the smallholder farm households residing in the country's' highly diversified and risk prone agro-ecologies.

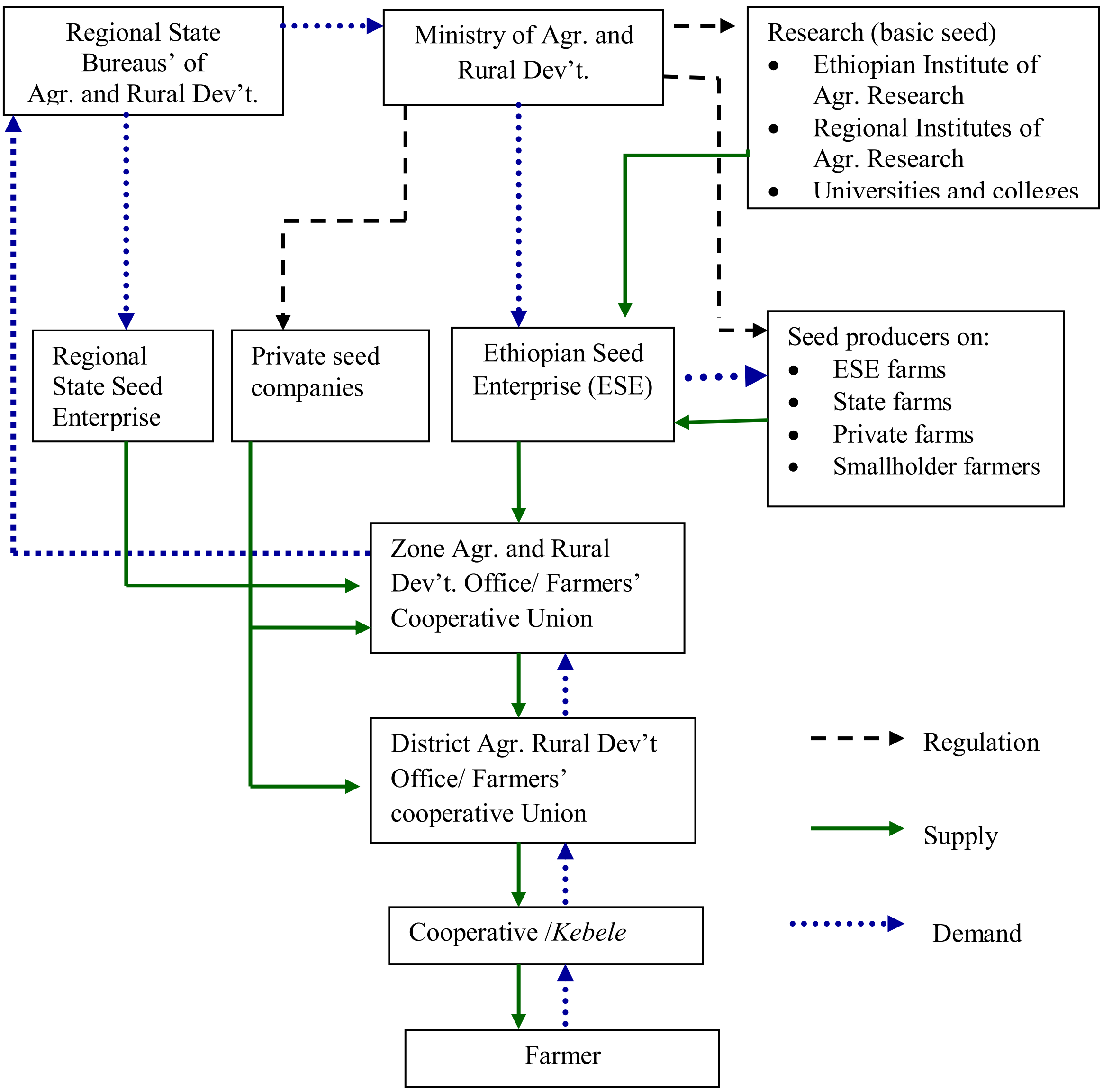


Figure 2-4 Organization of the formal maize seed system in Ethiopia

Source: Modified from Alemu *et al.*, 2008

In drought-prone agro-ecology, early to medium maturing OPVs are recommended. The production of certified seed of those varieties is stagnant or declining, however. For instance, the supply of OPVs seed has steadily declined at -1.9% per year between 2001 and 2009. In contrast, hybrid maize average annual seed production increased at 8.7% over the same period (Figure 2-5). Moreover, old varieties such as Awassa-511 and Katumani that were released in the early 1970s are the predominant, signifying a slow seed replacement rate in the early to medium maturing OPVs maize in Ethiopia certified maize seed supply. The slow seed replacement rate is partly explained by the number of maize varieties released for drought-prone agro-ecologies particularly in the 19980s and the 1990s. During those days and before, focus in maize research was placed on high rainfall areas while low genetic base for early maturing and drought tolerant varieties and less established selection criteria were plausible reasons mentioned for the modest attention given to drought-prone agro-ecology maize breeding (Nigussie *et al.*, 2001).

Generally, few crops and varieties dominate the supply of certified seed provision in Ethiopia. Wheat and hybrid maize seeds constitute the highest proportion of the seed supplied (Table 2-3). From the total amount of the seed produced by the ESE between 2001 and 2009, the average share of wheat seed was 64%, hybrid maize 20%, OPV maize 3% and all other crops 13%. The amount of maize seed supplied by the ESE between 2001 and 2009 is shown in Figure 2-5.

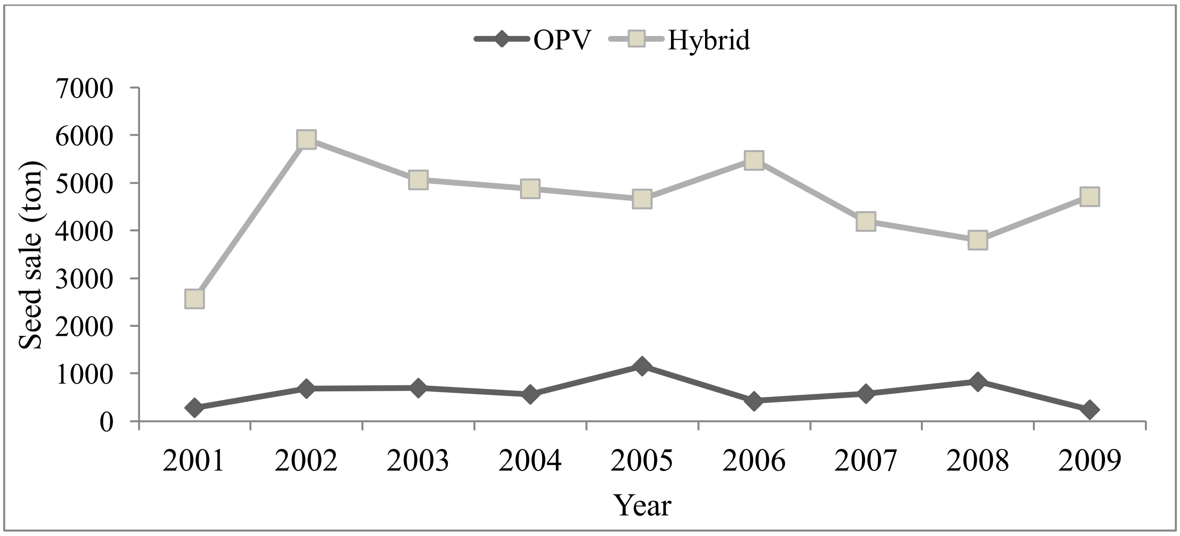


Figure 2-5 ESE annual certified OPV and hybrid maize seed distribution trend, 2001 - 2009

Source: ESE maize seed sales records, 2010

Table 2-3 Certified seed distributed by the Ethiopia Seed Enterprise, 2001 to 2009

Crop	Amount of seed (10 ton) and year								
	2001	2002	2003	2004	2005	2006	2007	2008	2009
Wheat	79.35	910.63	1389.37	642.34	1158.88	756.02	1217.48	1232.15	2213.63
Maize hybrid	228.56	522.89	436.89	431.57	350.82	505.54	361.57	297.4	447.1
Maize OPV	28.27	68.44	69.65	56.34	115.68	41.94	57.77	82.76	24.24
Others‡	24.08	64.36	185.46	234.87	266.93	241.13	302	454.6	366.08
Total seed	360.26	1566.32	2081.37	1365.12	1892.31	1544.63	1938.82	2066.91	3051.05
% wheat & maize	93%	96%	91%	83%	86%	84%	84%	78%	88%
% wheat & hybrid maize	85%	92%	88%	79%	80%	82%	81%	74%	87%

Note: ‡Others are: barley, tef, faba bean, haricot bean, soya bean, chick pea, lentil, line seed, sorghum, cotton, pepper, onion, potato, apple seed, *sinar* (triticale)., finger millet, rape seed, sesame and rice.

Source: ESE seed sales records, 2010

Maize varieties recommended for drought-prone areas of Ethiopia

The beginning of an organized maize research dates back to the 1950s in Ethiopia with the establishment of agricultural colleges. Since then 42 varieties of maize were released among which 11 of them are recommended for drought-prone areas. Seven out of the 11 of the varieties were released within the last one-decade and a half. However, the adoption those released improved varieties is mild. Still late maturing varieties that are susceptible to drought stress are grown. Close analysis and understanding of the seed access and adoption decision is a point of empirical as well as theoretical importance towards improving smallholder farmers' adoption of improved varieties. Description of the varieties recommended for drought-prone areas of Ethiopia is discussed in detail in Chapter 4 Section 4.3 (see also Table 4.3).

Livestock farming

Livestock farming is an essential agricultural activity that supports crop production in the area. Livestock provide draught labor, food and income for the farm households. The major livestock includes cattle, donkeys, and small ruminants. Oxen are critical resource for land preparation and the average oxen owned per household is 1.7 slightly less than a pair-what is required for land preparation. Lack of a pair of oxen restricts a farm household in undertaking important land preparations particularly as rapid responses are required to rainfall condition. This is particularly critical for the 40% (21% do not have ox and 19% have only one ox) of the farm households that do not have sufficient oxen draught power (Table 2-4). Repeated droughts have affected farmers and have led them to emergency sales of livestock including farm oxen[13]. Likewise, maize and livestock farming are highly interrelated. Maize

[13] Farmer repeatedly mentioned shortage of oxen to be a critical problem in crop production. They indicated, during group discussion (during field study of Aug.-Sep 2010) that the number of cattle is declining rapidly from time to time due to recurring droughts.

stalk provide fodder for livestock. Farm households who own larger livestock tends to use higher seeding rates. That is because the farmers feed to their animals by thinning from maize field and they want to get higher amount of fodder during the dry season as well.

Table 2-4 Ox ownership of farm households in the study area

District	Number of ox owned, number and per cent of farm households									
	0		1		2		>2		Total	
	number	%	number	%	number	%	number	%	number	%
Adama	20	30	13	19	31	46	3	4	67	100
Boset	13	21	15	24	26	41	9	14	63	100
ATJK	5	7	16	22	26	36	25	35	72	100
Dugda	19	25	9	12	29	39	18	24	75	100
Total	57	21	53	19	112	40	55	20	277	100

Source: Author field study, 2011

Land use

The land use of East Shewa Zone is composed of cultivated farm land, grass-land, social service areas, forest and shrub, water bodies, mountainous and rocky, and others (gorges, swamps and marshes) (Table 2-5). There is a low opportunity for farmland expansion in the zone; rather the land is shrinking due to urbanization[14]. Thus, the likely source for productivity increase in the near future will be intensification of crop production through use of inputs such as improved variety seeds, irrigation and fertilizers.

[14] According to CSA data, the crop area of East Shewa Zone was 511,695 ha in 2006 and 434,451 ha in 2011 annually shrinking at the rate of -2.69%. From the author's observations, there are several agricultural *Kebele* were included to the urban areas.

Table 2-5 Land use type and its area in East Shewa Zone, Ethiopia

Land use type	Area (ha)	Percent
Farm land	477,695.90	51.8
Grass land	102,773.49	11.2
Social service (residential) areas	56,258.22	6.1
Forest and shrubs	42,684.91	4.6
Water bodies	34,069.10	3.7
Mountainous and rocky	43,321.00	4.7
Others (gorges, swamps and marshes)	164719.27	17.8
Total	921,521.89	100.0

Source: East Shewa Zone Agricultural and Rural Development Office land use records, 2010

Maize in the farming system of drought-prone areas

In the eastern Africa, maize constitutes 16% of crop production in drought-prone agro-ecology where rainfall is unreliable and crop production is a risky (M'mboyi *et al.*, 2010). Maize is a vital food crop in southern and eastern Africa. Likewise, in Ethiopia, maize is the first in production and the second in area planted to food crops (Central Intelligence Agency, 2011). Two-thirds of the farming population in Ethiopia annually undertake maize production by allocating about 1.768 million ha (Central Statisical Authority (CSA), 2010). Maize is particularly essential in drought-prone agro-ecologies of major maize grower districts in East Shewa Zone where it occupies 46% of the farmland and 60% of the annual average grain production of farm households (Table 2-6). Maize has the potential of unlocking productivity growth in Ethiopian agriculture in particular, and the SSA at large, because of its high potential yield increase to feed the growing population in the region.

Table 2-6 Average area and average production of major crops of surveyed farm households

Crop	Area/yield	Adama	Boset	ATJK	Dugda	Total	Per cent total
Maize	Area (ha)	0.625	1.00	1.575	1.10	1.075	46
	production (t)	1.630	3.4	3.50	2.05	2.63	60
Common bean	Area (ha)	0.300	0.65	0.45	0.425	0.45	19
	production (t)	0.460	1.16	0.50	0.78	0.71	16
Tef	Area (ha)	0.675	0.35	0.175	0.575	0.45	19
	production (t)	0.790	0.41	0.08	0.37	0.40	9
Other crops‡	Area (ha)	0.400	0.25	0.225	0.575	0.375	17
	production (t)	0.940	0.48	0.31	0.83	0.64	14
Total	Area (ha)	2.00	2.25	2.43	2.68	2.35	100
	production (t)	3.82	5.45	4.39	4.03	4.38	100

Note: ‡Other crops include wheat, barley, peas, lentil and chickpea

Source: Author field study, 2011

OPVs of maize are recommended in drought-prone area of CRV and elsewhere (MoARD, 2004; MoARD, 2006; MoARD, 2008) since they are genetically heterogeneous and are differently responding to the erratic moisture conditions. Moreover, the seeds of OPVs can be recycled up to five years without significant yield losses (Venkatesan, 1994). On the other hand, hybrids are also successfully grown in some parts of the CRV areas during sufficient moisture years or using irrigations. The issue with hybrids in drought-prone areas is that it is more susceptible to moisture stress particularly at flowering due to its uniformity that highly reduces its yield. Furthermore, the productivity of using its grain for seed significantly affect yield and requires replacing seed every year (Pixley and Bazinger, 2002).

Research on maize in Ethiopia has been intensively underway since the establishment of the Ethiopia Institute of Agricultural Research in 1966. A number of varieties were released and disseminated. The rate of those varieties adoption, however, has been low. Maize breeding was focused on high rainfall areas variety development and the drought-prone areas were marginalized in the beginning of maize research though it has given research attention in recent years.

Likewise, the research and dissemination approach in maize has taken participatory method such as mother and baby trial (Abebe *et al.*, 2005) and FRG approach. In the FRG approach, farmers in collaboration with researchers and agricultural experts select from released varieties or near to the variety release stage as that of participatory variety selection (PVS). The unique characteristic of this approach is that it includes seed production and dissemination beyond variety selection practice. The approach has been underway for about ten years in the CRV of Ethiopia at varying intensities. There is a paucity of information available, however, to understand the influence of the FRG practice in adoption of improved varieties in drought-prone areas and the contribution of FRG approach in improving farmers' access to improved seed.

2.2 Data collection method

A field survey is the principal method of data collection. Data (e.g., farmer resource endowments-human and physical resources, seed sources, varieties grown, etc) were gathered from farmers (see Table 2-8 and Annex 1). Supplementary information was gathered from grain traders, researchers and seed experts. Structured questionnaires were used for household interviews while guidelines were employed to collect information from the other stakeholders. Seed samples were collected from farmers, traders, research center and farmers cooperatives in the area that represent the formal and informal seed sources and quality of the seeds were analyzed. For the questionnaire interview, the farmers were randomly selected while the traders were selected on the base of convenience and information obtained from farmers. The detailed procedures pursued in data collection is presented as follows.

Sampling method of farm household head interview

Multi-stage sampling was employed in this study. East Shewa Zone was purposely selected because its major maize growing area located in drought-prone agro-ecology. The zone is also important in maize production in terms of the area allocated and the households involved in maize production[15] . Four districts namely: Adama, Boset, Dugda and ATJK were selected based on their maize production area.

The respondent farmers from each *Kebele* [16]were randomly chosen (Table 2-7). The total number of farmers interviewed was fixed based the on statistical requirements for Logit Model adopted. Accordingly, 277 farm household heads were interviewed. The household heads were selected because they are the ones who make day-to-day decisions on farming activities representing the household[17]. The number of farmers was proportionally assigned to each district. Then, the respondent farmers were selected using rural land use taxpayers list of 2010. The field research was conducted between May to June 2011 during the planting time.

[15] According CSA, in 2011 among 270,818 cereal crop producer farmers in East Shewa Zone 173,703 (64%) grow maize.
[16] *Kebele* is the lowest administrative tier in Ethiopia
[17] From group discussion with farmer in Aug-Sep. 2010, the household heads make decisions in consultation with household members particularly the spouses and adult family members and grown up children.

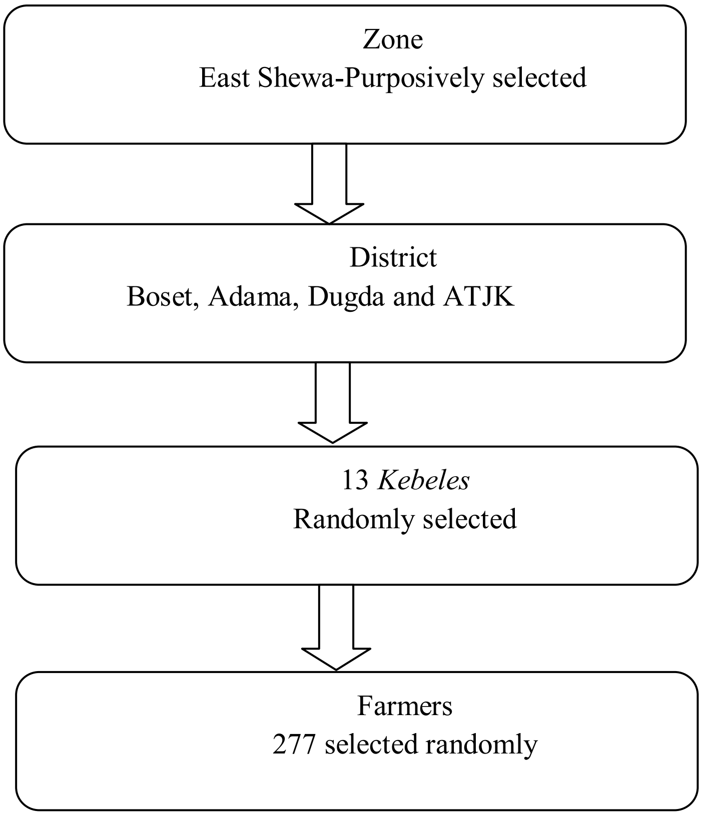


Figure 2-6 Multi-stage sampling procedure used in farmer selection for interview

Source: Author

Table 2-7 Population, number of farm households and *Kebeles* selected for the interview in the districts of study

District (a)	Rural population (b)	Number of farm households (c)	Average land holding per household (ha) (d)	Name of *Kebele* selected and number of farmers interviewed (e)
ATJK	121,943	20,883	2.6	Marabe-Mermersa, Dibibisa- Waculafa, Bokoji-Dewero, Bato-Degaga (n= 72)
Dugda	108,635	21,139	3.2	Delecha, Giraba- Korke - Adi, Baymo -Gusa (n=63)
Boset	114,687	19,012	1.7	Dongore-Furda, Sara-Arada, Dire-Degaga Derara (n=75)
Adama	129,003	18,045	1.5	Anano-Shisho, Habule-Gutumumma, Edo-Gojola (n=67)
Total	474,268	79,079	2.26	277

Source: (a)-(d) East Shewa Agricultural and Rural Development Office population and land holding records, 2011 and (e) Author field study, 2011.

Survey tools and the data collected

The principal data collection method was a questionnaire interview of farm household heads a case study of seed grain traders, researchers and seed experts' producer farmers group. The data were collected using structured questionnaires developed on the basis of the research objectives, research questions through discussion with groups of farmers and consulting literature. Prior to conducting the interview, the questionnaires were pre-tested for accuracy and consistency. The data included about the characteristics of household head, landholding and livestock holding, crop area and their production, seed sources, terms of seed acquisition, household resources etcetera (Table 2-8 and Annex 1). Supplementary data on annual certified seed production and distribution by the public seed enterprises were obtained from the ESE. In addition, documents of seed regulations, statistical abstracts and grey literatures were consulted.

Table 2-8 Topics included in the farm household questionnaire interview survey

Topic	Description
House hold head data	district, *kebele*, name, age, gender, year of schooling, household size
Economic characteristics	farmland holding size, livestock holding, non-farm farm activity
Crops produced	types of crops grown (area, production in 2009 and 2010) maize production (variety, area, seed source), utilization of the production (sale, seed and consumption in 2009 and 2010)
	sources for the maize seed obtained, terms of acquisition, time of acquisition, maize seed distributed
Maize seed management	selection for seed, selection criteria, storage method maize for seed and grain, seed production experience of isolated field
Information source for seed	distance from development agent office, distance from the nearest grain market, participation in field day

Source: Author summary of topics of questionnaire, 2011

The case of FRG based improved OPV maize seed production and dissemination

In line with farm household survey, a case of FRG based improved OPVs maize seed production and dissemination is included in the data collection and analysis. The data were collected from the member of FRGs who were participated in variety selection then seed production and distribution activities in the study area. Data on the quality of the seed produced, terms of the seed exchange and the benefit and cost of seed production was gathered, described and analyzed. The detail discussion of the methodology is presented in Chapter 6.

Seed sampling and seed quality analysis

In this study, the quality of the seeds obtained from the seed sources was analyzed. Physical and analytical quality characteristics were tested. These quality features are important for maize in the study area areas and elsewhere. Farmers primarily refer to these quality aspects when they are explaining about seed quality. Households in drought-prone areas do not want or need seed to meet all the standards that International Seed Testing Association (ISTA) based certification systems provide; whilst the physical purity of seed and good germination percentages are valued and characteristics (Tripp, 1994). They are also the basis for improving seed quality at the farm household level as well as developing basic standards for regulation (Tripp and Rohrbach, 2001). The detail procedures of seed analysis are discussed in Chapter 4 Section 4.2.

Seed samples were collected from the interviewed farmers, research center, informal seed markets and farmer cooperatives. One kilogram of seed of maize was collected from the sample farmers. According to the Quality and Standards Authority of Ethiopia (2000c) a 100 kg weight of seed is taken as the basic unit and small containers are combined to make sampling unit. For example, 20 containers of 5 kg or 33 containers of 3 kg are combined to constitute one basic unit. In the case of this study, the farmers are smallholders and they store their seeds mainly in 50 to 100 kg containers (sacks) hence 1kg of composite sample is considered sufficient because 900 grams is enough for the quality analysis (National Seed

Indutry Agency, nd). For others sources: seed enterprise, research and farmers' cooperative 2 to 4 kg were obtained depending on the volume of the seed stored[18].

Data analysis

SPSS Statistics 17.0 was the main data management and data analysis used. The data collected were analyzed using descriptive and analytical statistical tools. In Chapter 4 and Chapter 6, descriptive statistics were used including non-parametric test of association namely chi-square tests. In Chapter 5, both descriptive statistics and Logit Model were employed. The Logit Model was adopted since the dependent variable is dichotomous while the independent variables are the combination of both dichotomous and continuous variables. Logit Model is based on cumulative logistic probability function and its interpretation is easier than other models such as Probit Model. The Logit Model helps the prediction of probability that a farmer does adopt or not adopt a technology based on given variables.

2.3 Theoretical framework

The conceptual approach to analyze the adoption of improved variety and farmer seed access behavior, presented in Chapters 4 and 5 is based on the farm household production theory (Mendola, 2007; Ellis, 1992) and the literature of adoption of agricultural innovations (Feder *et al.*, 1985; Feder and Umali, 1993). A farm household head's decision to adopt a new or improved agricultural technology in a preference to the other (or old) technologies depends on different factors. Resource endowments such as socio-economic and demographic characteristics, institution factors (extension, credit, market service) are commonly mentioned

[18] One primary sample is recommended for each 500 kg samples according to Quality Standards of Ethiopia (2000).

(Feder and Umali, 1993; Feder *et al.*, 1985; Kaliba *et al.*, 1998a). The essence of those theories and literature are presented as follows.

Smallholder[19] farmers in drought-prone agro-ecology struggle under complex and risk prone farming. A peasant farmer operating under uncertainty induced by drought is expected to be cautious and exhibit a risk aversion behavior in his or her decision-making because drought poses a threat to his or her crop production. Thus, such a farmer become risk averse because he or she has to secure household needs from his or her current production otherwise faces starvation. A risk averse farmer prefers a consistent crop production scenario to high production scenario with high fluctuations. A farm household production model based on the assessment of such a feasible decision making process is known as safety-first model of choice under uncertainty (Ellis, 1992). A household head is expected to ensure the survival of the household members and thus strives to avoid risks in his or her production so as not to fall below a subsistence level. The safety first model is a positive model that captures certain behaviors that is omitted from expected utility maximization theory. The utility maximization theory does not highlight problems such as extreme poverty, insecurity, deprivation and environmental challenges that characterizes a peasant lives in most parts of the world (Mendola, 2007). The model of profit maximization rather disregards the effect of household behavior under condition of uncertainty and the risk involved in peasant production and the context in which peasant production takes place. Most of these models are static and assume prospects are certain or, a farm household is risk neutral. On the other hand, the safety first model explicitly captures the aspects of a risk prone environment and the poverty of peasant household. Risk preference is influenced by the resource constraints and market imperfections

[19] The term smallholder farmer and peasant farmer are interchangeably used in this section (Section 2.4) in order to apply the original term peasant farmer in the theory of peasant household. In other sections, the terminology smallholder farmer is employed since it designates the farm size owned by the farmer beyond use of household labor as that of peasant farmer and the term is commonly used in Ethiopia and contemporary literature.

faced by the poor farm households. Hence, resource poor farm households are expected to select low risk and low return activities.

A smallholder farmer in response to risk takes different mechanisms of *ex ante* risk management where there is a danger of crop failure due to environmental risks such as drought and where there is no institutional risk management mechanism in place. *Ex ante* risk management strategies involve shaping the risk by exercising caution in making production decisions. In risk prone areas, a farm household is expected to adopt activities that are more favorable in terms of risk management. Cultivating drought tolerant or early maturing crops and varieties, adopting intercropping and perusing off-farm activities are included.

The technology transfer approach of improved varieties, inorganic inputs and accompanied agronomic practices were the main strategy in the linear top-down agricultural development model (Chambers and Jiggins, 1987). This model has been widely utilized for quite a long time inspired by the achievements of the Green Revolution of rice and wheat cultivated under homogenous agro-ecological conditions, simple cropping system; abundant complementary inputs and low risk climatic conditions. The top down technology transfer approach, however, has been observed to be a poor approach for resource poor farmers operating under diverse agro-ecological conditions with complex cropping system, poor or absent inputs markets and high risk climatic conditions (Ellis, 1992).

The linear worldview and method of formal science observed to be slow and inefficient means of achieving wide spread improvements in productivity in drought-prone area farming (Chambers and Jiggins, 1987). Transfer of genetic materials and ideas from farmer to farmer, from scientist to farmer, and between research and other stakeholders for sustainable food production is a prerequisite. In the process of technology flow from research to farmer or from farmer to farmer, a farm household adoption of improved varieties has been of special economic interest since it is commonly believed that the introduction of innovation increases productivity (Feder *et al.*, 1985). An innovation is a technological factor that advances the production frontier. It can be an idea or object perceived new by the adopter. Because of perceived newness there is often perceived or objective (or both) uncertainty about the result an innovation. However, uncertainty diminishes overtime through acquiring of information and developing experience. In the case of divisible agricultural technologies, such as improved varieties for instance, farmer allocate small piece of land for experimentation that will reduce uncertainty (Feder, 1980). In this aspect, farmer participatory research offers an opportunity for smallholder farmers to choose among varieties in their own environment that better suits their needs and conditions (Ceccarelli and Grando, 2007; Witcombe *et al.*, 1996). Chapter 6 of this dissertation looks at a case of a farmer research group in the improved variety maize seed production and dissemination for smallholder farmers' access to seed and improved variety adoption in the drought-prone area of Ethiopia.

2.4 Summary

This chapter has pointed out the factors that shape the crop production by presenting major climatic condition and agro-ecology characteristics of the CRV of Ethiopia. Farmers face a significant crop failure due to recurrent rainfall shortage every three years where every ten years a severe drought occurs.

The theoretical framework of the study is based farmers technology adoption decision and farmhouse hold model. Farmers' adoption studies highlight that farmers make adoption based on resource-endowment, institutional and agro-ecologic factors. A farm household head decision making may assume models such as utility maximization in perfect market and safety-first model in drought-prone area. In this study, however, safely first model is taken into account since the farmers in the CRV area are making decision under uncertain condition among which adoption of drought tolerant and early maturing crop variety adoption is taken as an option to secure subsistence production for the poor household.

Adoption of drought tolerant variety help mitigate crop failures. In this respect, understanding what factors influencing the adoption decision of improved crop variety maize is crucial. This point is of particular interest since the adoption of improved varieties is low in risk prone area farming. There is paucity in the literature concerning such risk prone agro-ecology. Maize is an essential to all farm households in drought-prone area where open-pollinated varieties are dominantly grown and research recommends improved OPVs of maize. Livestock keeping is vital in crop production where particularly oxen ownership is of critical important.

The study employed a range of data gathering and analysis method. Farm household survey was the principal data collection method while case study, group discussion, seed sample make the complementary data. The data analyzed using descriptive statistics and while Logit Model was employed in adoption analysis.

CHAPTER 3

REVIEW OF LITERATURE

This chapter presents a review of literature related to seed access, seed source, and improved variety adoption issues. It highlights formal and informal seed sources and their complementary functions as an overarching issue for enhancing access and improved variety adoption. Farmer access to seed, seed quality and adoption of improved varieties are the focus of the literature review since they are essential aspects of a seed system (Almekinders, 2001; Sperling and Cooper, 2003). The literature review included: 1) farmers' access to seed, seed sources and seed quality aspects, 2) farmer participatory research; 3) the factors influencing farmer improved varieties adoption decision.

Farmers' access to seed is often seen as a central element of a seed system analysis (Sperling and Cooper, 2003). Exploring how farmers' access seed uncovers empirical details about their seed security in cases where household endowment help determine what source of seeds are available to them. Seed accessed from various sources (own saved seed, local exchanges, informal seed markets and the formal source). Likewise, timeliness, physical, physiological and genetic aspects are of seed are important (McGuire, 2001).

Both formal and informal seed sources have their own merits and deficiencies. Integrating the two has a complementary function particularly when crops or varieties of less commercial importance are coupled with environmentally stressed areas. Farmer participation in variety selection, seed production and dissemination is one potential area for the seed systems integration though empirical evidence is scanty. The chapter reviews factors influencing farmers' adoption of improved variety. Numerous studies from developing countries, particularly SSA are summarized in Table 3.2.

3.1 Farmers' access to seed, seed sources and basic seed quality characteristics

Farmers' access to seeds characterizes the function of a seed system (Daniel and Adetumbi, 2006). Environment and socio-economic conditions do influence farmers' access to seed (David and Sperling, 1999) while it may vary from crop to crop and from season to season.

Seed represents genetic material and it limits the maximum productivity of all the other inputs in crop production (Jaffee and Srivastava, 1992). Farmers require quality seed of appropriate varieties to produce household food requirements. Thus, their access to seed of appropriate quality for use is of critical importance (Remington *et al.*, 2002). Access to seed may vary by season and the socio-economic conditions of farmers (David and Sperling, 1999).

A farmer accesses seed from different sources that can be categorized as formal and informal. In the seed system analysis of informal system emphasized the importance of farmer-to-farmer seed exchange in seed access based on mutual support of kin and neighbors (Sperling and Loevinsohn, 1993). However, the norms of farmer-to-farmer seed exchange are evolving. It varies from one society to another where seed exchange on commercial base are increasingly important including subsistence crops such as sorghum (McGuire, 2008).

Seed sources are categorized in a various ways. Some authors adopt binary classification schemes of formal and informal sources and off-farm and on-farm seed sources (Tripp, 2006). Others employ more elaborate categorization schemes such as own saved, another farmers, seed dealers, extension agents and research institutes (Daniel and Adetumbi, 2006). Bishaw (2004) divides them into own save, another farmers, seed enterprise, agricultural development office, research center, trader and relatives. Almekinders *et al.*(1994) categorize seed sources into own harvest, another farmer, grain market and formal.

Formal seed sources operate within a legal framework with some level of differentiation and specialization (Venkatesan, 1994). In the formal sources, the activities included crop breeding, variety release, seed multiplication, seed processing and marketing. These activities may be accomplished by different departments of one institution or by different institutions. The legal framework provides for variety release, seed quality control, and seed certification, seed import etc.

On the other hand, own harvest, another farmer, grain market constitute the informal seed sources including farmer managed seed production programs. The informal seed sources are indigenous types where seed and grain production are interrelated. The informal seed sources are also known as local seed systems because their scale of operation is largely in the local networks (Almekinders *et al.*, 1994; Venkatesan, 1994). The present study adopts the elaborated seed source categorization scheme (that is own harvest, another farmer, grain market and formal seed source) since it is more descriptive than the binary categorization scheme. In terms of their merits, own harvest seed has the advantage of being cheap, of known quality and being readily available. Traditionally, farmers save their own harvest seeds from previous harvests and many cereal crops and pulses have been obtained in this way. Moreover, use of own harvest seed is associated with the reputation of a good farmer (Badstue *et al.*, 2007).

It is also customary for a farmer to obtain seed from another farmer in a bad year or for experimentation. Seed obtained from another farmer is appreciated because the seed adaptability is known in the local agro-ecology and socio-economic conditions. Likewise, the seed obtained from people known to the farmer is perceived as entailing less risk of crop failure due to inadequacy of seed quality as compared to the seed acquired from sources of impersonal relationships (Badstue *et al.*, 2007). Seed access from another farmer mostly takes place through traditional networks of family relations and it can be effective in the diffusion of new varieties (Seboka and Deressa, 2000; Almekinders *et al.*, 1994). McGuire (2005) argues that farmer to farmer seed diffusion is associated with the wealth of a farmer where the better off farmers provide seeds to the poor, both improved and local varieties.

Another important informal seed source is informal seed market. The informal seed market plays a significant role in the supply and dissemination of local seeds particularly in drought-prone areas (Nagarajan *et al.*, 2007). Informal seed market has been observed to be important among the poorer farmers where fifty per cent of the poor in Rwanda access the annual common bean seed required while a very few better off farmers obtained common bean seed from informal seed markets (Almekinders *et al.*, 1994). The informal seed markets were resilient in times of stresses such as civil strife and natural calamities (drought, flood, etc.) than expected. This was witnessed during Burundi civil war (Sperling, 2001) and Haiti massive earthquake (CIAT *et al.*, 2010). However, the informal seed market has been marginalized by the national seed reform and improvement efforts. This may emanate from the bias held about the quality of seed obtained from of informal seed sources. However, the evidence available on seed quality is scanty for informal market sources.

There are different rationales for farmers in procuring seed from informal seed markets. According some authors (McGuire, 2008; Sperling and McGuire, 2010) the major reasons for accessing new varieties while the other reason is to obtain credit services. Farmers prefer obtaining seeds from informal markets to borrowing seeds from neighbors in order to avoid high transaction costs and the stigma associated with requesting seed from a fellow farmers. Similarly, McGuire (2005) observed that there is a tendency of shifting from farmer to farmer seed exchange to the informal seed market due to recurrent droughts which eroded the capacity of farmers to save seed beyond what is necessary for their own fields.

Furthermore, farmer-to-farmer seed exchange is often based on social ties that are declining due to livelihood diversification involving non-farm activities; hence, there is a shift to informal seed market.

Additionally, when crops have to meet specific standards of quality in the product market, farmers purchase higher-quality seed from discriminating merchants to attain the quality standards (Sperling and McGuire, 2010). In this case, merchants perform specialized functions in preserving seed, absorbing risk or maintaining quality seed. Yet, some authors characterize seed from the informal market as poor quality seed source of last resort which may expose farmers to risks (Seboka and Deressa, 2000; Almekinders and Louwaars, 1999). However, there is little tangible evidence of quality failure of the seed obtained from informal seed markets. Therefore, it is important to verify the quality of the seed from informal sources to get comprehensive understanding since it is an essential seed source to smallholder farmers residing in drought-prone areas.

Sperling and McGuire (2010) observed that farmers approach the informal seed sources such as informal seed market strategically. They identify particular varieties by their names, traits and adaptation areas. Farmers consider storage conditions by assessing insect damage and the presence of disease indirectly by inspecting holes or checking for a musty smell, for example. Sperling and McGuire (2010) also found that farmers choose farmer merchants known for producing good seed, or merchants from whom they or their neighbor or relative have previously bought high-quality seed. Likewise, prices differentiate grain from seed since certain merchants charge a premium price for purity and handling for selected grains of seed (Beshir and Nishikawa, 2012).

Other than the informal seed sources, formal seed sources including commercial seed enterprises, agricultural research institutes, and farmers cooperatives become increasingly important seed sources to farmers. The seed obtained from formal source, more specifically commercial sources, is usually adapted to a wider agro-ecology. At the same time, they tend to be suited to high rainfall areas and are often less suited to farmers living in marginal areas such as drought-prone agro-ecologies (Chambers and Ghildyal, 1985).

The formal seed source constitutes a small portion of the seed annually planted in Ethiopia (Central Statisical Authority (CSA), 2010) and elsewhere in SSA. On the other hand, the informal seed sources in drought-prone areas are vulnerable to the fluctuating moisture conditions and this would affect the seed security of the farming community (McGuire, 2008). In such cases, the formal seed source is a high potential option to acquire seed for farmers (Remington *et al.*, 2002).

The formal seed sources are vital in introducing seeds of improved varieties. Scientific breeding has changed the potential of crop production frontiers through yield increases, and introduction of stress tolerance traits such as drought resistance and disease tolerance (Cromwell *et al.*, 1992). There was a great deal of enthusiasm in the 1970s and 1980s to reach a majority of the farm households with improved variety supplied from formal sources provided by public seed enterprises with the support of international institutions and nation states. On these premises, African governments established highly subsidized parastatal seed enterprises with the help of donors (Zerbe, 2001; Bishaw, 2004). The ultimate goal was to replace the informal seed systems, which were considered as a source of inferior quality seed. However, the expectations has not been met due to diminishing international financial support, lack of smallholder farmer orientation in variety development and seed supply (Rubyogo, nd). In the 1980s, a policy shift was made by encouraging private commercial seed enterprise involvement in the seed supply. The commercial sector has been, however, limited to hybrids and vegetable seeds targeting high potential areas (Zerbe, 2001). Seeds of grain crops of open-pollinated and self-pollinated subsistence crops were rarely supplied by such agencies (Guei *et al.*, 2011).

Commercial seed production is influenced by technical and biological characteristics of crops, potential profitability of seed production and marketing among other factors (Maredia *et al.*, 1999). Crops with high multiplication rates and low seeding rates are more suitable for the commercial seed enterprises while, in contrast, crops with low multiplication and high seeding rate are suitable for informal sources (Venkatesan, 1994).

Formal seed sources are expected to inject new varieties or certified seeds into a farming system for seed replacement or for specific characteristics of interest such as high yield, drought tolerance, early maturity and disease resistance. Moreover, the share of formal seed source increases with a country's economic advancement and stages of seed system development. In most cases, the formal seed source handles crops of typical biological characteristics such as hybrids and crops with specific environmental requirements such as vegetables to guarantee property rights and ensure a continuous seed supply (Jaffee and Srivastava, 1992; Loch and Boyce, 2003).

A farmers' access to seed differs as the influence of farm household economic characteristics and season. Moreover, the seed sources have their own merits and deficiencies. The informal sources have been underestimated considering as a source of poor quality seed though it is resilient and respond to immediate needs of farmers. The formal seed source per se unable to provide quality seed to the majority of smallholder farmers as it was anticipated yet it plays crucial role in improved variety introduction. Thus, as the deficiencies of one seed system complements the other the integration between the two seed systems can enhance farmers' access to adequate quality and preferred variety seed.

Seed quality is an essential element of a seed system. Seed quality characteristics comprise physiological, health, physical and genetic qualities. Physiological qualities include germination, resistance to environmental conditions such as drought, soil conditions, fertility, etc. The health quality of a seed refers to the seed being free from important seed borne diseases while physical seed quality refers to freedom of seed from foreign materials such as weed seed, other species seed and inert materials. Whereas genetic quality is what establishes the production of a crop including yield, tolerance to drought, resistance to disease etc (Bishaw, 2004). Though genetic seed quality is difficult to assess, varieties susceptible to common environmental stresses are considered of poor genetic quality. The genetic quality of crops has been refined over time by farmers and breeders through selection and hybridization processes (Bishaw, 2004; Almekinders and Louwaars, 1999). The recognition of these seed quality parameters enables to develop seed quality standards for seed quality regulation. Through observations farmers and informal seed traders assess seed quality in terms of physical quality, freedom from foreign materials, diseases and insects; thus basic principles for assessing seed quality is similar for formal and informal seed source grain crops (Sperling and McGuire, 2010). Quality of seed accessed from informal sources has been considered inferior and attempts were made to replace them entirely with seed supplied from formal sources. There is scanty of evidence, however, concerning the seed quality from informal sources except few preliminary observations (Almekinders *et al.*, 1994) and opinion (Seboka and Deressa, 2000).

Improved variety adoption and farmers' seed access is a process of decision making among alternatives available. The Farmers' decision-making process is highlighted in the following sections.

3.2 Integration of the seed sources

For effective seed system development, an integration between the formal and informal seed systems is believed to improve efficiency, since they are complementary (Almekinders *et al.*, 1994). The integration may happen in different ways, such as farmers' participation in breeding and the variety selection process. Breeders can collaborate with farmers to take advantage of farmers' selection capacity and better understand their selection criteria. A farmer-led collaboration can also happen in situations where farmers look for support from breeders to obtain better-adapted varieties. The integration in participatory plant breeding is referring to a flow of genetic materials into informal seed system. Furthermore, research can help farmer selection efforts that at times may include undesirable characteristics. For instance, the predominant farmers' maize selection criterion is large ears. Such type of selection can easily lead to undesired lateness through which farmer may enhance unwanted characteristics unknowingly particularly when the moisture regime is shrinking (Almekinders *et al.*, 2007; Lanteri and Quagliotti, 1997). In drought-prone areas, early maturity and drought tolerance are believed desirable qualities of maize. For drought-prone maize farming, the genetic base for drought tolerance is narrow and the formal seed system is in a better position to access the suitable genetic resources or create varieties with desired characteristics (Nigussie *et al.*, 2001).

Likewise, storage conditions and practices result in sub-optimal seed quality as well. Social and geographic barriers between different social classes and communities reduce farmers' access to a novelty seed. Traditional seed exchange mechanisms or migration may affect the resilience of informal seed system to recover seed from lost varieties, natural and man-made disasters may also may disrupt it (Almekinders *et al.*, 1994).

Variety selection and seed management expertise and technologies are often available in both formal and informal seed system where the farmers also have rich local knowledge. In many cases, such expertise has hardly been applied to strengthen and harmonize the seed systems. Hitherto, much of the expertise used to build a formal seed system has targeted high input agriculture (Louwaars, 1994; Almekinders *et al.*, 1994). Enriching the informal seed system with new genes and adapted materials increase farmers' capacity to evaluate and select good performing materials of improved as well as local varieties can be potential modes of the integration of the seed systems.

The availability of a quality seed of improved and well-adapted varieties would allow agricultural research to take the full advantage of the potential of the informal seed dissemination system. It has been observed that strategically introduced small amounts of seeds of new varieties can rapidly diffuse through farmer-to-farmer seed exchange (Almekinders *et al.*, 2007). It is less costly for farmers to access seeds from fellow farmers in or around their locality because besides physical proximity and familiarity the information about the seed is easier to obtain (Stromberg *et al.*, 2010).

Technical support from formal sector specialists is indispensable for improving the knowledge and capacities in the farmer seed quality maintenance. Recognition and integration of the informal seed system in the national seed policies and seed regulation is vital to the development of an integrated seed system (Almekinders *et al.*, 1994; Bishaw and Turner, 2008). Linkage and integration between farmers and formal seed system was found to be crucial in the development of sustainable smallholder seed enterprises in quality seed production and marketing including subsistence food crops such as maize, sorghum and millets in remote areas of northern Cameroon (Guei *et al.*, 2011).

A progressive approach in developing seed system integration for improving farmers' access to quality seed and bringing about improved variety adoption may occur through farmers' involvement in variety development and seed production and supply. In the last two decades, different modalities of farmer participatory approaches have been exercised among which participatory variety selection (PVS) is the dominant. PVS involves exposing farmers to nearly finished or finished varieties whose genetic identity is largely established (Bishaw and Turner, 2008). The underlying issue is creating modalities for effective seed systems integration. Some potential areas are farmer participatory variety testing, seed production at reasonable cost and seed dissemination where empirical evidence is scarce in order to improve farmer access to improved and quality seed. Table 3-1 summarizes possible areas of integration between formal and informal seed sources.

Table 3-1 Comparative summary of formal and informal seed sources and areas of their potential integration

Areas/characteristics	Formal	Informal	Mode of integration
Variety development	Breeding, variety release, seed production, seed multiplication, seed processing are performed by one unit or departments of one organization	Farmers select, store, plant and exchange seed in available social networks. Selection process, at times, may encourage undesirable characteristics e.g. selecting large cob maize.	Farmer participation in variety selection process to reduce time of release and include farmers preference criteria (Ceccarelli and Grando, 2007)
Varietal adaptation	Tends to adapt to wider agro-ecologies.	Adapted to local agro-ecology and socio-economic conditions.	Small kit, demonstration, seed fairs to provide option to farmers (Tripp, 1995).
Access to new germplasm	Have access to wide range of germplasms from international and regional research institutions. Moreover, it can produce varieties from expertise and technologies available to m.	Farmer may access new germplasm from different sources. Number of germpalsm may be restricted to few and change can be slow depending on number of germplasm available in area and nearby.	Different varieties can be tested including local varieties to increase choices. A range of participatory plant breeding approaches PVS (Ceccarelli and Grando, 2007; Witcombe *et al.*, 1996) or Farmer Research group approach can be employed
Agro-ecologic suitability	More suitable for potential agro-ecologies where market is more readily available	It is both available in high potential and low potential areas. However, it is comparatively more effective in low potential areas where environment is diverse and flexibility is important.	For varieties of low genetic resource formal seed system in better position to in introduce (Nigussie *et al.*, 2001)
Flexibility in time of supply	Less flexible and unpredictable	Flexible. Local and improved varieties are available during planting time	Seeds of new varieties can be introduced and produced by farmers, research need to provided basic for long term farmers benefit (Almekinders *et al.*, 2007)
Seed quality	Genetic quality of seed is usually guaranteed through strict field isolation procedures and laboratory tests.	Seed production is part of grain production, maintaining high genetic purity may not be possible. Physical quality may vary from storage condition and insect pest management	seed quality of informal seed source can be improved through training (e.g. field and storage management (Almekinders and Louwaars, 2008).
Commercial seed production interest	Largely seed of high commercial value, and property right protection attract attention	Local varieties of food crops area availability	Varieties of less commercial interest produced through research, local agricultural expert and farmer collaboration (Guei *et al.*, 2011)
Seed distribution	Assume hierarchical process of procurement in supply chain	Seed disseminate or distribute through multiples of networks using market and non-market channels.	Farmer preferred seed may quickly disseminate through informal system by different techniques seed introduction (Almekinders *et al.*, 2007; Tripp, 1995)
Legal framework	Seed certification and quality control	No binding legal framework but trust and social networks	informal seed source need to be considered in legal framework to recognize informal seed source including community based seed production (Simane, 2008)

Source: Authors' summary, 2012

The integration between formal and informal seed sources is expected to be established in different ways. Farmer participation in variety selection, seed multiplication and distribution are major important areas for integration (Table 3-1). The integration is believed to enhance the complementarity between the formal and informal seed sources. Thus, this is discussed in the following section.

3.3 Farmer participatory research

The importance of farmer participation in crop research has been widely discussed after poor adoption of the varieties released through conventional breeding [20] in environmentally stress areas such as drought-prone areas was questioned (Chambers and Ghildyal, 1985). Chambers and Ghildyal (1985) contrasted the physical and socio-economic conditions of research experimental station and that of smallholder resource poor farmers. To mention a few, on research experimental station, the soils are fertile, the topography is flat, access to in inputs (seed, fertilizer etcetera) is unlimited, and labor is unlimited and there no or few hazards. In contrast, smallholder farmers' farmland soil usually unfertile, the topography is undulating, access to input seed and other inputs are constrained, labor constrained at peak season and hazard (drought, flood) are more common.

[20] The conventional breeding and variety release procedure involves germplasm collection (introduction), planting on the observation nursery (2 years/seasons), multiplication variety trials of selected materials (2-3 years/seasons) and verification trial (1 year or season) for release. On the other hand, farmer participatory research (FPR) takes different typology including participatory plant breeding (PPB). In PPB, a few farmers involve in on station research starting with large number of germplasms and there is a frequent contact between researchers and farmers. The most common FPR is PVS. This involves farmer participation in nearly finished or a few finished materials (varieties) evaluation and presents their preference criteria. Successful PVS believed to improve the acceptance of varieties due to farmer involvement in selection process. Farmer involvement in PVS, is believed to reduce the time for variety release since varieties can be tested across several locations at a time with active farmers' involvement.

Farmer participatory plant breeding was for instance claimed to save considerable breeding time, meet farmers needs, and be efficient in selection for drought-prone areas in the West Asia and North Africa Regions (Witcombe *et al.*, 1996; Ceccarelli and Grando, 2007). Ceccarelli and Grando (2007) further narrated a distinctive experience of an efficient farmer variety selection and adoption followed by variety release as contrasted with extended system of conventional plant breeding (Table 6-1).

PVS has been intensively employed in farmer participatory research for identifying farmers' variety selection criteria. In PVS, farmers at times do select and own variety by assigning descriptive vernacular names even before variety release. For instance, five common bean varieties were selected and designated local names (Rubyogo, nd), in the CRV of Ethiopia. However, the variety release committee officially released only one variety. The variety evaluation by conventional research criteria is mainly based on yield across wider areas where only one variety is released for production at one release (National Seed Indutry Agency, 2001). The variety release committee is composed of researches and experts[21]. Tripp (1995) proposed farmer representation in variety release committees and a flexible approach in variety release procedures. The practice of farmer participation in variety selection is not an end in itself unless farmers benefit from the research output through seed access and utilization. Tripp (1995) presented an example where farmers accepted varieties taken for seed production directly before official release in Zambia.

PVS has been criticized for its focus on technical issues of farmer selection criteria while seed supply and policy environment for variety regulation and release mechanisms have remained uncovered. McGuire (2007) describes the hindrance to breeding and variety release

[21] The variety release committee, in Ethiopia, is consists of two breeders, one agronomist or physiologist, one entomologist, one pathologist, one economist one food scientists one extension specialist. They come from ministry of agriculture, seed enterprise, research institutes, universities or colleges and other relevant organizations (National Seed Industry Agency, 2001).

reform to be the structural lock-in. The concept of the lock-in signifies that different pathways could have been taken that there is no a single equilibrium exists. However, historical events influence the emergence of a particular pathway. An option for seed source reform can be the linkage between PVS and informal seed sources that represent a flow of genetic materials, and the exchange of knowledge or combination of thereof to the farming community. There are numerous reports of successful variety selection through farmer participation (Ceccarelli and Grando, 2007; Witcombe *et al.*, 1996) whereas cost effective quality seed production and dissemination through farmer participation is rare.

In recent years, a farmer research group (FRG) approach, a family of farmer participatory research has been underway (Zerfu, 2005). The FRG approach refers to a research method through which a research team, extension workers and groups of farmers jointly conduct research on selected topics based on farmers needs on farmers' fields. The approach also considers the issues of technology dissemination such as seed production and distribution by linking the FRG with extension service and public seed enterprises. The seed production and dissemination aims at improving farmers' access to improved varieties for which formal seed provision is limited. The aspect of seed production and distribution differentiates FRG from the common practice of farmer participatory research, PVS, which focus on farmer variety selection and variety selection criteria identification. The FRG based seed provision approach is believed to be one potential area for formal and informal seed integration (Mekonnen *et al.*, 2005). In the FRG, the major stakeholders in agriculture researchers, farmers and agricultural experts act together from the beginning with variety testing and selection. This creates mutual understanding and easily to reach consensus on activities to pursue. The researchers and agricultural experts more easily provide their services and inputs[22] to group of farmers than to individual farmers. Furthermore, the researches and experts understand farmers needs, learn about local situation from them and utilize their expertise. Such groups can be developed to a farmer seed enterprise or cooperatives. Consequently, the seed produced through FRG approach is expected to quickly disseminate and be adopted because large number of farmers is exposed to the improved varieties and their information. FRG approach is expected to improve seed dissemination and adoption because it involves participatory variety selection including seed dissemination. Thus, it deserves scrutiny using empirical data from field for its significance in seed production and dissemination.

3.4 Adoption of improved crop varieties

Farmers' decision-making behavior

The theories decision-making have been largely rooted in disciplines economics and psychology. In economics mathematical probability analysis are conducted to explain what value people assign to the utilities for alternatives outcomes of and seek to maximize their expected utility. In psychology, observations are made to describe human judgment process and how people make alternative judgments based on their perception.

According to Dunn (1984) decision-making is a ubiquitous activity inherent in the behavior of individuals or society. Decision can be categorized as intuitive, programmed, and analyzed (ibid). Those choices that individuals make without conscious thought as to the alternatives and the relative evaluation are known as intuitive decisions. Whereas programmed decision-making are which in principle capable of being automated. There are

[22] Research provides basic seed of selected varieties while both extension and research organize training and field monitoring in quality seed production.

certain decisions that one has to analyze possible outcomes and their consequences (Gebre-Mariam, 2012).

When an individual has alternatives each with significant consequences, and that he or she in unsure about which choice is the best a decision problem exists. A decision problem consists of: (i) alternatives available to the decision maker, (ii) state of nature (rainfall, price etc), (iii) probability attached to the state of nature influencing the decision problem (iv) consequence of action, (v) process of conducting experiments to obtain additional income, (vi) process of conducting additional information about the likelihood of outcome give the state of nature, and (vii) the strategy for action which are conditional on the experimental outcome observed (Dunn, 1984). The distinction between farmers producing improved or varieties or old or both key for study farmers behavior which is much complex when the environment is highly unpredictable.

Decision-making takes different aspects. According to the Rational Decision-making Model; a model in which decisions are made systematically and based consistently on the principle of economic rationality people strive to maximize their individual economic outcomes (Taher, 1996; Mendola, 2007). Information about all possible alternatives, their outcomes and the preference of decision makers is assumed available.

To describe the characteristics of the farmers’ decision-making some author refers to the characteristics of farm management. Various statements identified the factors influencing the decision-making process in farm management. Taher (1996) emphasized the community influence on the farmer. He argues that decisions in farming will be determined not only by the goal of maximizing the benefit or of reducing the risk, but also by willingness to accept criticism from the community (depending very much on a farmer's social position in different groups).

According to Reijntjes *et al*. (1992), the decision-making process is influenced not only by the culture of the community to which the household belongs but also by other factors such as personality of the decision maker, biophysical characteristics of the farm, the availability and quality of external inputs and services, and socio-economic and cultural processes within the community. More details about the characteristics of households that influence the farm household decision-making are the number of men, women and children, their ages, state of health, abilities, desires, needs, farming experience, knowledge and skill, and the relations between household members. Those factors that influence the farmers' decision-making to achieve their outcomes can be systematized in physical environment, socio-economical environment (included political aspect), and farmers' household size and production factors.

Farmers' variety adoption

Decision of farmers to adopt a new agricultural technology in preference to other alternative technologies based on intricate factors. Farmers' resource endowment, socio-economic status, demographic characteristics access to institutional services (Negatu and Parikh, 1999).

Farmers' decision-making in environmentally stress areas may not based on as rational decision-making model suggests based on the assumption that individual have perfect information and there are less constraint in choices thus individuals are expected to maximize their economic outcomes (Taher, 1996). As McGuire (2005) puts farming in drought-prone area is more a performance than a plan. The issue of community influence on the adoption is not expected as a greater for since improved variety adoption does not entail any criticism from community members. However, the argument in this dissertation concerning the issue seed access and adoption decision-making is about selecting feasible decision based on securing household as presented in theoretical framework Section 2.2 which is in line with Reijntjes *et al*. (1992) where personality of the farmers, biophysical, socio-economic factors are important.

The adoption of agricultural innovation has obtained substantial attention among researchers and policy makers because the majority of the populations of less developed countries derive their livelihood from agriculture mainly crop farming. Improved agricultural technologies (improved varieties, fertilizer, irrigation etc) are believed to offer an opportunity to increase production substantially. The introduction of improved agricultural technologies, however, has met with only limited success, as measured by observed rates of adoption. Spielman *et al.* (2010) documented aggregate adoption of crop in Ethiopia between 4.7% to 19%. Langyintuo *et al.* (2010) reported that improved maize adoption in many Africa countries is low with few exceptions (see Table 1-1). Agricultural technology adoption is described as a decision made to use an innovation in usual farming practice (Feder *et al.*, 1985). An innovation can be described as technological entity that can improve the production frontier, yet it has perceived uncertainties since it is new for the adopter. The uncertainty is expected to weaken over time as the adopter develops experience and confidence (Feder *et al.*, 1981). In this dissertation, adopters are farmers who have experience using improved open-pollinated varieties of maize in their production. The adoption of crop technologies may vary from one agro-ecology to another example high rainfall and suitable soil for instance were the focus in the previous research and extension placed in Ethiopia and elsewhere. Innovation is an idea, practice or object that is new or perceived as new by an individual or other unit of adoption. Adoption of improved variety is the decision made by farmer to include a new variety in his/her usual farming practice.

In high rainfall areas, the ultimate objective of a farm household is to produce optimum yield while farmers in low moisture areas strive to secure subsistence level of production and tends to avoid high yielding technologies that have risks when there are environmental stresses. For this purpose, the adoption of crop varieties with suitable characteristics to meet those objectives such as drought resistance or early maturation varieties adoption are expected (Ellis, 1992).

A number of studies have been conducted to understand and explain what factors affect the adoption of improved crop varieties particularly that of the Green Revolution (Feder and Umali, 1993; Feder *et al.*, 1981). Numerous authors have undertaken related research in many parts of the world including SSA countries such as Ethiopia, Tanzania, Kenya, and Uganda etc (Kaliba *et al.*, 1998a; Ouma *et al.*, 2002; Feleke and Zegeye, 2005). In Ethiopia, studies conducted on the adoption of improved maize variety have so far focused on high rainfall areas (Beyene, 2008; Tura *et al.*, 2010; Fufa and Hassan, 2006; Feleke and Zegeye, 2005) whereas low rainfall areas such as drought-prone areas have been forgotten.

The adoption of improved varieties can be analyzed from an individual adopter point of view or on aggregate, at a regional or national level. Aggregate adoption is the degree to which a new technology spreads within a region or farming community. Accordingly, aggregate adoption is estimated by the collective level adoption of a specific technology in a given geographical area as the proportion of the farming population involved in the use of specific technology under consideration. Thus, the percentage of farmers using an improved agricultural technology constitutes the rate of adoption while the level of technology use represents intensity of adoption. For instance, the amount of hectare planted with improved varieties or the amount of fertilizer used on a hectare indicates the intensity of adoption (Beyene, 2008).

An individual household level analysis, represented by the household head, is the predominant approach to adoption studies where the factors influencing farmers' behavior are scrutinized in understanding the reasons behind adoption of an improved agricultural technology under question (Alene *et al.*, 2000). On the other hand, the aggregate level adoption rate does not lend itself for in-depth analysis at the actual decision makers' level beyond finding the proportional figure of adopters in an area. In this work, the adoption study is approached at farm household level for a thorough analysis and the aggregate level adoption is estimated from the sample as the proportion of farmers using improved maize varieties. In the analysis of adoption, existence of innovation is presupposed and the study of adoption process evaluates whether an adoption takes place or not, and what factors are influencing adoption if it is happened (Alene *et al.*, 2000).

A farm household choice of whether to adopt or not to adopt new technology depends on a careful evaluation of a large number of factors. Feder and Umali (1993) concluded that after analyzing the final stage of Green Revolution technology adoption agro-climatic environment as the most significant for adoption rates at local level. However, agro-climate environment is composed of different elements where each has its significant influence on adoption are not explicitly indicated. Where agro-climatic environment encompasses rainfall, temperatures, soil type, relative humidity, altitude etc

Several factors are presented to explain what is responsible for decision to adopt or not to adopt improved agricultural technologies such as improved varieties, fertilizer, pesticides, agronomic practices and farm implements. The factors influencing adoption are differently categorized depending on the hypothesis. Some authors for instance categorized the factors for adoption into a) farm and farmers' associated attributes; 2) attributes related with the technology (Adesina and Zinnah, 1992) and (Misra *et al.*, 1993) and, 3) the farming objective or farming attributes (CIMMYT, 1988).

After my reviewing literature on adoption studies, more than fifty variables have been identified in the improved crop variety adoption studies. Extension visit, age of the household head, education, and farm size are the most frequently used factors (Annex 3).

Taking into consideration the intricacy of improved variety adoption decisions and the large quantity of empirical literatures available on adoption studies of agricultural innovations, I have summarized (Table 3-2) the results of selected works on the improved variety adoption studies, particularly those of developing countries with a focus on SSA over the last fifteen years mainly on maize. The most important factors selected are those that were frequently used though there are slight differences in the way they were treated or measured. Besides, certain factors of theoretical and practical importance in the study area such as Farmer Research Group (FRG) which is a recent introduction and promoted in many parts of Ethiopia and drought encounter frequency that indicate agro-ecological stress are included in the study of factors influencing adoption. The selected factors are divided into three categories.

I would list the categories and highlight them. The first is human and physical resource endowments. In this category gender, age, education, household size and livestock ownership are included. Concerning gender of the household head, male household heads are expected to have better access to information since they are supposed to have higher social networks that in turn affect improved variety adoption decisions positively as compared to female household heads. However, empirical studies conducted show mixed results; that is from absence of any meaningful influence of gender to strong and significant association with improved variety adoption. Many studies conducted did not establish sufficient evidence of the claim that gender makes a difference in adoption in either way (Tura *et al.*, 2010 ; Groote *et al.*, 2002; Getahun Degu *et al.*, 2000). Still, Ouma *et al.* (2002) found that men are better adopters of improved maize varieties and basal applications of fertilizer in Kenya.

The age of the household head is often considered as an important factor of improved agricultural technology adoption, based on the assumption that with the passing of years a farmer becomes more conservative to take risks. While the counter argument is that with the passing of time, experience and confidence build up with a consequent positively influences improved variety adoption. However, studies show a range of results from negative through absence of significant effect to strong positive influence of age on improved variety adoption. Some authors have documented that age negatively and significantly affects improved variety adoption (Beyene, 2008; Fufa and Hassan, 2006; Feleke and Zegeye, 2005; Morris *et al.*, 1999a). On the other hand, many studies in SSA and elsewhere fail to establish any significant relationship between age and improved variety adoption (Cavane, 2009; Paudel and Matsuoka, 2008; Groote *et al.*, 2002; Ouma *et al.*, 2002; Alene *et al.*, 2000; Kaliba *et al.*, 1998b). Yet, some researchers indicated that age has a positive and significant influence in the adoption of improved varieties (Regassa Ensermu *et al.*, 1998; Kaliba *et al.*, 1998a). There is no agreed conclusion on the direction and strength of age in terms of its influence on improved variety adoption.

Education is presupposed to positively affect improved variety adoption since an educated person is expected to seek, analyze and utilize information on a new technology. The literature, however, presents inconsistent results in this aspect. Tura *et al.* (2010) reported that years of formal education had a strong and negative association with adoption of improved varieties. A considerable number of studies find no meaningful influence of education on improved variety adoption (Cavane, 2009; Beyene, 2008; Fufa and Hassan, 2006; Degu *et al.*, 2000; Ouma *et al.*, 2002; Kaliba *et al.*, 1998a). Simultaneously, several others (Abdissa Gemeda *et al.*, 2001; Alene *et al.*, 2000; Feleke and Zegeye, 2005; Paudel and Matsuoka, 2008) documented that education level of farm households is directly associated with and significantly influences improved variety adoption.

Household size is expected to positively influence improved variety adoption by providing labor for intensive management required accompanying improved varieties. However, it exhibited different results from an insignificant influence to a strong influence on improved variety adoption. Some studies revealed that the availability of household labor does not have any distinct influence on improved variety adoption (Abdissa Gemeda *et al.*, 2001; Kaliba *et al.*, 1998a). On the other side, several others (Alene *et al.*, 2000; Feleke and Zegeye, 2005; Kaliba *et al.*, 1998a), claimed that the larger the household size the higher the probability improved variety adoption.

Farm size is one of the factors that numerous researchers considered in their improved variety adoption studies. The existing empirical works show inconsistent findings. Certain studies establish no significant effect of farm size on improved variety adoption (Fufa and Hassan, 2006; Ouma *et al.*, 2002; Degu *et al.*, 2000), whereas others (Beyene, 2008; Tura *et al.*, 2010; Alene *et al.*, 2000) concluded that the larger the farm size the more it contributes to improved variety adoption.

Livestock ownership in a mixed farming system is supposed to positively influence improved crop variety adoption. The underlying reason is that livestock sale provides cash income for buying improved variety seeds and supplementary inputs while oxen provide draught labor for timely land preparation. The existing literature on this, however, provides mixed messages. Some studies conducted in Ethiopia and elsewhere in SSA pointed out that there was no strong association with the level of adoption of improved varieties (Tura *et al.*, 2010; Beyene, 2008; Feleke and Zegeye, 2005; Groote *et al.*, 2002; Abdissa Gemeda *et al.*, 2001). In contrast Degu *et al* (2000) claimed a significant association between livestock holding and improved variety adoption.

The second category constitutes institutional factors, which includes extension visits, field day participation, distance from the nearest grain market, and distance from agricultural research center and residence in FRG *Kebele*. Extension visits are expected to positively affect improved variety adoption because extension agents are assumed as reliable sources for new agricultural information. Empirical studies conducted in SSA and other developing countries show that extension visit is strongly associated with improved variety adoption (Paudel and Matsuoka, 2008; Feleke and Zegeye, 2005; Ouma *et al.*, 2002; Abdissa Gemeda *et al.*, 2001). Other authorities conducted their research in those countries and elsewhere and did not find any meaningful influence of extension visits on improved variety adoption (Beyene, 2008; Adesina and Zinnah, 1992). Abdissa Gemeda *et al.*(2001*)* found an interesting result that extension visit positively influenced hybrid maize variety adoption while its influence was found to be negative in the case of open-pollinated maize variety adoption.

Field day participation is expected to considerably influence adoption of improved varieties. However, the available literature present varied results concerning the influence of field day on improved variety adoption. Abdissa Gemeda *et al.* (2001) reported a positive and strong influence of field day participation on improved variety adoption. Whereas others (Ouma *et al.*, 2002; Rahmato, 2008) did not find any meaningful influence of field day on improved variety adoption.

Distance to the nearest grain market is expected to negatively influence improved variety adoption since farm households living close to market center are expected to be more market oriented and use improved technologies to optimize yields. The literature pertaining to improved variety adoption does not establish effective association between the distance of the nearest grain market and improved variety adoption. Tura *et al.* (2010), Beyene (2008) and Feleke and Zegeye (2005) did not find any meaningful influence of grain market proximity on improved variety adoption.

The third category of factors that influence improved open-pollinated maize variety adoption constitutes agro-ecologic conditions. In the agro-ecology, altitude and the frequency of drought that substantially reduced maize yield in the last ten years were captured. Agro-ecology, particularly altitude, in Ethiopia the most salient feature that affects temperature and precipitation, is considered as a determining factor in farm household decisions to adopt improved crop varieties. Altitude was found to be significantly and directly influencing improved variety adoption decisions (Cavane, 2009; Ouma *et al.*, 2002). Fufa and Hassan (2006) documented negative and strong relationship between fertilizer adoption decisions and farmer perception of drought. They measured drought as one if the farmer perceived bad rainfall season the result was that farmers with the perception of bad rainfall had lower probability of fertilizer adoption.

Table 3-2 Summary of the results of variables included in selected adoption studies

Authors	Model used	Farm size	gender	House hold size	Age HH	Education HHH	Livest ock	Extensio n visit	Field day/Wor ship	market distan ce	climate perception /drought	Attitude
Abdissa Gemeda *at al* (2001)	Tobit	X				X(**)	X	X(***)	X (**)			
Alene *et a*l (2000)	Tobit	X (*)			X	X (*)		X (*)				
Fufa B and RM (2006*)*	Tobit	X			X (-)	X					X(*-)	
Tura *et al* (2010)	Tobit	X				X (**-)	X	X(*)		X		
Negash, R. (2007)	Tobit	X			X	X	X	X	X	X		
Bekele, A. and Beshir. B, (2004)	Logit	X (*-)	X (***)		X	X	X (***)	X (***)	X		X (***)	
Kaliba , A (1998a)	Logi and Tobit				X	X		X(***)				
Michael *et al* (1999)	Descriptive stat	X (*)			X	X(*)		X(*)				
Morris L., (1999)	Probit 2 Stage	X (**)	X	X	X(**-)	X (***)		X(**)				
Feleke, S., Zegeye, T, (2005)	Logit				X(**-)	X(**)	X	X(***)		X(*)		
Cavane, E. (2009)	Logit			X	X	X						X (***)
Paudel, P. and Matsuoka, B., (2008)	Logit	X (**)		X	X	X (**)		X (**)				
Groote, H.*et al* (2002)	Logit	X	X		X	X	X	X (*)				
Ntege-nayeenya, W. et al (1997)	Logit	X	X		X	X(***)	X	X				
Ensermu, R. , (1998)	Logit Model	X			X (**)			X (**)				
Adesina, A (1995)	Tobit				X (*)			X	X(**-)		X(**-)	
Beyene, H. (2008)	Regression (Xtprobit & Xttobit)	X (**)		X	X(**-)	X	X	X		X		
Kaliba *et al* (1998b)	Logit and Tobit				X	X		X (*)				
Degu, G. *et al* (2000)	Tobit and Logit	X	X		X	X	X (**)	X (***)				
Ouma, J. *et al* (2002)	Logistic Model	X	X (**)		X	X		X (*)	X			

Note 1: (*), (**), (***) significant at 1%, 5% and 10% respectively and the negative sign (-) next to the significance shows sign of the variable.
Note 2: HHH=household head,
Note 3: X represents independent variable

Source: Author summary from miscellaneous adoption studies, 2012

Analytical models employed in assessing improved variety adoption

Different econometric models are employed in this study to analyze the adoption of improved technologies. The application of Logit, Tobit or Probit Model is customary in adoption studies. In the case of dichotomous dependent variable, such as improved variety adoption or non-adoption measured in nominal dummy variables, the Logit or Probit model is applied. The choice between the two parameters is somewhat tricky since both models yield equally efficient parameter estimates using an iterative maximum likelihood approach (Demaris, 1992).

Deramis (1992) further remarks that when continuous variables are included in the model the Logit Model is preferred. The models used improved variety adoption studies in the selected twenty articles are summarized in Table 3-2. Among the 20 articles, eight of them employed the Logit Model; six used the Tobit model, and two of them each employed Logit and Tobit and one descriptive statistics. Probit two stages model employed one study while one researcher used Xtprobit and Xttobit regression. In this study, the Logit Model is adopted since the dependent variable is binary, measured as improved variety adoption or non-adoption while the independent variables are the combination of both continuous and discrete variables.

3.5 Summary

This chapter reviews literature on seed access and farmers' sources. Farmers access seed mainly from own, another farmer, informal seed and formal sources. Access to those sources may vary by household economic characteristics and season. Previous research focus on farmer-to-farmer seed exchange using social networks and mutual help and the importance of own save as personal reputation as a good farmer were discussed. The importance of other sources such informal seed market farmers group based seed production and dissemination had not been focused on in previous studies.

Farmer decision-making is a daily routine activity. Some decisions, including introduction of new agricultural technology or choosing among farming options, requires farmers to make choice among alternatives. Farmers' decision-making in drought-prone areas may not based on as rational decision-making model that assumes people strive to maximize their individual economic outcomes. Again, the community influence as some author assume as a negative on the adoption new technology is not expected in such major food crop variety adoption, as it does not entail any criticism from community members. The important point concerning the issue seed access and adoption decision-making is about selecting suitable crop varieties based on securing household sustenance safely as the model of household theory suggests. Farm household head decision making in this aspect may depend on the personality of the farmers, as well as socio-economic and environmental factors.

The formal source even though unable to serve the majority of smallholders farmers as envisaged it plays important role in new variety introduction. For such reasons the integration of seed systems is envisaged to develop their complementary functions. The integration approach of the seed systems may vary from farmer participation in variety selection and seed production to improving the seed storage condition though demonstration and training.

Farmer participatory research where farmers involve in variety selection and seed production perceived to be a plausible area and it is discussed in this chapter considering the major approach in farmer participatory research- PVS. For empirical data analysis and discussion, FRG, one kind of participatory research, is taken into account. The final goal of farmer participatory research is to benefit farm household from new technologies.

The last section dwells on the factors employed in improved variety adoption. After examining numerous recent studies in adoption, the factors considered to influence improved variety adoption are resource endowment, institutional and environmental. The data analysis Logit Model is selected based on characteristics of data and suitability of the model. The detail explanation is presented in Chapter 6 Section 6.2.

CHAPTER 4

AN ASSESSMENT OF FARMERS ACCESS TO MAIZE SEED AND THE SEED QUALITY

4.1 Introduction

Access to quality seed is crucial of a farm household for a reliable food production. In order to realize sustained crop production and productivity, modern breeding has considerably increased the yield potential and improved stress tolerance of crops over the last century. Both modern breeding and farmer seed selection have significantly contributed in generating suitable seed for sustainable food production. The provision of improved variety seeds has remained a point of discussion in developing countries such as Ethiopia (MoFED, 2010).

Different approaches of seed provision such as local seed projects and emergency seed projects have been tried in developing counties in order to increase farmers' access to suitable seed (Tripp, 2006). In Ethiopia, for example, farmer based seed multiplication and marketing schemes were executed across the country to boost certified seed provision (Sahlu *et al.*, 2008). However, the practice did not last beyond the project periods as it was based on creating contractual seed producers for the formal seed enterprise rather than establishing a self-sustaining seed provision entity at the community level with sufficient linkage to basic seed provision. A successful smallholder seed enterprise development for commercially unattractive and subsistence food crops such as rice, maize, sorghum and millets found in Guei *et al.*(2011). They present that forging of partnerships and strong managerial and institutional capacity, and the training of local quality certifying experts realized success in local seed production and distribution.

Farmers' reliance on their own harvest seed stock or access to seed from off-farm sources (both formal and informal) can vary by season, socio-economic characteristics and environment among farm households. This study takes a step forward in understanding maize seed provision by assessing household seed sources and access behavior. It further looks at seed quality, as it is a guiding factor in using a seed where there is a paucity of evidence beyond stereotypical beliefs that the seed of informal sources are unknown or poor quality (Seboka and Deressa, 2000).

The chapter describes smallholder farm household maize seed access behavior and the seed quality of different sources. For that purpose, important socio-economic variables such as landholding, livestock holding, and gender literacy were taken into account in the data analysis in normal and stress year.

4.2 Materials and methods

Agro-ecology of the study area

The study was conducted in the CRV, East Shewa Zone of Ethiopia. The altitude of the study sites ranges between 1335 to 1700 meters above sea level (masl). The area is semi-arid and drought-prone where the effective length of crop growing period lasts between two to four months (Nigussie *et al.*, 2001). Rainfall is bi-modal, a small rainy season from March to April and a dry spell in May followed by the main rainy season from June to September. The distribution and amount of rainfall is erratic where evapo-transpiration is in excess of the precipitation for most of the time. The reliable crop-growing period tends to be between June and September (Figure 4-1) where the coefficient of variation (CV) of rainfall is around 50% or below (Figure 4-2). There is a recurrent drought in the country once in ten years while in the CRV area it tends to occur every three years. The most recent drought year was 2009. For this study, the data of 2009 and 2010 is considered during 2011 data collection since considering the farmers can easily remember inputs used and the production activities.

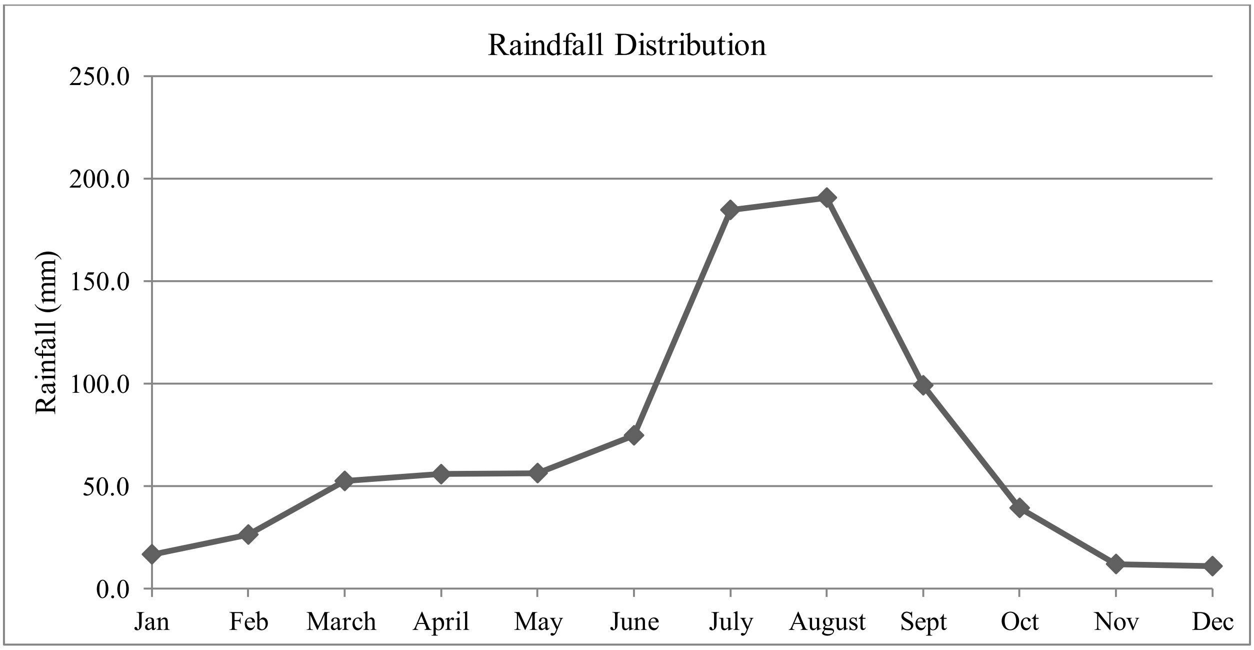


Figure 4-1 Monthly average rainfall distribution at MARC CRV of Ethiopia, 1977 to 2011

Source: MARC Center agro-meteorology rainfall data, 2012

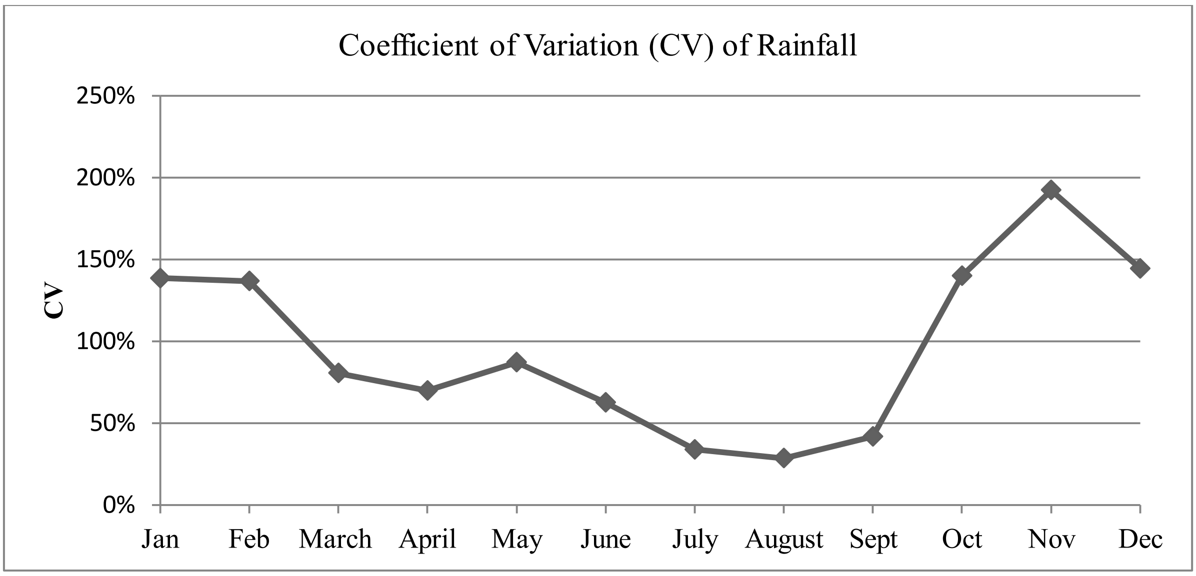


Figure 4-2 Coefficient of variation of monthly average rainfall distribution at MARC CRV of Ethiopia, 1977 to 2011

Source: MARC agro-meteorology rainfall data, 2012

Crop production and utilization in the study area

The main crops grown in terms of average farmland allocation are maize (46%), common beans (19%), tef (19%), wheat (7%) and others each in small amounts (10%). Common beans and tef rank second in area planted, while common beans were slightly more than two times as productive as tef (see Table 2-6). Sixty-one per cent of maize produce was consumed while 36% was sold and 3% used for seed.

Sampling procedure, methods of data acquisition and respondent characteristics

A multi-stage sampling procedure was employed in selecting farm household heads for questionnaire interview. East-Shewa Zone was purposively selected for its semi-arid area maize farming. Four districts, namely: Adama, Adamitulu Jido kombolcha (ATJK), Boset and Dugda were chosen among the ten districts of the zone based on their maize production acreage. Finally, 277 farmers (Table 4-1) were randomly selected from respective *Kebele* agricultural taxpayer lists then interviewed face-to-face using structured questionnaires (Annex 1). Grain traders in the nearby markets to the selected farmers *Kebeles* were also interviewed using guidelines (Annex 2).

Table 4-1 Summary description of socio-economic characteristics of the sample maize grower farmers

District	Number			Average age (year)	Average household size	Average land holding (ha)	Average TLU	Mean year of formal schooling
	Male	Female	Total					
Adama	52	15	67	41	5.7	2.01	2.60	1.3
ATJK	67	5	72	38	7.9	2.44	6.11	3.8
Boset	53	10	63	44	5.9	2.26	4.31	0.7
Dugda	62	13	75	42	7.0	2.69	5.39	1.6
Total/average	234	43	277	41	6.7	2.36	4.66	1.9

Note: Total livestock unit (TLU)

Source: Author field study, 2011

Seed sample and seed quality analysis

Seed samples were taken from the interviewed farmers, informal seed market, research centers, the ESE and farmers' cooperative. One kg of composite seed sample was collected from farmer seed stored in sacks of 100 kg or less and 1 to 3 kilo grams collected from research and farmers' cooperative based on the seed volumes. Finally, 1 kg from each source of composite seed samples were used for the seed physical and germination quality analysis (Quality and Standards Authority of Ethiopia, 2000a).

Seed physical purity analysis

The seed purity was analyzed according to the Ethiopian Seed Industry Agency seed-testing manual (National Seed Indutry Agency, nd). In the analysis, the seed samples collected were further reduced for analysis into 900 gm. The seed sample was further sub-divided into two equal parts after uniformly mixing the sample. Then each seed sample was categorized into pure seed, weed seed, other crop seed and inert matter. The difference between the averages of the components of the two half samples was calculated and compared against tolerance level to check consistency. Then the seed purity percentage was calculated based on the sub-divided (into two) sample weight of each 450 gm.

Germination quality analysis

Germination tests were conducted subsequent to purity analysis by taking random seed samples from the pure seed category. The germination test was conducted at an ambient temperature of 22 to 30^{o}C (the recommended temperature is 20 to 30^{o}C). Sand media was used for germination after separating bigger sizes of sand using an 8 mm sieve. Then the sand was put into standard plastic pots of an average 5.5 kg. The seed was planted at 1 to 2 cm depth. Sufficient water was supplied by monitoring the soil moisture. The pH of both the sand and water was 6.55 to 7.43. Complete Randomized Design (CRD) at eight replications of 50 seeds were planted from each sample. The time taken for one batch was 10 days. The first count was done on the 6th day and the final count on the 10th day. The ISTA recommendation of 4th and 7th day to count for emergence and germination for maize is not found applicable in this experiment because no seed emerged on the 4th day from planting. The seedlings were categorized into normal seedlings, abnormal seedlings, fresh un-germinated (dormant) and dead seed. The average normal germination was calculated based on the final count. The result was compared to the Ethiopian maize seed certification standards(Quality and Standards Authority of Ethiopia, 2000b).

Basic seed is the seed class used by seed producers to produce certified seed. Basic seed is kept by breeding institutions such as agricultural research, seed company, universities. Certified seed is a seed class produced from basic seed and offered to farmers for crop grain production. The certified seed further classified C1, C2, C3, D and E depending on their generations (Table 4-2). This kind of long generation seems to have created expecting critical seed shortages. In practice, only C1 is used in certified seed production in the in the Ethiopia open-pollinated maize supply (Yonas Sahlu 2012, personal communication).

Table 4 -2 Minimum requirement for open-pollinated maize seed certification in Ethiopia

Characteristics/ Laboratory standard	Basic seed	Certified C1	Certified C2	Certified C3	Certified D	Emergency seed class
Pure seed (min %)	99	98	98	98	97	95
Other crop (max %)	0.2	0.3	0.5	0.5	0.5	1
Weed seed (max %))	0.2	0.3	0.2	0.5	0.5	1
Infected seed (% fusarium)	0.02	.03	.05	.05	.05	.1
Inert matter (max %)	2	2	2	2	2.5	3
Germination (min %)	90	85	85	85	85	85
Moisture content (max %)	13	13	13	13	13	13

Source: Quality and Standards Authority of Ethiopia, Quality Standard document, 2000

Data analysis

Farm household head was the main unit of analysis. The data obtained were subjected to descriptive analysis and non-parametric tests. The analysis involved categorization according to household socio-economic characteristics. The data were analyzed in percentages, averages, standard deviation and chi-square was performed for testing associations. Seed purity and germination were analyzed according to the national seed industry agency seed testing procedures that are based on the International Seed Testing Association (ISTA) guidelines (ISTA, 1996).

4.3 Results

Maize varieties released for drought-prone areas and varieties grown in the study area

The National Maize Research System is composed of public research institutes (Agricultural Research Centers and Universities), private seed enterprises, and international research centers such as CIMMYT (International Maize and Wheat Improvement Center). The public research institutes develops and releases open-pollinated varieties (OPVs) and hybrid maize while the private sector is entirely involved in the hybrid research and seed production. For instance, among 23 hybrid maize varieties released in Ethiopia, seven belong to private seed companies while public research institutes released 16 hybrids and all the 19 OPVs in the Ethiopia maize research system (Annex 5).

The conventional procedure of maize breeding, starting from nursery observation to release of an OPV requires on average about seven years for introduced materials, while other techniques such as crossing takes as much as twice as long as introduced materials to get a variety released. So far, forty-two varieties of maize were released in the national maize research system between 1973 and 2008. Eleven varieties were recommended for drought-prone areas while 31 of them were for high moisture areas (> 900 mm average rainfall). The number of maize varieties released for drought-prone areas has been doubled in the last decade (since 2001) as compared to the preceding three decades of release (Table 4-3) when the focus was on high moisture areas.

Table 4-3 Description of maize varieties released for drought-prone areas of Ethiopia

Variety Name	Release Year	Rainfall (mm in 100)	Altitude (in 100 masl)	DM*	†Y (t/ha)	Special feature	‡Observation
Awassa-511	1973	8-12	5-18	150	5.6	High yield	Yes
Katumani	1974	6-10	15.5	110	3.1	Early maturity	Yes
ACV3 (*Fetene*)	1996	6-10	15.5	100	4.1	Early maturity	No
ACV6 (*Tesfa*)	1996	6-10	15.5	110	4.3	Early maturity	No
Melkassa-1	2001	4.5-7.5	10-17.5	85	4.2	Extra early	Yes
Melkassa-2	2004	6-8	12-17	130	5.0	Drought tolerant high yield	Yes
Melkassa-3	2004	6-8	12-17	125	5.0	Drought tolerant high yield	Yes
Melkassa-4	2006	5-7	10-16	105	4.0	Early maturity	Yes
Melkassa-5	2008	6-8	10-17	125	4.0	Early maturity	Not
Melkassa-6Q	2008	5-8	10-17.5	120	5.0	Drought tolerant, Quality protein	Yes
Melkassa-7	2008	5-8	10-17.5	115	5.0	Early maturity and poultry feed	Not

Note 1: masl (meter above sea level),

Note 2: † yield on research station,

Note 3: ‡ Indicates whether observed or not under production during the field study

Note 4: ∗ DM= days to maturity

Source: Maize Production Manual, Ministry of Agr. and Rural Dev't (unpublished), variety release documents of miscellaneous years and (Nigussie *et al.*, 2001)

Increase in the number of varieties released is expected to increase farm household production options and thus contribute to varietal diversity and household resilience in risk prone environments. The varieties widely used by farmers are medium to late maturing seeds of improved, local and a few unknown varieties (unknown by name to farmers). Such variety diversification would provide production alternatives in mitigating the recurrent drought and sustain food production (Fujisaka, 1997; Singh, 2010) where farmers face a considerable yield stresses once in three.

Depending on the rainfall regime, farmers grow different varieties of maize in the CRV area. Late maturing varieties (require more than 140 days to mature) are planted based on the onset of rain. If sufficient rain comes early from February, late maturing varieties are planted from April. However, when there is still sufficient rain is available in February for land preparation but not sufficient for planting of late maturing varieties farmers shift to medium maturing varieties (mature in 116 to 140 days). The medium maturing varieties are planted mainly after mid of April up to the end of May. Early maturing varieties (mature in less than 116 days) are planted from the end of May when there is late on set or there is an interruption of rain during at planting time of late or medium maturing varieties.

In the CRV, the majority of farmers grow open-pollinated and medium maturing varieties, while hybrids are also grown in mid altitude (around 1630 masl) areas though they are not in the list of recommended varieties (Table 4-3).

Seed sources and varietal diversity

Seed source is an essential characteristic of a seed supply indicating available alternatives for farm households. Own saved seed, seed from the informal seed market (ISM) and seed obtained from another farmer (farmer-to-farmer seed exchange) constituted on average 84% of seed among maize grower households over 2009 and 2010 (Table 4-4). Another farmer and informal seed market sources each constituted on average 26 to 31% of the farmer obtained seed from off-farm sources. Farmer to farmer seed exchange was found to be significantly higher than what was reported as minimal (Daniel and Adetumbi, 2006). ISM as well offers a significant proportion of seed in normal and stress years. It was found not to be a marginal or a last resort option as Almekinders and Louwaars (1999) and Seboka and Deressa, (2000) suggested, for example. Rather ISM was a key seed and a hopeful source during stress years for the majority of farm households in drought-prone areas of the country, where 38.3% of farm households consider it as the first promising seed source in years of crucial seed shortages due to drought (Annex 4).

Table 4-4 Maize seed sources by volume and the number of farmers' accessed

Source	Year	Number	Average seed (Kg)	Per cent of farmers	Per cent Volume
Own harvest	2010	71	59.1	25.6	34
	2009	75	43.4	27.8	28
Another farmer	2010	73	37.5	26.4	22
	2009	85	41.2	31.5	31
ISM	2010	86	40.0	31.0	29
	2009	71	40.7	26.3	25
Formal	2010	47	37.2	17.0	14
	2009	39	46.4	14.4	16
Total	2010	277	44.0	100.0	100
	2009	270	42.4	100.0	100

Source: Author field study, 2011

There are different varieties are available in the local maize production system where 28 maize varieties are grown across the rift valley agro-ecology. About fifty per cent of farm households grow new varieties (new are those varieties released and used in the last twenty years) while the remaining half grow old (43%) and mixed or unknown variety (7%). The seeds of different varieties at times deliberately mixed during replanting to compensate when the population of a variety planted is poorly established largely due to moisture stress. In addition, some varieties are unknown by name to farmers. Among 28 varieties observed, 20 varieties were on offer by ISM and 16 varieties were of them were on offer through farmer-to-farmer seed transfer and only 4 varieties were on offer through formal source (Annex 6).

Maize seed sources in normal and stress years

The main seed sources in the study area were own harvest seed, another farmer, ISM and formal based on the seed volume each offers. The proportion of farmers' accessed seed from off-farm sources in a normal year and a stress year represented about three quarters of the farm households without a significant difference between normal and stress years (χ^2(3, n=277)=0.767, P(.85)>0.1). Farmers in the CRV area use the four seed source both during normal years and during stress years. There is, however, a tendency of shifting from another farmer (farmer-to-farmer) seed sourcing to ISM and formal source after a yield stress year. The share of ISM and formal sources increases while that of own harvest seed use and another farmer shrinks. This is in line with what farmer indicated ISM and formal seed are hopeful seed sources during seed shortages due to stress (see Annex 4). The details of seed access in relation to socio-economic and environmental factors are discussed in the following sub-sections.

Farmers' access to maize seed by gender of household head (HHH)

Gender is supposed to be one source of difference in farmers' access to seed since a female-headed household is usually poor and their access to information and social networks expected to be limited. A higher proportion (35 to 47%) of a female-headed household secured seed from ISM as compared to male-headed households (25 to 28%) (Table 4-5). The second off-farm seed source for both the female-headed and the male-headed households was another farmer. A relatively higher proportion of female-headed households obtained seed from another farmer as compared to men headed households.

The findings do not suggest, however, that ISM is a minor seed source and last resort since slightly more than a quarter of the sample households acquired seed from ISM. On the other hand, a higher proportion of male-headed households access seed from formal source as compared to female-headed households. The association between gender of a household head and seed source is statistically significant at 5% level ($\chi^2(3, n=277) = 9.743, p=0.021$) for the year 2010. That is more female-headed farm households access seed from ISM than another farmer while more male-headed households acquired seed from formal source after a stress year. The proportional increase in ISM user among female-headed households was 12% as compared to only 3% among the male-headed households between the year 2009 (2009 was stress year while 2008 normal year) and 2010. This may indicate more vulnerability of female-headed households than the male-headed households following a year of drought stress.

Table 4-5 Farmers' access to maize seed sources by gender of the household head

Seed source	Year	Within gender (%)		
		Female	Male	Total
Own harvest	2010	19	27	26
	2009	23	29	28
Another farmer	2010	30	26	26
	2009	37	30	32
ISM	2010	47	28	31
	2009	35	25	26
Formal	2010	5	19	17
	2009	5	16	14
Total (N)	2010	100 (43)	100 (234)	100 (277)
	2009	100 (43)	100 (227)	100 (270)

Note: Male=227 and Female=43 in 2010 and Male=234 and Female=43 in 2009

Source: Author field study, 2011

Farm household access to maize seed by literacy of HHH

Access to major seed sources show differences by literacy of HHH. There is higher tendency of acquiring seed among the literate farmers from formal seed sources than the illiterate farmers both in stress and in normal years. The average proportion of farm household accessing seed from the informal source over the two years (2009 and 2010) was 88% among illiterate and 78% among literate farmers. Literate farmers had greater access to formal sources as compared to their counterparts while, in contrast, more illiterate farmers obtained seed from informal seed markets (Table 4-6). There is strong positive association between literacy and seed sources at 5% significance χ^2 (3, 277) =9.990, p=0.019 for year 2010 planting.

Table 4-6 Farmers' access to maize seed sources by literacy of the household head

Literacy	Year	Seed source			
		Own harvest	Another farmer	ISM	Formal
Illiterate (%)	2010	28	24	35	13
	2009	28	30	31	12
Literate (%)	2010	22	30	24	25
	2009	27	35	19	20
Sample mean (%)	2010	26	26	31	17
	2009	28	32	26	14

Note 1: Literate=101 and Illiterate=176 in 2010 and Literate=97 and Illiterate=173 and 2009

Note 2: N=277, in 2010 and N=270 in 2009

Source: Author field study, 2011

Farm household access to maize seed by household landholding

Landholding is an indicator of household wealth. In Ethiopia, the predominant majority of the farmers are smallholder holders where 99% own harvest is less than five hectares of farm land[23]) (Rahmato, 2008). In this study, the holding was categorized into

[23] There is no clear categorization of farmers by their land holding in Ethiopia. Observation at the distribution of households by their holdings 7.6% own less than 0.1 ha, 29.5% own 0.1-0.5 ha, 25.7% own 0.51 -1.00 ha, 24.3% own 1.01-2.00 ha, 11.9 % own 2.01-5.00 ha and only 1% own more than 5 ha (Rahmato, 2008:139). Land is very scarce in high land areas largely high potential area. This study is conducted in drought-prone area and the average land holding per household 2.35 ha is significantly higher than the country's average (about 1.12 ha per household).

small, medium and large sizes based on mean and standard deviation of the data obtained from the field study within the general smallholder farmers since there is no sub categorization of smallholder farmer in Ethiopia. In 2009 and 2010, 43 to 50% of small landholders procured maize seed from the ISM while the proportion was 23 to 27% and 22 to 32% for medium and larger landholders respectively. Medium landholders tended to use the three informal seed sources fairly equally, whereas a higher proportion of large landholders accessed seed from formal sources, the ISM, their own harvest including another farmer in a deceasing order (Table 4-7). A higher percentage of small landholders accessed seed from the ISM than medium and larger landholders, while a higher proportion of large landholders have better access to formal seed sources than the other two off farm seed sources. The association is significant at 5% χ^2 (6, n=277) =20.052, p=.003 for year 2010 planting).

Table 4-7 Farmers' access to maize seed sources by land holding of farm household

Seed source	Year	Land holding type			Sample mean
		Small (%)	Medium (%)	Large (%)	
Own harvest	2010	16	28	21	26
	2009	29	28	26	28
Another farmer	2010	27	28	11	26
	2009	24	35	19	32
ISM	2010	50	27	32	31
	2009	43	23	22	26
Formal	2010	7	17	36	17
	2009	5	14	33	14
Total	2010	100(44)	100(205)	100(28)	100(277)
	2009	100(42)	100(201)	100(27)	100(270)

Note 1: Small (<=1 ha); Medium (1.1 to 3.0 ha); Large (>=3.1 ha)
Note 2: Figures in the parenthesis, in total, show the actual number
Note 3: large=28, medium= 205 and small=44 in 2010; large=42, medium= 201 and small=27 in 2009
Source: Author field study, 2011

Access to maize seed by livestock holding of household

Livestock holding is another indicator of household wealth and a key draught power source in crop farming. Livestock is the source of security and supplements crop production in the mixed farming system of CRV area. Livestock holding was classified into small or none, medium and large holders depending on mean and standard deviation in terms of

Tropical Livestock Unit (TLU)[24], based on the survey data. Thirty-six percent of small or none holders of livestock accessed seed from another farmer while 40 to 47% of them obtained seed from the ISM. Large livestock holders used formal seed sources more than the other two off-farm seed sources. Medium size livestock holders used all the major informal sources consistently and fairly equally (Table 4-8). The proportion of formal source seed users increased with the category of livestock owned, suggesting that the better off farmers have better access to formal seed sources than small or non-holders over both stress and normal years. The association between seed sources and livestock holding category is statistically meaningful at 5% level $\chi^2(6, n=277) =21.5$, $p=0.001$ in 2010) and $\chi^2(6, n=277) =16.1$, $p=0.013$ in 2009). McGuire (2008) documented similar trend that a higher number of farmers who own more oxen preferred government (formal) seed source as compared to one or non-owners of oxen in semi-arid areas of Eastern Ethiopia.

[24] The tropical livestock (TLU) is equivalent to livestock weight of 250 kg; and the conversion factor varies according to the livestock type. Accordingly, ox=1.12 TLU, cow, heifer =.8 TLU, sheep=.09 TLU, goat=.07 TLU, horse=1.3TLU, mule=.90 TLU, donkey=.35 TLU. In the calculation, the total livestock owned changed into one unit (the TLU) then categorized into three based on average and standard deviation of the sample. That is, those who own less than one TLU standard deviation from the mean categorized as small or none, those own between one SD from mean medium and those who own more than one standard deviation large.

Table 4-8 Farmers' access to maize seed sources by livestock holding of farm household

Seed Source	Year	Livestock holding (%)			Sample
		Small or none	Medium	Large	mean
Own harvest	2010	11	28	30	26
	2009	21	28	35	28
Another farmer	2010	36	27	4	26
	2009	37	33	9	32
ISM	2010	47	28	30	31
	2009	40	23	30	26
Formal	2010	7	17	35	17
	2009	2	16	26	14
Total (N)	2010	45	209	23	277
(%)		16	76	8	100
N	2009	43	204	23	270
(%)		16	76	9	100

Note 1: small or none (<=.4 TLU), medium (1.1 to 8.8 TLU) and large (>= 8.9 TLU)

Note 2: small=45, medium=209 and large=23 in 2010; small=43, medium=204 and large=23 in 2009

Source: Author field study, 2011

Grain traders in the informal maize seed source

Grain traders are the major players in the ISM of maize and do represent it. Thirteen-grain traders from seven local markets were interviewed using open-ended questionnaires. Most of them (11 out of 13) were from farm families and four of them were practicing farming at the time of this research. The traders had an average 10 years of experience in seed/grain marketing. On average, each trader had clients from five *Kebeles* (between three to ten *Kebeles* and each *Kebele* has 630 average households in the area). Farmers' market seed demand is at the planting time from the mid of April to the mid of May where still few need until the mid of June. The number of client *Kebeles* depends on the market size, financial capacity and the reputations[25] of the trader. The number of rural *Kebeles* using the market, number of the urban *Kebeles* the market place constitutes, if any, and types agricultural commodities (crop and/or animal) sold on the market used to explain the market size in the area. Each trader sold, on average, about two tons of maize grain of seed per cropping season, between 2009 to 2011 (Table 4-9). The average market price margin for seed over grain price was 5 to 10% per kg over grain market price. Traders adopted unique approaches in obtaining what Sperling and McGuire (2010) call implicit seed[26]. The traders collect seed from farmers known for their good grain production, participation in extension programs or select good grain produced in well-known areas for good maize farming. The seed is visually inspected for its grain filling, freedom from mixture or impurities besides asking for its area of production, yield and related information. Traders who practice farming by themselves also know good farmers in their areas and obtain seed from them (e.g., ATJK and Meki areas).

[25] The interviewed farmers and others mention the names of well-known traders in their local market. This is particularly common in smaller towns and their markets. Some of the traders (e.g., Bofa, Melkassa and Wolinchiti markets). I have contacted them depending on the information obtained during farmers' questionnaire interview. On the other hand, traders mentioned that farmers come for seed to them, as they get more 'popular'.

[26] A special subset of grain sold for seed by grain traders (Sperling and McGuire, 2010).

Table 4-9 Maize seed sold by sample informal seed traders in selected CRV grain markets

District	Statistics	Amount of grain sold as seed (ton) and year			
		2009	2010	2011	Average
Adama	N	1	1	1	1
	Mean	2.50	1.00	.50	1.33
Boset	N	5	5	5	5
	Mean	2.6	2.3	1.7	2.2
	SD	1.52	1.3	0.97	1.24
Dugda	N	2	2	4	4
	Mean	1.3	1.8	5.98	1.01
	SD	0.42	0.28	9.43	.24
ATJK	N	3	3	3	3
	Mean	3.83	4.13	4	3.99
	SD	1.76	1.8	3.46	2.26
Total	N	11	11	13	13
	Mean	2.69	2.59	3.45	2.18
	SD	1.53	1.57	5.36	1.65

Source: Author field study, 2011

As far as trader farmer relationship concerned in seed access, certain traders are known by name for their good quality seed provision in Melkassa, Dhera and Bofa local market centers (mentioned by the interviewed farmers) in the study area. Traders are promising seed sources to the smallholder farm households, particularly during stress year (Table 4-5 and Annex 6). However, the traders do not have direct access to formal seed sources (improved or certified seed) though they are providing about a quarter of the annual maize seed annually accessed.

Reasons for farmers' for accessing seed from off-farm sources

The reasons for accessing maize seed from off-farm were to get a new variety, to replace a lost seed lot, to renew seed lot, to acquire early maturing variety, to get quality seed and others (Table 4-10). Farmers manage crop production challenges in the drought-prone area by adopting new varieties or growing early maturing ones in years of late rain onset. Likewise, they plant late to medium maturing varieties when the rain starts early and early maturing when the rain comes late. Growing varieties of different maturity periods is a major part of a farm household adaptation strategies in the CRV areas for sustaining crop production. For this purpose, a large number (about 28) of maize varieties grown in the CRV (Annex 6). Farmers in one area, however, tend to grow similar varieties in one season and varietal diversity in a particular *Kebele* was not as high as the aggregate number of sample suggests. The average number of varieties grown in one *Kebele* is about four to twelve varieties.

There is a changing tendency towards the integration of informal and formal seed sources as most medium to early maturing varieties were introduced from formal sources and circulate within the informal channels. The number of medium maturing varieties tends to be dominating as the local varieties are being replaced by improved medium maturing varieties (Annex 6). Moreover, new variety seed need among the most important reason for acquiring seed from off-farm source and this shows that a farm household readiness for improved variety adoption (Table 4-10). Likewise, seed lot changes and annual hybrid renewals are important recent developments in local seed source for accessing off-farm seed that may enhance local seed business development. Acquiring seed for replacing a lost seed lot is an extreme case of severe drought stress and a major challenge in the area that calls for proactive measures including suitable variety provisions through diversified channels to reach all categories of farm households. For instance, availability of early maturing varieties reduces vulnerability to harvest loss thus helps to replace the old seed lot as well. Drought tolerant varieties can serve the same purpose in addition to their better yield.

Table 4-10 Reason for farmers accessing maize seed from off-farm sources

Reason	Number	Per cent
To acquire a new variety	89	41
Lost own seed	40	18
Annual hybrid seed renewal	31	14
To acquire early maturing variety	17	8
To get a new variety and early maturity	16	7
Seed lot change for OPV	8	4
New variety and seed quality	4	2
Expert advice	3	1
For trial	3	1
Others (advice from neighbor, etc)	13	6
Total	224	100

Source: Author field study, 2011

Quality of the seed obtained from different sources

Seed quality is one of the basic characteristics valued by farmers. It is a guiding criterion in any discussion of seed source issues (Almekinders and Louwaars, 1999). For this purpose, seed samples of different seed sources were subjected to quality analysis, namely purity and germination.

All the seed samples obtained from ISM, and other informal sources on average met the minimum germination and purity standards set by the Ethiopian standards (see Table 4-2). A few samples (8%) obtained from farmers were found to be below germination standard while 1% of them did not meet the purity standard (Table 4-11). On average, the germination rates of the seeds planted were above the minimum standard. Seed from research centers (among formal seed sources) was the purest while that of the ISM of higher impurity among the three though the difference is not statistical significant and seeds meet the minimum standard. The seed sample obtained from farmers' cooperatives had high impurity due to high breakages of the seed itself rather than foreign matter.

In the farmers' seed, there were greater diversities among farmers in seed storage conditions. Storing the seed/grain above the ground on wood or stone beds is the predominant method. Others were stored without beds on the ground, which at times expose the seed to moisture. Some farmers were stored their maize with its husk hanging under roofs in dry places. As observation suggests, the seed stored hanging is the purest seed while those kept on the dust floor are the most susceptible to insects and moisture.

Moreover, there is a growing awareness among farmers in their seed management that on average they intend to change their seed lots every three year[27]. Among, the surveyed households, 77.6% indicated that they normally practice selection. The first selection criteria are large cob (60.9%), multiple ears (7.9%), early maturity (3.7%), and both large cob and multiple ears (27.4) (Annex 7).

[27] Most of the farmers (94%) indicated that they have intension to change the seed lot of their OPV variety maize on average very three years in the range of 1 to 10 years.

Table 4-11 Results of maize seed physical and germination quality analysis

Seed source	Percent of the sample that meet minimum germination requirement		Per cent of the sample that meet minimum purity requirement		Pure seed % Average	Germination % Average
	No	Yes	No	Yes		
Farmer (n=185)	8	92	1	99	99.3	89.6
ISM (n=6)	0	100	0	100	98.7	91.4
Formal (n=8)	0	100	0	100	99.3	91.5
Total (N=199)	8	92	1	99	99.2	89.7

Note: N (n) represents number

Source: Author field study, 2011

4.4 Discussion

Maize is a key staple food in drought-prone areas of Ethiopia. Access to suitable maize seed is crucial of farm households for sustainable food production where seed provision is an ongoing issue in agricultural development. Concerning formal and informal seed sources, the informal seed source can be further categorized into three major sources own harvest, another farmer, and ISM for analysis and discussions. The informal source represents the lion's share (84%) of annual maize seed accessed where the contribution of each informal source is roughly equal (Table 4-4) suggesting a greater dynamics in maize seed source than what was reported from different countries. For example in the Mexican Oaxaca Valley three quarters (75.8%) of the seed was obtained on farm (Badstue *et al.*, 2007) while about half of the total seed in Nigeria was obtained on farm (Daniel and Adetumbi, 2006). Daniel and

Adetumbi further noted that 17 to 33% of the farmers' accessed maize from ISM. It is in line with the result of this study while their finding that another farmer (farmer-to-farmer) seed source was negligible is not supported by this study. The ISM has been largely forgotten in the studies of seed issues and development endeavors. However, ISM is found to be more responsive to the local conditions and flexible in serving different categories of farmers. Likewise, the formal seed source plays a significant role in maize seed source where about 16% of the farm households obtain their maize seed. The number of varieties offered from formal sources is, however, limited and its supply is unpredictable. Inefficiencies[28] in seed distribution channels (Sahlu *et al.*, 2008) and inconsistent seed quality of the formal seed source has also been reported (Spielman *et al.*, 2010).

Formal and informal seed sources have their own peculiarities in terms of seed supply flexibility in time and in amount), types of the farmers served, and seed management (Table 4-12). For instance, Almekinders *et al.*(1994) noted a strong and efficient formal seed source being complementary to informal seed source through new variety seed introduction, production and dissemination. Different workers have suggested an integrated approach to be effective in seed system development in developing countries particularly for crops of low commercial interest such as OPVs maize and self-pollinated crops (Amstel *et al.*, 1995; Almekinders, 2000).

The issue is in creating modalities of an integrated seed system in Ethiopia and elsewhere. Firstly, success in seed system development and enhanced seed supply calls for a continuous basic seed supply and a proactive breeding strategy to meet the evolving challenges of a drought-prone environment when maize research for drought-prone areas are

[28] There are issues of (a) high production and distribution costs related to low levels of effective demand, and to the high cost of transport from centralized seed production facilities to rural areas; (b) a relatively narrow range of crops/varieties that do not meet smallholder farmer needs; (c) inconsistent seed quality; and (d) limited capacity to enforce and harmonize the seed policy and legislations are noted in the Ethiopian formal seed system related to the inefficiencies (Sahlu *et al*, 2008:34).

concerned. This will be looked at in Chapter 6 during discussion about farmer research group in seed production and dissemination.

Secondly, grain traders play a significant role in seed supply where considerable portion of the farming community utilize ISM in drought stress years as well as in normal years. Until now, policy makers and researchers have overlooked ISM (and its players) in the seed supply improvement efforts. Grain traders, who are well involved in informal seed provision, have to be included in providing information about seeds including varietal description, training on seed handling and management aspects.

Thirdly, extension experts and policy makers need to appreciate the significant contribution of the ISM (grain traders) and another farmer (farmer-to-farmer) transfers in seed dissemination. Thus, involving those stakeholders in the introduction and dissemination of new as well as existing varieties using different models of seed diffusion such as random sample distribution, production kit distribution, sample sale and demonstration may be some options to involve diversified seed sources and stakeholders (Louwaars, 1995; Tripp, 2006). Hence, developing a functional local or national maize supply system for drought-prone environments is vital to address those areas for possible integration to establish smallholder farmer equitable access to quality seed for enhanced food production.

Table 4-12 Comparative accounts of formal and informal maize seed sources

Characteristic	Formal sources	Informal sources
Flexibility in seed supply	Usually slow or not responsive to local changes (e.g., weather, price) due to extended chain of supply channel, etc	Quickly responds to changing situation in locality such as price and weather conditions.
Supply time	Unpredictable; supply time takes longer while processed through extended procedures of request collection, processing, seed allocation and distribution.	Traders and farmers offer seed on time for local needs. Traders at times bring seed from different markets/places as per immediate needs e.g., early maturing maize varieties are available in local market including seed for late planting while it is absent in formal sources.
Types of farmers get more access	Relatively better off farmer, who are better educated, or have contact with formal sources for demonstration purposes (Tables 4-4, 4-6, 4-7, 4- 8).	All types of farmers (poor, medium, and better off; men and women) have access to informal seed source (Tables 4-4, 4-6, 4-7, 4- 8).
Number of varieties available	Few selected varieties are offered while seed inter-annual supply is erratic.	Wide arrays of old and new varieties are offered at required time at small margins over market price. Many local varieties and new varieties are available shortly before planting and throughout planting season.
Knowledge about specific quality of seed and variety	Generally have good amount of information about crop and variety, though there are limitations at local levels where development agents, at times, lack information about varieties grown (on both local and improved).	Knowledge may not be accurate (for example, names of varieties were not at times clearly mentioned (or inconsistently named), or rather general local names are given such '*limat,' filatamaa'* to refer to improved varieties and some varieties are not known to farmers by their names.
Seed management	Properly constructed and ventilated structures are used. Seeds are free of crop and varietal mixtures.	There are diversified storage methods used. Some farmers store selected cobs separately hanging under roofs in ventilated dry space. Majority farmers store seed as bulk in sacks. While others store different crops and varieties in unventilated spaces and in a liable way to mix-ups and insect attacks.
Seed quality	Acceptable quality except some inconsistencies in physical quality (e.g., breakages). Genetic purity is taken care of through adhering to standard field isolation distances, roughing off types, field supervision and careful seed processing procedures.	Seed quality is acceptable to farmers and generally meets standard tests of physical and germination quality with minor defects. However, genetic purity cannot be maintained, as there is no isolation distance between varieties in case of farmer seed/grain production.

Source: Author's synthesis from field study, 2011

Concerning the socio-economic background of farm households in their access to seed, there is a greater tendency among smallholder and female-headed households in acquiring seed from the ISM and another farmer. The tendency was especially high following drought stress year. What has to be underscored is, however, that even if the proportional number of female headed and resource poor households is high, one fifths to one thirds of male-headed and the better off farm household still access seed from the ISM during normal and drought stress years as well. The number of male-headed households is high in real terms though the proportion within gender is lesser for male. Thus, the available evidence, does not suggest that ISM seed source is a marginal one for female-headed households and the poor. Likewise, the quality of seed from the ISM is not poor either.

Seed acquisition by farmers and traders is done selectively and strategically. Farmers approach the ISM through social or client relationships in addition to employing their own harvest and other farmers' expertise in verifying the seed quality. Similarly, traders selectively obtain grain for seed based on grain quality and acquaintances with farmers. There are farmers known in a farming community for producing high quality grain or for their involvement in seed production activity from who traders obtain seed. One distinguishing criterion between implicit seed from grain is the price margin attached to the clean seed, while variety name and area (agro-ecology/village) of production are other important indicators. The average price margin for seed over grain was about 5 to 10% higher than the daily grain market price. At times, traders provide the seed to their clients at grain market price, expecting to get bulk grain on sale from their clients after harvest.

Another farmer (farmer-to-farmer) seed exchange was higher among medium holders than small and larger resource holders were. Seed exchange among farmers is still higher for the food crop maize. Larger livestock owners tend to prefer ISM to other farmers among off-farm informal seed sources, presumably to adhere to the notion of seed self sufficiency by acquiring seed from the market rather than from fellow farmers (Sperling and McGuire, 2010). This suggests that research and extension needs to consider a household's socio-economic conditions, especially the poor and female-headed households who face multiple constraints in their access to seed. For instance, socio-economic background can be considered in new seed introduction. Likewise, in awareness development about new varieties public meeting places such as local grain markets can be used in addition to the conventional practices of demonstrations and field days. The quality of the seeds from informal seed sources such as farmers and ISM was found to be of acceptable though a few samples of minor deficiencies were observed in germination as compared to the standard among seed obtained from farmers. Observations suggest that storage condition is one of the reasons for such poor germination.

4.5 Conclusion

Seed access behavior characterizes the seed supply of a crop in an area or country. The informal seed source is the main maize seed source for smallholder farmers in drought-prone CRV of Ethiopia. It offers a wide range of varieties annually acquired for planting. Own saved, another farmer, and informal seed markets are consistently used both during normal and drought stress years. Another farmer and ISM each contributes about thirty per cent of annual household seed accessed, signifying their key position in seed source for food crops such as maize which is largely reported to be used from own harvest or formal source (Sperling and McGuire, 2010). On the other hand, the formal seed source supplied certified seeds that have been diffused further through the informal channel. The formal seed source contributes a significant share (16%) of the seed accessed by farm household contributing towards the integration of the seed systems.

A higher proportion of the poor households and households headed by female, the illiterate farmers tend to procure seed from informal sources, particularly from the ISM and other farmers. Nonetheless, it is important to highlight that the ISM is not the last resort given that slightly higher than a quarter of farm households in CRV access seed from this source in normal and stress years. The seed accessed from the ISM is of good quality on average either.

The informal and formal seed sources can play complementary roles in that the informal seed system more flexibly and effectively diffuses diversified varieties, while the formal source introduce new germplasm but is less flexible. As noted in annual rainfall distribution, 2009 was stress moisture stress year while 2010 was normal year including 2008. The effect of 2009 also felt in 2010 that the proportion of farmers who accessed seed from own save and another farmer reduced in 2010 as compared to 2009 planting. In 2010, the proportion of farmers' accessed seed from ISM and formal source increased. This indicates the tendency of shifting to ISM and formal source during stress as own harvest and another farmer seed source diminished. This is in line with the farmers' opinion that they claimed for looking ISM and formal source when they face seed shortage.

There are bulks of maize varieties are available in local maize including old varieties of late maturity trait and poor yielding though improved varieties of drought tolerant and high yielding potential have been introduced. Replacing those maize varieties susceptible to the environmental stress it inevitable to sustain food production.

The maize seed supply tends to perform more effectively through formal and informal seed source integration in introducing new varieties, delivering information about new seed, involving farmers and informal seed traders (e.g., locally known traders for offering quality seed) in seed supply, and facilitating their access to improved varieties of seed. Public actions aimed at supporting the local seed development have to consider the integration of the seed systems through basic seed provision for certified seed production, strengthening seed production and distribution through established farmer-to-farmer seed exchange networks.

CHAPTER 5

DETERMINANTS OF ADOPTION OF IMPROVED OPEN-POLLINATED VARIETIES OF MAIZE

5.1 Introduction

This chapter analyzes the factors affecting improved OPVs of maize in the study area. In the analysis, open-pollinated varieties of maize are considered since they are recommended in drought-prone areas because their yield is stable and their seeds can be recycled. To enhance maize productivity, Ethiopia has pursued the application of improved seeds of varieties and accompanying inputs focusing on high rainfall areas. Meanwhile, areas of low rainfall have virtually been ignored in maize research and extension. In the past two decades, however, substantial amounts of resources have been devoted to the development of improved maize varieties including those for drought-prone areas, and seven improved open-pollinated varieties of maize were released targeting drought-prone area. The research and extension of maize has also employed a new approach, namely FRG. An FRG approach refers to a farmer participatory research tool through which a research team, extension workers and groups of farmers jointly conduct trials on farmers' fields on selected topics, which are based on the needs of farmers. Accordingly, FRG based improved OPVs of maize selection, seed production and dissemination was implemented on farmers' fields at their residence *Kebele*.

Pertaining to OPVs and hybrid maize, each has its own advantages and disadvantages. OPVs are composed of plants of different genetic makeup that respond differently to environmental conditions, such as drought, diseases and they are more stable in yield. OPVs have different flowering dates, which is an essential mechanism to withstand intermittent short drought stress yield failure (Pixley and Bazinger, 2002). The seed of OPVs can be recycled for three to five years without considerable yield losses, thus are useful for smallholder farmers.

On the other hand, hybrids are high yielders, needing more stable moisture conditions and intensive management. Hybrids have uniform flowering dates and are highly affected by any of moisture stress particularly during flowering, and are therefore less stable in yield than OPVs. Furthermore, hybrid seed has to be purchased every year otherwise its yield highly decline.

Thus, open-pollinated varieties are considered more suitable for drought-prone areas where drought is a major yield-limiting factor. Seed production cost of OPVs is cheaper than the hybrid seed because farmers can maintain part of their grain produce or obtain them from local sources. Seed, particularly from OPVs, is cheaper input that is expected to be readily adopted by smallholder farmers of Ethiopia. For this reason, OPVs of maize seed are a higher priority than hybrids.

Nevertheless, the average productivity of maize is low in drought-prone areas. In Ethiopia, drought-prone growing areas constitute approximately 40% of the maize growing areas yet contribute only 20% of the total production (Nigussie *et al.*, 2001). That is mainly because the adoption rate of improved maize variety is low and farmers continue using varieties that do not have drought tolerance traits. Thus, understanding and analysis of the factors influencing the adoption of improved OPVs of maize in this area is a vital question for empirical research.

Therefore, this chapter aims to analyze factors influencing the adoption of improved OPVs of maize in drought-prone areas of CRV of Ethiopia.

5.2 Methodology

Study area and data collection

A cross-sectional sample survey was conducted in the East Shewa Zone, Ethiopia. Data for this study were collected through a farm household survey conducted in 2011, employing a multi-stage sampling procedure. East Shewa Zone was purposively selected because of its drought-prone agro-ecology, the area allocated to maize production and experience in employing the FRG approach. Indeed, four districts were selected based on area allocated to maize production.

Analytical framework: model and variables

The study of improved agricultural technology adoption received attention of researchers and policy makers expecting that the adoption of agricultural innovation improves production. A household level adoption study considers the decision made by the household head to included new or improved variety in usual farming practice. The decision made to adopt or otherwise depend on different factors. Literature show slightly more than fifty variable used in different adoption studies. Most of the study conducted in high moisture areas unlike this study that deals with drought-prone area. Some variables are more commonly employed than others are. After my reviewing adoption literature, observation and discussion with group of farmers the factors expected to affect improved maize variety adopted identified and categorized. The results of the variables have shown to vary from study to study and there was no conclusive results. Furthermore, new variables, FRG and drought encounter frequency, that are particularly important in the study area are included in the analysis.

Farmers' decision to adopt improved varieties is assumed to be the product of a complex preference comparison made by a farm household. Factors influencing the adoption of improved varieties can be estimated using Logit, Probit or Tobit Models. Farm household decisions to adopt improved varieties are assumed to be a dichotomous outcome of adoption or non-adoption. Hence, when the outcome is a dichotomous dependent variable measured by a nominal dummy, either Logit or Probit model can be employed. A choice between the two models is sticky since both models provide equally efficient parameter estimates (Demaris, 1992). Nonetheless, when continuous independent variables are included in the model, the Logit Model was well suited for testing the hypotheses about relationships between categorical outcome variables and one or more categorical or continuous independent variables. Shakya and Flinn (1985) suggested the application of the Probit Model for the functional form with limited dependent variables that are continuous between 0 and 1, and the Logit Model for dichotomous dependent variables. On the other hand, the Tobit Model assumes the outcome variables to be on a continuous scale, which is cut-off or censored at some particular value. Hence, the Tobit model is not suitable for the estimation of dichotomous dependent variables. Therefore, the Logit Model was selected since the dependent variable is dichotomous and the independent variables are constituted from both categorical and continuous variables.

The model assumes dichotomous results of the binary responses of adoption (as 1) and absence of adoption (as 0). Y stands for the conditional probability that a farmer adopts improved OPVs of maize, while (1-Y) represents the conditional probability that a farmer does not adopt improved OPVs of maize; β_s are coefficients of independent variables; and Xs are independent variables.

The choice of independent variables in this study is based on the review of literature of adoption studies as well as preliminary observation and discussions with groups of farmers to refine the independent variables, since there is no firm economic theory that dictates the choices of independent variables in adoption studies.

Literature on adoption suggests that a farmer's decision to adopt agricultural technology depends on farm household socio-economic, institutional and environment factors (Mariano *et al.*, 2012; Feder *et al.*, 1985). It is expected that a farm household head's decision to adopt, or not to adopt, an innovation influenced by a combined effect of a number of factors related to the farmer's objectives and constraints. The adoption study assumes that there exists an innovation and the study of adoption decisions evaluates determinants of adoption (Alene *et al.*, 2000). Empirical studies conducted in high rainfall areas in Ethiopia, Kenya and Tanzania (Feleke and Zegeye, 2005; Abdissa Gemeda *et al.*, 2001; Ouma *et al.*, 2002; Kaliba *et al.*, 1998b) present a range of factors such as gender, age, education, land holding, livestock holding, extension visits, etc. to explain the adoption of improved maize varieties. The results of those factors are not consistent and vary from study to study.

Therefore, the Logit Model for adoption of improved OPVs of maize is specified as follows.

Specification of the Logit Model

According to Menard (2002), Logit Model for the log odds of improved variety adoption of improved crop varieties can be specified as:

Logit (Y) = Logit (Y) = $\beta_0 + \beta_1 X_1 + \beta_1 X_2 + \ldots + \beta_k X_k$

We can convert logit (Y) back to the odds ratio by exponentiation [odds the Y=1] $=e^{\text{logit (Y)}}$. Odds (Y=1) $e^{\ln[\text{odds(Y=1)}}$. Again, we can convert the odds back to the probability that (Y=1) by the formula P (Y=1) = [odds that Y=1]/ [1+odds that Y=1], where P_i=prob(Y=1) is the conditional probability that a farmer adopted an improved maize variety. The conditional probability that a farmer does not adopt an improved variety is given by (1-Pi) =Prob(y=0). βs are parameters to be estimated and X_s are the set of independent variables. Some researchers name Logit with categorical independent variables Logit Models and with the one with mixed categorical and continuous independent variables Logistic Regression Models. Other researchers do not make distinctions between the two. In this dissertation, the term Logit Model is used regardless of the type of explanatory variables included following that of Liao (1994).

Table 5-1 Description of the independent variables and their a priori expected signs

Variable Name	Symbol	Unit (Type)	Sign	Description
Gender	Gnd (X_1)	Dummy	+	Male household heads are expected to be better adopter than female household heads
Age of household head	Age (X_2)	Year	+/-	Age of HHH either positively or negatively influence improved variety adoption
Household size	Hhsiz(X_3)	Ha	+	A larger household provide more labor thus expected to positively influence adoption of improved varieties of maize.
Education of household head	Edc(X_4)	Year	+	Education is expected to influence improved variety adoption positively
Farm size	Frmsz(X_5)	number	+	Farm size is expected to positively influence adoption improved varieties
Oxen owned	OX(X_6)	Number	+	Number of oxen is expected to influence improved variety adoption since farmers who own more oxen are expected to prepare land on time
Extension visit	EXTN(X_7)	Number	+	The frequency of extension workers' visits is expected to positively influence farmers' adoption decision.
Field day participation	FLD(X_8)	Dummy	+	Farmers' participation on farmers' field days encourages farmers to try improved crop varieties and is expected to positively influence adoption decision.
Market distance	Tmkt (X_9)	Time (minutes)	+	It is expected that the closer the grain market is the higher the probability of improved variety adoption.
Farmer Research Group *Kebele*	FRG_K(X_{10})	Dummy	+	Farmers living in FRG *Kebeles* are expected to be better adopters due to the influence of demonstration, farmer-to-farmer seed dissemination
Research Distance	RC-dist(X_{11})	Kilo meter	+	The closer the research center the higher the probability of improved variety adoption.
Drought encountered	Drght(X_{12})	Dummy	-	A household who experienced more frequent yield stress due to drought is less likely to adopt
Altitude	Alti(X_{13})	masl	+	The higher the altitude the higher the improved variety adoption is expected since precipitation increases with altitude.

Source: Author summary from miscellaneous adoption studies and own hypothesis, 2012

Empirical model

There is no firm theory that dictates the choices of independent variables in adoption studies. However, improved variety adoption literature suggests that farmers' decisions to adopt an agricultural technology depends on farmers' characteristics, their economic position and institutional environment as discussed in the previous sections. Description of and hypothesis of the independent variables in the study are summarized in Table 5-1

$$OPVA = \beta_0 + \beta_1(Gnd) + \beta_2(Age) + \beta_3(Hhsiz) + \beta_4(Edc) + \beta_5(Frmsz) + \beta_6(Ox) + \beta_7(Extn) + \beta_8(Fld) + \beta_9(Tmkt) + \beta_{10}(FRG\text{-}K) + \beta_{11}(RC\text{-}dist) + \beta_{12}(Drght) + \beta_{13}(Alti)$$

OPVA represents adoption of open-pollinated varieties of maize; Gnd, gender; Age, age; Hhsiz, household size; Edc. education of household head; Frmsz, farmland size; Ox, oxen owned; Extn, extension visit; Fld, field day participation; Tmkt, time taken to the nearest grain market; FRG-K, being in a Farmer Research Group *Kebele* or otherwise; RC-dist, distance to Agricultural Research ; Drght, frequency of drought encountered; and Alti, altitude.

Factors influencing the adoption of OPVs of maize in the drought-prone areas can be categorized into three. First, human and physical resource endowments, including gender, age, education of household head, household size, farmland size and number of oxen owned. Female-headed households are often poor and their access to information and innovations is limited, thus negatively influencing their adoption. Age is a proxy for farmer experience in farming that can generate or erode confidence to adopt improved varieties. Household size accounts for household farm labor since an intensive management is required for the optimum yield from improved varieties. The level of education of the household head is expected to influence a farmer's adoption decision since it boosts the capacity of the farmer in acquiring, processing and utilizing information. Farmland and livestock are key assets of a farm household. Within livestock, oxen provide extensive draught power. Hence, a farm household's ownership of farmland and oxen is anticipated to positively influence the likelihood of adoption of improved OPVs of maize.

The second category of factors influencing improved OPVs of maize adoption constitutes the institutional factors extension visits, field day participation, the time taken to the nearest grain market, membership in FRG-*Kebele* and proximity to Agricultural Research Center. Extension visits are presumed to be a major means for farmers to access new and reliable agricultural information and thus are expected to positively influence the adoption decision. A farmer's participation on demonstration field days of improved OPVs of maize is a means to develop confidence and reduce subjective uncertainty about the variety and thus it is expected to positively influence the likelihood of adoption. Distance to the nearest grain market is a proxy to market accessibility. Farmers residing close to grain markets are assumed to have access to up-to-date information on the availability of agricultural inputs and outputs, including improved varieties, and hence would be expected to adopt improved OPVs of maize. FRG a family of farmers' participatory research, have been implemented in Ethiopia to identify, release and multiply farmer preferred varieties. In the FRG approach, farmers are involved in a series of research and extension activities, such as maize variety evaluation and selection, seed production and dissemination activities. Thus, FRG-*Kebele,* where farmer participatory research is conducted, is expected to have a positive influence on the likelihood of the adoption of improved varieties.

The third category includes environmental characteristics, namely altitude and drought. In Ethiopia, altitude is the salient feature that alters both temperature and rainfall (FAO, 1984). The altitude is expected to positively influence the likelihood of adoption of improved OPVs of maize. Drought is a major challenge of crop production, particularly in drought-prone areas of Ethiopia. Drought risk was proxied by the number of substantial yield stress encountered in the past ten years. Moreover, in drought-prone areas, improved variety adoption studies are scarce. The focus of previous adoption studies were on high rainfall areas for anticipated promising results from those areas.

5.3 Results

OPV maize growing farm households

The basic characteristics of the sample farm households are shown in Table 5-2. Female-headed households constitute about 16% of the total 277 sample farm households. On average, a household constitutes about 7 persons, headed by 41 year-old adult with a low level of education (≈ 2 years). The adoption rate of improved OPVs of maize is still low, 29%. Male household heads tend to more readily adopt than female household heads.

There was no significant statistical difference between adopters and non-adopters in both their average age and household size. Adopters tend to own larger farmland and more oxen than non-adopters. Both adopters and non-adopters have the same level of access to extension services as measured by the frequency of visits. Average distance to the nearest grain market is 83 minutes for adopters compared to 98 minutes for non-adopters. Droughts that substantially stressed maize yields were encountered, on average, three times in the last ten years and the frequency of the substantial yield stress encountered tends to be higher among non-adopters. Adopters more frequently participated in field days than non-adopters did. Indeed, farmers in FRG *Kebeles* tend to be better adopters than those in non-FRG *Kebeles* do (significant at 1%). FRG-*Kebeles* were where improved variety maize was conducted through participation of farmers among other farmer research group activities accomplished in the study area. The activities included comparison and evaluation of improved and local varieties by group of farmers- mainly the FRG members. The trial fields were visited by the FRG members and non-members on field days, group meetings etc. The FRG members were selected varieties well suited to their areas. The seeds of those varieties were shared among farmers through the local networks and means of exchanges (sale, swapping, and gift). The FRG members involved in improved maize seed production and distribution activity in the FRG-*Kebele*s. Chapter 6 discusses more about the FRG based seed production.

Table 5-2 Average values of selected variables included in the OPV of maize adoption model in CRV of Ethiopia

Independent variable	All respondents (N=277)	Adopter (N=80)	Non-Adopter (N=197)	F
Gender of HHH [(1)] (% male)	84	91	85	3.96*
Age of HHH (year)	41	40	42	0.95
House hold size (persons)	6.7	7.1	6.5	2.06
Education of HHH (year)	2	3	2	6.35*
Farmland size (ha)	2.36	2.68	2.23	5.57*
Oxen owned (head)	2.4	2	1.7	4.52*
Extension visit (times per month)	2.4	2.5	2.4	0.39
Field day participation (%)	20	30	17	3.72
Time to the nearest grain market (minute)	94	83	98	5.14*
FRG *Kebeles* (% farmers)	20	46	10	56.58**
Distance from Agricultural Research Center (km)	89	92	80	0.26
Drought frequency (in recent ten years)	2.7	2.3	2.9	13.0**
Altitude (meter above sea level)	1560	1543	1568	2.48

Note1: [(1)] HHH: Household head;

Note 2:* and ** denote statistical significance at 1% and 5%, respectively.

Source: Author field study, 2011

Determinants of adoption of improved OPVs of maize

The independent variables that have shown significance differences between adopters and non-adopters were entered into the Logit Model (Table 5-3). Prior to running the Logit Model, the presence of multicollinearity among the independent variables was checked using the variance inflation factor (VIF). Since the highest VIF obtained was 2.7, far less than the threshold 10. Thus, there was no problem of multicollinearity.

Results of the Logit Model estimation are presented in Table 2. The model is well suited to the data as shown by the likelihood ratio χ^2 59.88 ($p<0.001$). The null hypothesis that all the variables could be dropped, was also rejected at 1% level of significance since the Wald χ^2 45.81 ($P<0.001$). The factors influencing the adoption of improved OPVs included farmland size, distance to grain markets, droughts encountered and FRG-*Kebele*. Distance to the nearest grain market was negatively associated with the log odds of adoption of improved OPVs. The frequency of substantial yield stress encountered was found to be negatively and significantly associated with the log odds of adoption of improved OPVs ($P < 0.01$). The log odds of adoption of improved OPVs of maize was found to be strongly and positively associated with FRG-*Kebele.*

Table 5-3 Estimates of the Logit Model of adoption of improved OPV of maize in CRV of Ethiopia

Independent variables	β	Wald's χ^2	Sig.	Exp(β)
Gender of the HHH	.611	1.479	.224	1.841
Education of the HHH	.018	.114	.736	1.018
Farmland size	.047	2.394	.122	1.048
Oxen owned	-.035	.062	.803	.965
Time to the nearest grain market	-.005	1.970	.160	.996
Field day participation	.287	.607	.436	1.333
FRG *Kebele*	1.848	28.126	.000	6.344
Drought encounter frequency	-.330	6.806	.009	.719
Test		χ^2	P	
Likelihood Ratio (LR) χ^2(8)		59.88	0.000	
Wald χ^2(8) statistic		45.81	0.000	
Percent of correct predictions		77.6		
Cox and Snell R^2		.20		
Nagelkerke R^2		.28		

Source: Author field study, 2011

5.4 Discussion

The adoption of an improved variety is a dynamic decision making process of introducing agricultural technology into the existing farming system. The decision involves a number of factors that are related to human and physical resource endowments, as well as institutional and agro-ecology conditions. In this study, the adoption of medium maturing improved OPVs of maize released and introduced within the past ten years was considered.

Farmland size was shown to positively influence the adoption decision of improved OPVs in the drought-prone area of CRV of Ethiopia. This is in line with the finding of Alene and Hassan (2000) and in contrast to that of Abdisa Gemeda *et al* (2001). Distance to the nearest grain market was found to be negatively associated with the likelihood of adoption. Similarly, Feleke and Zegeye (2005) noted the negative and significant association of market distance with adoption of improved maize. This indicates that a farmer living at a distance from market centers is less likely to adopt improved maize varieties than those who are located closer.

Strong association of adoption decision of improved OPVs of maize comes from FRG-*Kebele.* Farmers in FRG-*Kebeles* were found to more readily adopt than those who were in the non-FRG *Kebeles*. The FRG-*Kebeles*, where farmers conducted variety testing and seed multiplication had an overriding positive influence on the adoption of improved OPVs of maize. Farmers who obtained seed from the FRG farmers appreciated the quality of the seed, yield of the variety and its drought tolerance. Farmers in FRG-*Kebeles* were over six times more likely to adopt improved OPVs of maize than the farmers in non-FRG-*Kebeles*.

A possible explanation can be because FRG members work in collaboration with researchers and agricultural experts and are involved in variety evaluation, selection, seed production and dissemination of improved OPVs of maize seed. Thus, the FRG activities had enhanced other farmers' access to improved OPVs maize seed.

The frequency of substantial yield stress encountered due to drought was negatively associated with and depressed the adoption of improved OPVs of maize in drought-prone CRV of Ethiopia. The negative effect of drought on the adoption of improved varieties was observed in previous works (Feder *et al.*, 1985). This effect, in Ethiopia, can be tackled by adopting drought tolerant and early maturing varieties tested under farmer participation, such as the FRG approach.

The FRG-*Kebele* is used as a proxy for the FRG approach used as farmer participatory research is believed to have strongly influenced the adoption of improved variety maize for couple of reasons. The FRG has facilitated information dissemination about new variety. Farmers in FRG *Kebele* participated on FRG field days and have contact with FRG members in daily activities. Secondly, FRG members shared improved variety seeds with fellow farmers on sale, credit, exchange, and gift. Local improved variety seed production and distribution of improved seed has been enhanced farmers' access to improved seed then adoption due to proximity; what Tripp (1994) calls "Proximity is a Plus'. The seed produced by FRG members appreciated by other farmers for its quality and availability reasonable price. The issue to what extent the client farmers appreciate about the FRG, appropriate size of FRG member for significant impact need to be to dealt with in further study as FRG functioning is concerned beyond seed production and dissemination aspects.

5.5 Conclusion

This chapter analyzes factors influencing the adoption of improved OPVs of maize, taking farmers resource endowment, institution and agro-climatic conditions into account. Among the resource endowment factors, farm size positively influences the adoption of improved OPVs of maize. On the other hand, the adoption decision of improved OPVs is negatively influenced by distance from the nearest grain market. The frequency of substantial yield stress encountered due to drought is an impediment to the adoption of improved OPVs of maize. Thus, it is important to mitigate through adoption of improved drought tolerant varieties. The finding of the importance of FRG-*Kebeles* in the adoption of improved OPVs of maize is interesting, where its influence was found to be significantly high for improved OPVs adoption. This suggests that this approach can be used as an effective tool in the introduction of improved OPVs of maize to enhance adoption of improved varieties in similar drought-prone areas of Ethiopia and elsewhere in SSA in contributing to food security at large.

CHAPTER 6

FARMER RESAERCH GROUP BASED IMPROVED OPEN-POLLINATED VARIETIES MAIZE SEED PRODUCTION AND DISSEMINATION

6.1 Introduction

This chapter discusses farmer group based improvement in open-pollinated variety maize seed production and dissemination in the drought-prone areas of CRV of Ethiopia. Providing improved variety seeds of suitable traits is crucial in boosting the yield of food crops. Certified seed supply efforts to smallholder farmer through the formal seed sources have been a particular failure in reaching farmers in drought-prone areas such as the CRV of Ethiopia. In the reforms made in enhancing improved variety seed availability, farmer participatory variety selection has been introduced. Accordingly, farmers' effectiveness in selecting suitable varieties for stress areas has been documented (Ceccarelli and Grando, 2007). The downstream concern of improved variety seed provision has remained unclear, however. Therefore, this study focuses on farmer participatory variety selection, seed production and dissemination taking the case of FRG.

Alemu *et al.* (2008) documented a limited dissemination and adoption of improved maize varieties due to constraints in improved seed provision. The authors further argued that public seed supply dominance has restricted competition in the seed market and suggested increased involvement of the private sector. However, Langyintuo *et al.*(2010) note that the private seed enterprises are not interested in a provision of OPVs maize seed for drought-prone areas. In the attempts to enhance farmers' access to improved variety seed, farmer participatory research has been adopted in agricultural research. The efficiency of farmer in variety selection particularly for moisture stress areas has been narrated (Ceccarelli and Grando, 2007). Other than variety selection, some farmer participatory research approaches such as FRG has included seed production and distribution. In Chapter 5, we have seen that crucial importance of FRG *Kebele* in improved OPVs maize adoption. It is believed that the adoption was enhanced due to quality seed made available by FRG members in the farming community where farmer can access the seed and related information.

This chapter discusses the contribution farmer group based improved OPV maize seed production and dissemination in drought-prone areas of CRV of Ethiopia. An integrated improved variety seed supply efforts and the cost issues closely looked at in local seed supply development in drought-prone CRV of Ethiopia.

6.2 Methodology

Farmer participatory research (FPR) in improved variety selection and seed provision

Different kinds of FPR approaches such as participatory plant breeding, participatory crop improvement, participatory variety selection (PVS) and farmer research group (FRG) have been exercised amongst which PVS commonly exercised. Ceccarelli and Grando (2007) noted farmer selected varieties ready adoption by PVS participants in contrast to the top-down hierarchical approach of breeding, variety release, seed multiplication, distribution and adoption (Table 6-1). As to the farmers' selection criteria search, the criteria can be as many as twenty[29] in maize (Mulatu and Zelleke, 2002) or a few as one in tef (color was the principal

[29] 1. Withstanding drought stress, 2. Withstanding water logging, 3. Anthesis-silking interval, 4. Ability to escape predator attack, 5. Compatibility to intercrop with sorghum, 6. Stalk thickness, 7. Grain color, 8. Absence of barren stalk, 9. Time to reach maturity, 10. Prolificacy (number of ears/plant), 11. Grain texture (type), 12. Level of resistance to leaf diseases (leaf blight and rust), 13. Level of resistance to stalk borers, 14. Resistance to

criterion) (Belay *et al.*, 2005). Farmers do select and name their own varieties by assigning descriptive vernacular names even before the varieties are released, yet the variety may be denied release when it is judged by conventional release criteria. The exercise of farmer PVS is not an end in itself unless the wider farming community benefits from the result. Participatory research, specifically PVS, largely focused on technical issues of breeding efficiency. A clear discussion is lacking regarding the provision and distribution of the seeds of improved varieties to farmers − a crucial issue for farmer participatory research. The FRG approach includes in the downstream issues of seed provision beyond variety selection and the selection criteria identification exercises. In commodity specific FRG activities, seed production and dissemination were included which may enhance smallholder farmers' access to quality seed.

Table 6-1 Summary of conventional breeding and farmer participatory research procedures

Period (year)	Conventional	Farmer participatory research (e.g., PVS)	Period (year)
1	Quarantine observation		
1	Observation nursery I		
1	Observation Nursery II	Discussion with farmers and consensus building on research activities to be conducted through participatory rural appraisal or focus group discussion techniques	0-1
2-3	Multi-location trial	Multi-location farmer variety evaluation and selection	1-2
1	Verification		
0-1	Evaluation and release notification	Production and distribution	1
1	Basic seed multiplication		
Total= 7-9	Release for production (adoption)		4-6

Source: Author summary, 2012

weevils, 15. Performance under sub-optimal soil fertility, 16. Green maize taste, 17. Quantity usable flour (pericarp: endosperm ratio), 18. Grain yield, 19. Stover yield, 20. Absence of bare tips as criteria in high land maize (Mulatu and Zelleke, 2000:17)

Description of the maize farmer research group

For the implementation of farmer participatory work of variety selection, FRGs were established in selected major maize producing *Kebeles* in collaboration with district and *Kebele* agricultural development workers. The contact of the *Kebeles* was based on predominantly involving in maize production and accessibility of the area in discussion with District Agricultural and Rural Development experts of the districts. In the beginning, Participatory Rural Appraisal (PRA) was conducted to understand and characterize the local condition to identify the constraints and needs of the farmers. On the PRA, large groups of farmers were participated. The PRA participant farmers identified drought, yield decline and late maturity of available maize variety concerning maize production. Repeated discussions were conducted on activities to undertake with farmers. Farmers were selected by their gender, interest and socio-economic conditions. The groups were composed of men and women of different age groups from five *Kebeles* comprising 90 households out of which 14 of them were female headed (Table 6-2). Based on the PRA tools, the commodities of experiments were identified at each *Kebele*.

Table 6-2 *Kebeles* and number of maize farmer research groups

District	*Kebele*/Group	Number of households	Gender of house hold head		Number of farmers†
			Male	Female	
Adama	Adulala- Hate-Haroreti	13	11	2	24
	Awash-Melkassa	10	9	1	19
Boset	Dongore Furda	11	9	2	23
	Dongore Tiyo	10	7	3	17
ATJK	Anano-Shisho Group 1	18	17	1	36
	Anano-Shisho Group 2	28	23	5	60
Total		90	76	14	179

Note: † number of farmers indicate both spouses since they both involved in the FRG activities such as variety evaluation, field day and training etc

Source: Author field study, 2011

Farmers improved maize variety selection and seed production

The evaluation of improved varieties or those materials close to the verification stage were conducted in comparison to the standard and/or local varieties. The principal varieties tested were medium maturing[30] OPVs (Nigussie *et al.*, 2001) (Table 4-3). Among the varieties[31], evaluated, Melkassa-2 and Melkassa-6Q were selected for seed production.

[30] Maize varieties are categorized based on their maturity dates. Extra early maturity (mature in less than 90 days and silking in less than 50 days); early maturity (mature in 90-115 days and silking in 50-56 days); medium maturity (mature in 116-140 days and silking in 56-65 days).

[31] The varieties of maize included were Melkassa-2, Melkassa-3, Melkassa-4, Melkassa-6Q among the new released varieties and Awassa-511, *Shaye, Limati and Hararghe* among locally available ones.

Melkassa-2 was selected for its yield and drought tolerance while Melkassa-6Q was selected for its quality protein[32] and yield.

Selected varieties were popularized through field days, mass media, and face-to-face contacts through which awareness was created and interest was developed. Based on interest subsequent discussions were held among farmers, researchers, agricultural experts, farmers' cooperatives unions, and public seed enterprise managers on improving the availability of the selected OPV maize seeds based on FRGs. Sites for seed production and FRG member seed producers were identified. The experience and confidence of the farmer on the variety, the demonstrated interest of the farmers and the suitability of the land for seed production (200 m isolation distance and one hectare or more area) were taken into account in selecting the seed producer farmers.

Training sessions were organized for the seed producer farmers and development agents on OPV maize seed production in classroom discussions concerning field selection criteria, the required isolation distance, crop rotation, fertilization, weed control, rouging out poorly established plants, diseased and abnormal plants, seed harvesting, seed cleaning and insect control. Likewise, practical training was conducted during field selection followed by field monitoring visits at flowering, maturity and harvest periods.

The seed fields were planted at a minimum of 200 m isolation distance where maize is dominantly grown. Researchers and seed experts periodically monitored the seed production fields to make sure that the quality of the on farm-produced seed was genetically intact. The seed was harvested at maturity when the moisture content was around 12%, and then threshed and stored separately in clean dry storages.

[32] Farmers liked the yield of the quality protein maize variety regardless of is protein quality which difficult to assess. Experts told them about this unique quality of the variety. Some farmers mention it being good in nutritional quality referring to high bird scaring incidence on the variety as compared to other varieties. Farmers' belief that the more a variety scared by birds as compared to the other (s) the quality the variety is.

Establishment of linkages between FRGs with other stakeholders

A close partnership has been forged among farmers, development agents, and researchers from the beginning of the introduction of varieties for evaluation. Afterwards, other stakeholders such as experts from public seed enterprises were involved in the training of farmers in seed isolation, identification of poorly established and diseased plants. As the number of stakeholders increased, the forum was linked to research-extension-farmer linkage advisory council of East Shewa Zone that oversees the liaison between agricultural research and development. The leader of the council is the Zone Agricultural and Rural Development Office head where the representatives of research centers and other stakeholders involved are the members. The council members meet twice a year for field visits and progress evaluation, and during this time, each of them reports on their accomplishments and plans in the presence of the key stakeholders. The roles and relationships of each stakeholder pertaining to FRGs is shown in Table 6-3.

Table 6-3 Stakeholders in OPV maize seed production and dissemination in CRV of Ethiopia

Stakeholder	Activities	Focal persons
Farmers /Farmers' cooperatives	Variety selection, field management Make inputs available (fertilizer and insecticides), Look for market or distribute seed	Individual farmers and cooperative managers
East Shewa Zone and District Agricultural and Rural Development Offices	Facilitate training at *Kebeles*/sites Facilitate seed distribution and other essential input provision Field monitoring(during site selection, planting, at flowering and harvest) Field follow up and farm management (land preparation storage and distribution) Co-organize field days	Extension department head Input supply head Agricultural Development Agents Development Agents and supervisors
MARC	Training farmers and agricultural development agents Supply basic seed to seed producers Monitor fields with other stakeholders Prepare technical material (leaflets, production guidelines). Introduce related technologies (e.g., maize shellers-manual and engine operated)	MARC researchers, District agricultural and rural development workers and OSE.
OSE-Oromia Seed Enterprise	Join training on seed producers Field inspection of seed farm production (quality control) seed distribution	Eastern Branch of Oromia Seed Enterprise

Source: Stakeholder meeting memo of sharing activities 2008

FRG in improved maize variety evaluation and seed production

The FRG members continuously evaluated early to medium maturing varieties of maize. The evaluation was conducted in-group at different stages among which flowering and maturity stages are common. The group practice was shared with local farmers on field days, exchange visits and meetings through which local awareness was created. All the FRG members adopted improved varieties (Emana, 2009). Moreover, most of them shared the seed on average with 10 farmers[33].

The FRG farmers received training in quality seed production such as maintaining isolation distances to maintain genetic purity of the variety selected. The training included removing diseased and abnormal plants (since farmers usually do not remove from their maize production fields) and harvesting time and storage conditions. The FRG activities have created close relationship between farmers, researchers and agricultural experts. The FRG farmer are requesting for new technology (e.g., varieties and farm implements) including visiting to research center and on other occasions (e.g., research field visit) as witnessed during this research fieldwork.

6.3 Results and discussion

Farmer improved OPV maize seed production and distribution

As shown in Table 6-4, about sixty-four tons of pure quality[34] maize seed was produced and distributed by the FRG members over four successive years. It was continuing up to the time of writing. The seeds were disseminated on sale, exchange and gifts. Sales accounted for 86% of the distributed seed while exchange and gifts comprised 5%. Seed producer farmers themselves disseminated most of the seed produced and the efficiency [35]of the seed distribution accounted for 91% of the seed harvested.

[33] A survey made to 61 FRG members in 2011 show that each FRG member was distributed seed to 12 farmers in 2009 and 8 farmers in 2010 the two years making 10 farmers on average.
[34] High germination, high physical quality and produced on isolated field
[35] Efficiency here indicates the percentage of the produced seed disseminated (see Sahlu *et al.*, 2008)

Table 6-4 Farmer group based improved maize seed production and dissemination efficiency

Year	*Kebele*	Variety	Total seed produced (ton)	Sale (ton)	Exchange (ton)	Gift (ton)	% seed distribution
2007	Anano-Shisho	M-2 †	8.5	7.46	.60	.25	98
	Dongore Tiyo	M-2	3.5	2.05	.22	.1	68
	Wakie Mia Tiyo	M-2	2.0	0.5	.61	0	56
2008	Anano-Shisho	M-2	7.2	5.86	0.57	0.1	91
2009	Malima Bari	M-2	10.0	10.0	0	0	100
2009	Melka-Oba	M-6Q‡	5.0	4.2	0	0	84
2009	Aneno-Shisho	M-6Q	10.2	10.2	0	0	100
2009	Aneno-Shisho	M-2	6.2	5.0	0.63	0	91
2010	Anano-Shisho	M-6Q	11.3	10.0	0	0	88.5
Overall			63.9	55.27	2.63	0.45	91

Note 1: †M-2 represents Melkassa-2

Note 2: ‡ M-6Q represents Melkassa-6Q

Source: Author field study, 2008 to 2010

Methods of the FRG produced seed distribution

The seed was primarily distributed for sale, for exchange and for gifts in a decreasing order of volume and frequency. Seed lending has not been observed in this study, which was claimed to constitute 50% of the cases in the late 1990s and the beginning of 2000s (Deressa *et al.*, 2002). On average, each seed buyer farmer purchased 90 kg seed from seed producer farmers for the 2008 planting season. This amount is far much in excess to plant to the average land holding of the area of 2.7 ha per household of the ample seed purchaser farmer. The average seed purchase is high because a few farmers purchased up to one-ton of seed to redistribute while about two-thirds of the buyers purchased less than 50 kg. The second reason for the higher seed purchase is unreliable moisture condition. Farmers plant about 40 kg per hectare maize seed while the recommendation is 25 to 30 kg. In the beginning, the seed was disseminated in the FRG areas. Then, it expanded rapidly within a short period to the neighboring districts and beyond.

Thirty-four *kebeles*[36] had obtained improved FRG produced maize seed by 2009 (in the second year of seed production) largely within a 30 km radius from seed producing farmers. A representative example where seed dissemination took place is indicated in Figure 6.1 and Annex 10. There are a few cases where FRG produced seed was transported up to 800 kms distance such as Gambella, and a few hundred kilometers to neighboring zones of Siltie and Wolaita, crossing ethnic boundaries which are, at times, considered as a barrier in farmer produced seed dissemination (Almekinders *et al.*, 1994).

[36] In the CRV area of Ethiopia, one *kebele* has on average about 630 households of average 7 persons.

Adami-Tulu-Jido-Kombolcha District

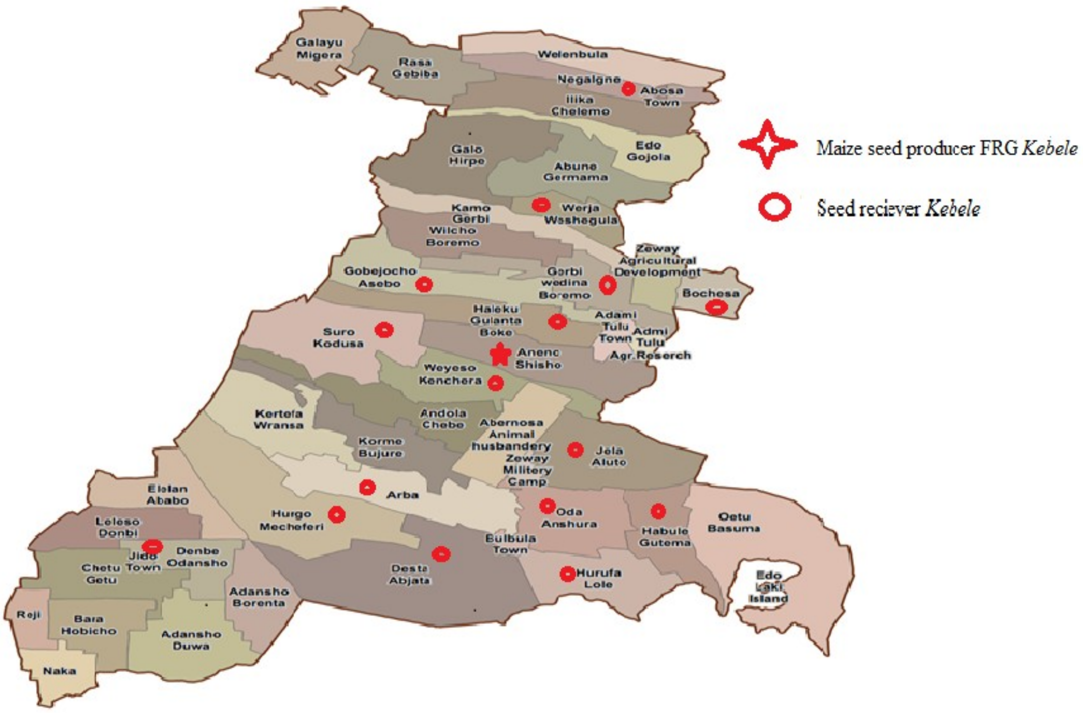


Figure 6-1 Map showing improved maize seed dissemination from FRG seed producer farmers

Source: Adapted from the Ethiopian Mapping Authority

Patterns of farmers produced seed dissemination

The seed was first disseminated in FRG areas. Then it expanded to its neighboring areas and far beyond. The dissemination of the new variety seeds was typically higher (31% of maize area) in the FRG *Kebeles* of Adulala-Hate-Haroreti, Awash Melkassa and Anano-Shisho than in non-FRG *kebeles*. Melkassa-2 (a wide distributed improved variety) accounted for 20% of total maize area planted, ranking third within a relatively short period (Table 6-5). In the FRG *Kebeles*, the dissemination and adoption were rapid most likely because of proximity to seed producers and involvement in field days, in-group discussions, etc. At the time of writing, the adoption of those improved OPVs in FRG *kebeles* was estimated to have reached about two-third of farmers[37].

Table 6-5 Area (ha) planted to OPV of maize in selected *kebeles* accessed to farmer group based improved seed

District	*Kebele*	Awassa-511	BH 540	M-1 (1)	M -2	K a (3)	Local maize	PhB (4)	Total
Adama	Adulala-Hatie*	12	-	5	14	-	87	-	118
	Awash Melkassa *	30	-	16	15	-	-	-	61
ATJK	Anano-Shisho *	250	50	2	700	-	172	-	1174
	Habule †	-	320	-	3	1	1094	-	1417
	Hurufa Lole†	13	75	3	23	-	887	-	1000
	Negalign†	-	115	-	114	-	-	20	249
	Oda Anshura†	-	493	-	3	-	850	-	1345
Grand Total		304.5	305	1053	26	871	1	3089	20
Rank		4	2	5	3	7	1	6	

Note 1: * Indicates FRG *Kebele*

Note 2: † non-FRG,

Note 3: M-1 represents Melkassa-1

Note 4: M-2 Melkassa-2

Note 5: Ka represents Katumani

Note 6: PhB represents =Pioneer hybrid

Source: Author field study, 2008

[37] Discussion with local agricultural development agents from their annual area estimation at *Kebele*

Quality of the FRG farmer produced seed

Seed quality is an essential characteristic of seed. It can be measured in terms of physical, germination, and genetic quality characteristics (Bishaw, 2004). The genetic quality of farmer seed production was taken care of by maintaining isolation distance and roughing out abnormal and diseased plants. The physical seed purity was 99.8%, and no weed seed and no other crops were observed. The germination rate of the seed was 93% (standard deviation (SD) = 2.8%). This is above the minimum (85%)[38] seed certification standard of Ethiopia. Similarly, basic seed from research had germination rates of 94% (SD = 5.8%). There was no significant difference in germination between the seed produced by farmers and basic seed obtained from Agricultural Research Center.

FRG in improving access to seed and improved variety adoption

The activities of FRG had contributed to smallholder farmers' awareness and access to improved varieties. Field survey data show that farmers in FRG *Kebeles* had more frequently participated on improved variety demonstration field days in the preceding five years. Field days are the occasion where farmers see and evaluate the performance of new varieties under their environments. Further, farmers discuss and get clarifications about inputs applied and agronomic practices performed from other fellow farmer involved in the demonstration. Likewise, a significant proportion of farmer in FRG-*Kebele* had tried numerous varieties of maize as compared to those farmers in non-FRG *kebeles* (in non –FRG-*Kebeles* a farmer tried only up three varieties). The practice of FRGs created opportunities for farmers to learn and try out the performance of new varieties that at the end they would include in their production practices.

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[38] Maize seed samples were collected from seed producer farmers and tested for purity and germination at MARC. Basic seed was included from MARC to compare germination to the farmer-produced seed.

The FRG, which proxied as FRG-*Kebele* in Logit Model in Chapter 5, had played a significant role by facilitating access to information and performance evaluation of improved varieties by local farmers. Likewise, farmers in FRG *Kebeles* had better information about management of improved varieties including seed rate and new varieties. Similarly, farmers in FRG-Kebeles tend to more frequently change their maize seed lots as compared to farmers living in non-FRG *Kebeles* (Annex 11).

The benefit and cost of FRG OPV maize seed production

The cost of seed production and distribution are the major limiting factors to the formal source OPVs seed supply (Sahlu *et al.*, 2008) which hamper smallholder farmers' access to quality seed in drought-prone areas. In this study, farmer based OPV maize seed production cost was considered to understand any cost effectiveness of FRG based seed production and dissemination practices. Labor for field operations and the inputs are the major maize production costs.

The average cost of production of one ton of maize seed in normal years 2008 and 2010 was 1077 and 1507 ETB[39], respectively. The production cost per ton was 3134 ETB in the stress year, 2009. That is because of reduced productivity due to drought stress in 2009. In the same manner, the average seed production cost for a hectare of maize seed production in 2008 was 4070 ETB and 2010 and 4857 ETB. The net-benefit per hectare was attractive and the benefit-cost ratio was as high as 6.94 in normal year and as low as 1.16 in a stress year (Table 6-6). The production cost was far below the ESE's seed production cost of 4074.6 ETB per ton (Alemu *et al*., 2008). Such high cost of seed production is a major constraining factor in seed supply by the parastatal seed enterprises along with high transportation costs of

[39] Ethiopian Birr-currency of Ethiopia 1USD =9.41 ETB, March 2008 and 13.43 ETB March 2010

centralized seed processing facilities (Sahlu *et al.*, 2008). Hence, such a cost reducing seed production approach presented from the case of FRG is a vital means to build upon in order to mitigate seed supply constraints particularly in drought-prone areas.

Table 6-6 Benefit cost analysis of farmer improved OPV maize seed production and dissemination

Cost items/Description	[(1)] SG1-2008	SG2 - 2008	Kenenisa SG-2009	Anano SG-2009	SG1-2010	Kenenisa SG-2010
Land rent and land clearing	900	0	800	0	900	1080
Land preparation and planting	1500	320	4000	4200	1240	3420
Cultivation and thinning	1020	690	2240	6440	900	2430
Harvest and post harvest costs	2030	1150	2192	1572	2062	3512
Inputs (seed, fertilizer and fumigant)	1687.2	341.5	4300	9191	1550	4569
Miscellaneous expenses (e. g., storage)	30	20	60	0	1289	2670.5
Total cost of production	7167.2	2521.5	13592	21403	7941	17681.5
Cost of production per ha	4778	3362	3398	3058	5294	4420
Cost of production per ton	1433	720	2718	3549	1281	1733
Gross income	25000	17500	17412.5	24825.0	25000	48925
Net income	17832.8	14978.5	3820.5	3422.06	12142	20841.5
Benefit cost ratio (BCR) [(2)]	3.49	6.94	1.28	1.16	3.15	2.77
Variety	M-2[(3)]	M-2	M-6Q[(4)]	M-6Q	M-2	M-6Q
Season(year)	Normal	Normal	Stress	Stress	Normal	Normal

Note 1: [(1)] SG stands for Sub-Group

Note 2: [(2)] BCR is gross return divided by the total cost of production

Note 3: [(3)] M-2 stands for Melkassa-2

Note 4: [(4)] M-6Q stands for Melkass-6Q where Q represents quality protein maize

Source: Author field study, 2008 to 2010

Issues for consideration in FRG seed production and dissemination

There are areas of concerns in FRG seed provision in spite of the progresses discussed which may persist in the near future. Production of open-pollinated maize seed requires a large area for isolation distances. In CRV, maize fields are located in adjacent fields where there is better moisture available and the land is fertile at valley bottoms. Hence, securing the isolation distance requires the willingness of farmers who own the adjacent plots[40].

Secondly, FRG based seed production depend on basic seed supply of new varieties. Thus, a sustainable seed production depends on a continuous basic seed supply. Continuous seed supply again calls for a favorable policy framework from research and public seed enterprises.

Basic seed supply in sustainable farmer based improved variety seed production

The central tenet of public crop breeding is to generate and provide improved variety seeds to seed producers or farmers. Hence, a decentralized basic seed supply is believed to be more accessible by small-scale seed producer farmers. Thus, it is easier to reach out from research centers to those farmers since they are located within the representative agro-ecological areas for research-mandated crops. In contrast, centralizing basic seed supply processes under centralized by headquarters creates inconveniences and confusion in accessing basic seed for small-scale seed producer farmers such as FRGs members.

A centralized basic seed supply approach would hamper lasting relationships between research centers and farmers in a number of ways. Firstly, small seed producer farmers have limited access to the headquarters. Hence, in the centralized basic seed supply arrangement

[40] For instance, in one case about 4.6 ha of farm area in the surrounding was planted for isolation purpose to produce one-hectare seed. To grow one-hectare seed by farmers, planting about another one hectare for maintaining isolation distance is commonly observed during field works of the author prior to this study. Again, during this research field study, discussion with seed producer farmer group in August 2010 pointed out the same issue.

most of the seed is channeled into extension or aid programs for grain production. Priority has to be given to seed producer farmers to get access to basic seed at their closest possible location. Secondly, centralizing seed allocation system hinders the development of trust and thus affects the existing positive relationships between farmers, particularly FRGs, and research centers.

Likewise, research centers need to capitalize on the established linkages with farmers and to pursue their farm research and disseminate outputs. Tripp (2006) suggests proactive measures from research institutes in promoting new varieties and supporting sustainable seed system development. In this aspect, FRG is a high potential area for improved variety seed introduction, and dissemination.

A reliable and sustainable basic seed supply requires a clear policy and cost recovery mechanism in place where research institute headquarters play pivotal roles, which is currently lacking in the Ethiopian Agricultural Research System. Major crop breeding centers are in a better position to justify seed allocation with advice from top research management. The headquarters are supposed to encourage research centers to adopt proactive approaches in effectively promoting seed varieties and pursuing cost recovery measures because basic seed production at research centers is an expensive business. For instance, only 72% [41]of the cost was recovered from the basic maize seed sold at MARC excluding overhead costs.

[41] Basic seed production cost for OPV maize at MARC was 20695.63 ETB per hectare under irrigation. The productivity per hectare was 5 ton per hectare. The cost of production is 4140 ETB per ton while the seed sold at 3000 ETB per hectare in 2008. The trend is continuing for long time partly due external project funds by CIMMYT and others.

6.4 Conclusion

The issue of smallholder farmers' access to quality seed of improved varieties has been an ongoing discussion in SSA countries such as Ethiopia. Reform in breeding and seed supply has been underway. One of the seed supply reforms was farmer participatory research. It has been tried in the last couple of decades with much focus on variety selection under the assumption that the seeds of selected varieties easily find their ways to farmers. Considerable savings in breeding time, improved efficiency in farmers' variety selection, and farmer capacity development through farmer participatory research were documented. The seed supply issue, however, remained a point of concern. This chapter deliberated on the issue of quality seed provision and dissemination through the FRG approach. Reasonable amounts (7 to 30 tons per year) of high quality maize seed was produced and disseminated by FRGs to the larger farming community residing in the drought-prone areas in the CRV of Ethiopia.

The FRGs produced improved OPVs at cost effective and disseminated it to the local farming community. The FRG approach has enhanced technical capacity of farmers in quality improved maize seed production though trainings on seed field management in contrast to field management for grain. The linkage between farmers, researchers and agricultural experts has been improved through joint planning and field activities. Likewise, farmers improved technologies demand was enhanced that FRG farmers started to request for improved varieties and farm implements. FRGs are potential partners in technology development and dissemination, thus they are a fertile ground to reach larger farming community with seeds improved varieties. The national agricultural research institutes need to focus on providing a policy framework for basic seed allocation, facilitating farmers group to get access to basic seed, introducing cost recovery mechanisms in basic seed production at major crop research centers, targeting high rates of variety adoption to increase productivity and enhance farm household food security.

CHAPTER 7

CONCLUSION

This research has sought to understand and explain farmers' access to seed and improved variety adoption in drought-prone areas of Central Rift Valley (CRV) of Ethiopia. The study considers OPVs maize in the analysis. The points addressed area: (i) factors influencing farmer access to seed and the seed quality from informal sources, (ii) factors influencing adoption of open pollinated varieties maize and (iii) the contribution of farmer research group to farmers' enhanced access to seed and improved variety adoption through improved OPV maize seed production and dissemination.

CRV of Ethiopia –the study area- is a drought prone agro-ecology where moisture is the major production-limiting factor. Timely land preparation to utilize the erratic rainfall also affected by shortage of oxen because 40% the farmers lack sufficient number of oxen- a pair. Such resource endowment would affect farmers' access to seed of different sources as well improved variety adoption other than environmental and institutional factors.

The study employs a combination of data gathering and analysis methods. In the data collection, household survey and case studies were utilized to gather socio-economic and agronomic data. Descriptive statistics and Logit Model were utilized for socio-economic data analysis and seed quality test was conducted in the agronomic aspect.

Maize seed sources tend to be dynamic where own harvest, another farmer and ISM, including formal sources, contributes large proportion of the annual seed utilized. The significant contribution of each seed source may suggest that an improvement made in any of those sources has greater impact on the local maize seed accessed. The findings from Chapter 4 show that there are a number of maize varieties in local maize production, including several old varieties of late maturity, susceptible to drought stress and low yielding, though improved varieties of drought tolerant and high yielding potential have been introduced.

It is a legitimate question, thus, to solicit what influences smallholder farmers' adoption of improved varieties of maize. This question is what Chapter 5 sets out to tackle. The chapter strives to identify what influence the adoption of improved OPVs of maize deemed suitable for production under erratic rainfall condition of the CRV of Ethiopia. The study finds that the adoption of OPVs of maize is positively influenced by farmland size and being in FRG *Kebele* but negatively influenced by the frequency of drought stress encountered and distance from the nearest grain market. Farmers who own larger piece of farmland tend to be readily adopting improved varieties as compared to smaller holders. This suggest that, further shrinking of farmland from the current average size may negatively affect improved variety adoption, though seed is believed to be scale neutral. FRG- *kebele* was found to be a highly influential factor in the adoption of improved OPVs of maize. Chapter 6 discusses the contribution of FRG in improved variety seed production and dissemination including the seed quality, improved variety adoption rates and the cost of production of improved OPV maize seed. The key findings of the chapter were rapidly improved variety seed dissemination, farmers' enhanced access to improved seed, cost effective seed production and forging linkages among different stakeholders involved in maize seed provision in the CRV of Ethiopia.

In the following section, a summary of the findings are highlighted based on the main chapters of the dissertation. Lastly, implications are drawn for seed system improvement in drought-prone areas of Ethiopia.

7.1 Summary of the main findings

Beginning with Chapter 4, this paper discusses the factors influencing farmers' access to maize seeds in the drought-prone CRV of Ethiopia. Within the broader notion of formal and informal seed sources, the informal seed source is further sub-categorized into own harvest, another farmer and ISM sources. The informal source contributes about 84% of the annual seed accessed while the remaining balance comes from formal source. A wide range of maize varieties are available in the informal seed source where nearly twenty-eight varieties are mentioned in the study area with varying frequency among different *Kebeles*.

A close look at the informal seed sources of maize in the study area shows that there is relatively balanced share among the three informal sources: own harvest, another farmer and the ISM. Contrary to the prevailing beliefs and reports, the share of another farmer and ISM in annual maize seed accessed is sufficiently high. Use of own harvest seed though used to be as an indicator for seed self-sufficiency there has been a growing tendency of shifting towards off-farm seed sources among farmers in the CRV. Both another farmer and ISM as a seed source each contributes one-third of annually accessed seed. ISM contributes a high proportion of the seed accessed contrary to what claimed an exceptional crop asserting that maize seed is rarely obtained from ISM most likely based on the stereotypic idea of a seed self-sufficient farmer. All categories of farm households, the male headed and the female headed the resource poor and the well-off accessed seed from the ISM. Access to ISM seed source tends to be higher among the poor farm households than among the well off. The finding further reveals that the ISM is a promising seed source for farm households during severe stress years since merchants swiftly respond to the farmers' requests by bringing varieties required from different market places.

Likewise, formal seed source has contributed through introduction of improved maize varieties or certified seed. The formal seed source is in a better position to access a large number of germplasm from abroad. The formal source, however, has limitations in the number of varieties and quantity delivered and diversity of the stakeholders served. In this respect, the ISM is in a better position to respond to the farmers' changing seed needs promptly with required variety and prices since it is embedded in the community and timely. Both traders and farmers strategically use the ISM because traders buy implicit seed from farmers known for their good grain production or using improved varieties. There are a few known farmers in certain villages for good or improved maize variety seed production. Farmers also ask the traders after those known farmers' names for producing variety of their need to identify the varieties of their preference when they approach traders in the ISM.

Maize seed quality from informal sources including the ISM was found to be acceptable with few exceptions. A considerable number of farmers intend to change their maize seed lot every three years on average, which is a major shift from growing a single variety seed lot indefinitely. Discussions with farmers revealed that they started changing seed lots because they had observed that maize seed from an old seed lot grows taller and remains barren rather other than they were heeding expert advice to change their seed lots. Such growing taller of a maize variety can be a disadvantage of farmers' selection criteria. The main criterion farmers use to select maize for seed are a big cob that introduces the trait of lateness (Annex 6).

Farmers largely depend on informal seed sources to access maize seed. Any seed development interventions have to involve actors such as grain traders, farmer seed producer, toward establishing a well-functioning seed sources. A comprehensive seed source needs for the integration of formal and informal seed sources for a inclusive seed system development.

For instance, the stakeholders in the formal seed sources such as research centers may provide basic seed and training in seed quality management to farmers and grain traders. They may also learn the farmers' criteria for variety selection and local knowledge of crop management. Moreover, rural agro-business initiatives may be opted for because large number of farmers' access seed from ISM and the farmer seed production projects may be linked to such efforts to establish a sustainable maize seed provision.

Chapter 5 analyzes the factors influencing adoption of improved OPVs maize. Even though numerous varieties are grown in the area, most of them are old and late-maturing varieties and thus fall to bear yield under erratic rainfall conditions. In response to this, research has generated improved varieties of maize and the varieties were introduced to the farming system in the drought-prone area of CRV. The adoption rate of improved varieties remained low, however.

Improved agricultural technology adoption has received the attention of researchers and policies makers since adoption of innovation, such as improved varieties, is believed to increase productivity. Numerous adoption studies have been conducted in high rainfall areas where research and extension have focused. The factors included in adoption studies are numerous and the results were varied from study to study. In this dissertation, drought-prone area improved OPV of maize is tackled. A number of factors grouped into farm household resource endowment, institutional and environmental aspects were analyzed based on empirical data gathered from farm household heads. Farmland size owned by a household found to positively influencing adoption of improved OPVs of maize. The factor found highly influencing improved OPVs maize adoption was FRG-*Kebele*. Farmers in the FRG-*Kebeles* found to be readily adopters of improved OPV of maize. This can be due to farmers increased exposure to improved variety, enhanced seed availability through local farmer provision by

FRG. This provides apparent evidence that the presence of FRG in a farming community strongly influence a farmer's adoption of crop variety. On the other hand, the number of years of yield loss from drought encountered in the last ten years had a negative effect on the adoption of improved OPVs of maize. The FRG approach may be utilized in improved variety seed introduction and evaluation in tackling the effect of recurrent droughts that do substantially stress yield in the area.

Chapter 6 discusses about the contribution of FRG in improved OPVs seed production and dissemination. The FRG served greater purpose beyond variety selection criteria identification that has been the major exercises in PVS the most common approach of the farmer participatory research. FRG members produced and disseminated high quality seed in the CRV area. The farmers also appreciated the quality of the seed purchased from FRG farmers. Moreover, farmers in FRG areas gained better exposure to different varieties and more knowledgeable about improved varieties and their agronomic practices.

The FRG managed to produce improved maize seed at lower cost and they have been able to supply at reasonable price. Cost of seed production of open-pollinated maize varieties was one of the bottlenecks for the commercial seed enterprises in seed provision (Alemu *et al.*, 2008). Hence, such cost reducing maize seed production can be a key to alleviate a perennial problem in seed production and dissemination in particularly in drought prone areas in Ethiopia and elsewhere. In that aspect, FRG has been found effective in improved maize variety seed availability to tackle substantial yield stress thus contribute to food security of farm households.

The process of FRG based sustainable seed production and dissemination, however, was not without challenges. Access to basic seed supply need to be guaranteed as there is no clear guideline or policy for research institutes in basic seed provision to small-scale seed producers such as FRG. In principle, basic seeds are supposed to be multiplied and delivered by variety releasing/maintaining institutions to seed producers. Seed enterprises, seed producer farmers group and other seed producer are legitimate clients to access basic seed from research.

However, the current orientation of the Ethiopian Institute of Agricultural Research to centralize basic seed supply would negatively affect small-scale seed producers' including the FRG access to basic seed for local improved seed multiplication and dissemination. What equally important for effective improved variety seed supply and enhanced adoption, public institutions such as research, public seed enterprises need is to consider FRG approach in their institutional policy of research and basic seed supply.

7.2 Implications

In developing countries, particularly those with drought-prone areas such as Ethiopia, meeting the seed requirements of smallholder farmers through seed production and dissemination from the formal source has not been successful and it may not be so in the near future. Seeds of improved or local varieties can still highly benefit the bulk of farmers through informal seed exchange in drought-prone areas. Hence, farmer seed production and dissemination continues to be a seed source for smallholder farmers.

A significant proportion of farmers still depend on ISM source, hence grain traders have obvious potential in the seed dissemination process. ISM was found to be essential in local seed supply and it provides acceptable quality seed. However, grain traders who are the principal agent in informal seed supply have been marginalized in the improved variety seed supply improvement efforts. Thus, ISM has to be recognized and included in seed provision efforts by involving grain traders in improved variety seed supply and related information provision.

FRG as farmer seed producer and a liaison between formal and informal seed sources, the formal seed sources i.e., public research and public seed enterprise through improved variety introduction and related information provision play essential roles in developing well functioning seed system development. Based on the findings of the study, we can propose an integrated development of the seed sources. Improving the seed system functioning should be the work of all the stakeholders involved in the seed source where the major seed sources will take the leading roles. The formal seed sources such as public research and public seed enterprise, farmers and merchants have to be considered in seed system development to enable them to play their appropriate roles for enhancing food security in drought areas in SSA and elsewhere.

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ANNEXES

Annex 1: Farmer access to seed and variety adoption survey questionnaire in the Central Rift Valley of Ethiopia

Date (Date, Month, Year)___ /___ /11

Enumerator: ____________________

Starting time: ____________________

Basic Information

District (Circle): Adama / Boset / Adamitulu / Dugda

Kebele __________________________________

A. Household Information

1. Name of the household head/respondent ____
2. Mark (X) gender of respondent: _____ [1=Male; 0=Female]
3. How old are you (year)?____
4. Experience in farming (years) ____
5. Number of household members (including you): ______________________________________
6. Number of the household members less than 10 years of age: __________________________
7. Number of the household members more than 65 years of age:__________________________
8. Education level 0. Illiterate 1. Read and write 2. Years of formal education (if any)

   3. Other specify ____
9. How many minutes you walk to the nearest grain market from your place?
10. How many minutes you walk to the *Kebele* Agricultural Development office?

B. Economic Characteristics

	Area (*Kert*)	Number of plots	Soil condition (*kert*)		
			Favorable (fertile)	Medium	Poor/marginal
11. Farm land owned (rain fed)					
Irrigable land					
Farmland rented in 2002/3 EC (2011)					
Farm land rented out 2002/3 EC (2011)					
Total area 2002/3 EC (2011)					

Note: 1 kert= 0.25 ha

12. Livestock holding (number)
    a. Oxen ___________________Cow__________ heifers______________ Bulls_________
    b. Small ruminants (goat and sheep)____
    c. Donkey:____
    d. Others (Mule)____________ Horse ______________Camel _______________
13. Do you do other job than the farming? _____ [1=Y; 0=N]
14. If Yes, what is the type of work? 1. Petty trade, 2. Sand mining, 3. Fattening; 4. Guard; 4. Other, specify____
15. If Yes, how much income did you get from the off-farm work in 2002/3 (Birr)? ____________
16. Other income sources in 2002/3 (Br) 1. Remittance ________ 2. Land rent _________ 3. Other, specify ____

C. Crop Production

17. What types of crops do you grow in the last two years?

N	Crop	2002/3 EC(2010)		2001/2 EC (2009)	
		Area(*kert*)	production(qt)	Area(*kert*)	production(qt)
1.	Maize				
2.	Common bean				
3.	Tef				
4.	Wheat				
5.	Barely				
6.	Sorghum				
7	Others, specify				

Notes: Kert= 0.25 ha, qt=quintal=100 kg ; 2001 GC~ 2002/3 EC (Ethiopian calendar)

Maize production

18. Please, name the varieties of maize, its area and production in the past two years and plan for 2011

N	2002/3 EC(2010)						2001/2 EC(2009)						Planting Plan for 2003/4(2011)	
	Variety	Area (*kert*)	production(qt)	Seed source Code 1	Sale (qt)	Seed (qt)	variety	Area (*kert*)	production(qt)	Seed source Code 1	Sale (qt)	Seed (qt)	Variety	Area (*kert*)
1.														
2.														
3.														
4.														

Code: 1. Own, 2. Another farmer, 3. Informal seed market, 4.1 ARDO, 4.2.Cooperative, 4.3. Research Center, 4.4 Private company, 5. Other, specify____

19. If he/she obtain seed from off-farm why he/she needed the seed? 1. New variety, 2. Lost own seed, 3. Early maturity 4. Drought tolerant, 5. Advice by experts; 6. Other specify________________________

20. If you procure maize seed from off farm source(s) in the last two years in what months of the year you did obtain the seed?

Sources	2002/3 EC(2010)				2001/2 (2009)			
	Month	It that a right time for planting schedule? (1.Y, 0. N)	Was that your variety of preference? (1.Y, 0. N)	Quality of the seed Code A	Month	It that a right time for planting schedule? (1.Y, 0. N)	Was that your variety of preference? (1.Y, 0. N)	Quality of the seed Code A
Another farmer								
Informal Seed Market								
Agricultural and Rural Dev't								
Cooperative /union								
Agricultural Research Center								
NGO								
Private seed company								

Code A 1. Good 2. Fair 3. Poor

21. Did you request maize seed from government/ formal sources in the last two years? _____ [1=Y; 0=N], If Yes,

		2002/3 EC (2010)	2001/2 EC (2009)	Plan for 2003/4(2011)
1	Seed of maize variety you requested (kg) (Code A)			
2	Amount requested (kg)			
3	Amount obtained(kg)			
3	Amount planted(kg)			

Code A: 1. Awassa-511; 2. Melkassa-2; 3. BH540; 4. BH660; 5. Melkassa-1, 6. Katumani, 7. Others, specify____________

22. Maize seed distribution

<table>
<tr><td colspan="3" rowspan="2"></td><td colspan="3">2002/3 EC(2010)</td><td colspan="3">2001/2 (2009)</td></tr>
<tr><td>1. Y
0. N</td><td>Variety Code C</td><td>Amo unt (kg)</td><td>1. Y
0. N</td><td>Variety Code C</td><td>Amount (kg)</td></tr>
<tr><td colspan="3">1. Did you distribute/give maize seed in the last two years?</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">2. If Yes, how many farmers did get your seed?</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="6">3. On what terms you did give the seed.</td><td colspan="2">Sale (price)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Gift</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Exchange</td><td>Code A- crop</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Code B- amount</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Loan</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Labor exchange</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

CODE A: 1. same crop, 0. Different crop; CODE B. 1. Same amount 2. More amount, 3. Less amount

Code C: 1. Awassa-511; 2. Melkassa-2; 3. BH540; 4. BH660; 5. Melkassa-1, 6. Katumani, 7. Others, specify____________

Please list the top three attributes in your maize variety preference for seed:

1st ____

2nd ____

3rd ____

E. Maize production and seed selection

23. Do you normally practice maize seed selection? _____ [1=Y; 0=N]

24. If yes, when do you do the selection? 1. in field before harvest, 2. During threshing, 3. Take the required amount from grain bulk, 4. Other, specify;____________________

25. If yes, what are your selection criteria?

1. Head size (big, medium, small) 2. Multiple ears, 3. Maturity (early, medium, late) 4. Other, specify____

26. In your opinion, what are the characteristics of a good quality maize seed?

1. Well grain-filling 2. Absence of insect damage, 3. Seed color (white/red) 3. Germination capacity; 4. Other specify____

Have you ever practiced maize seed production on isolated plot of land to produce a pure seed? _____ [1=Y; 0=N]

F. maize Storage

27. How do you store maize grain and seed?

1. As bulk (seed and grain in the same storage), 2. Separately (in different storages), 3. Other, specify____

28. If you store seed and grain separately, where do you normally store maize seed lot?

1. in sack, 2. in hut over smoke, 3. Other, specify ________________________________

29. Is any insect pest a problem for your maize seed storage? _____ [1=Y; 0=N]

30. If yes, what preventive/control measure do you apply?

1. Insecticides;2. Mix with ash; 3. Smoking; 4.Other, specify, __________________

31. Where do you usually get suitable maize seed in the case of seed shortages due to environmental calamities such as drought? 1. Informal seed market 2. Agricultural and Rural Development Office 3. Relative (living in different place) 4. Other, specify

____

32. Perception about varieties and seeds of maize (circle the number corresponding to the response)

Statement	agree	Neutral (do not judge)	disagree	I don't know
1. It is preferable to grow different varieties of maize than growing only one variety any production season.	1	2	3	4
2. A maize seed rejuvenates and gives better yield when it planted in new areas that have different soil type and climate.	1	2	3	4
3. There is no difference among maize varieties in their tolerance to drought.	1	2	3	4
4. A certified seed is usually more productive than farmer produced seed/grain of the same variety.	1	2	3	4

33. In how many years do you plan to change your maize seed lot for OPV?
   1. Every year   2. Every two years   3. Every three years 4. It depends, specify__

____

J. Climate

34. How do you describe the rain in the past three years for crop production (Mark X)?

Year	Very good	Good	Average	Bad	Very bad
2002/3 EC (2010)					
2001/2 EC (2009)					
2000/1 EC (2008)					

35. How many times in the last 10 years, you have encountered maize yield stress due to drought. ____

K. Information and social network

From whom do you usually get the information about a new maize variety seed?

1. Another farmer, 2. Informal seed market, 3. ARDO, 4.Cooperative, 5. Research, 6. NGO, 7. Private company 8. Other, specify___________________________

36. How many times you meet local extension agents during a cropping season?

1. More than twice a month, 2. Twice a month; 3. Once a month 4. Once in the season, 5. Other, specify____

37. Have you participated in maize demonstration/field day/seed production training in the last 10 years? __[1=Y; 0=N]

38. Have you planted/tried a new maize variety in the last five years? _____ [1=Y; 0=N]

If Yes, from where/whom did you get the seed? ___________________________________

What are/is new varieties of maize in your area?

1. Melkassa-1; 2. Melkassa-2 3. Melkassa-6Q 4. Melkassa-4; 5. BH 540; 6 other, specify __________________

39. How many farmers do you know who are planting any improved maize varieties in your village/area? 1) Many 2) few 3) none

Annex 2: Guideline for discussion with informal seed traders

District: Adama, Boset, Dugda, Adamitulu Market name: _______ Date:________

Name:________________________________

Experience in trade (yrs) ________________

1. What type crops do you trading?

Maize	C.bean	Tef	Wheat	Barely	Peas	Chick pea	Lentil	Sorghum

2. Do you selling for grain or seed? 1. Grain; 2. Seed; 3. Grain and Seed
3. If you sell for seed and grain, please indicate types of crops sold for seed?

	Maize	Common bean	Tef	Wheat	Barely	Sorghum	Chick pea	Lentil	Peas
1. Grain (G)									
2. Seed (S)									
3. Grain + Seed									

4. From which places (*kebeles*) your clients are?

1.	2.	3.	4.	5
6.	7.	8.	9.	10

5. How much of your sale is sold as seed every year? __________________________

Year	Maize		Common bean	
	Seed (qt)	Grain (qt)	Seed (qt)	Grain (qt)
2001/2 E.C				
2002/3 E.C				
2003/4 E.C				

6. What months usually farmers' come to you for seed?

	March	April	May	June
Maize				
C.bean				

7. Is there price difference between grain and seed? 1. Yes; 0. No

8. If yes, for how much did you sale the grain of maize and common bean in the last two years?

Year	Maize (Br/kg)		Common bean (Br/kg)	
	Grain	Seed	Grain	Seed
2003/4				
2002/3				
2001/2				

9. What are the differences between seed and grain?

Crop	Chemical treatment	Freedom from foreign material	Obtained from known farmer	Other
Maize				
Common Bean				

10. Do you keep the grain and the seed in the same store or separately (have a look if possible)?

	Maize
Same store	
Different stores	

11. Is seed the demand more or less smooth over years?

Smooth	Maize

13. If no, please explain when farmers usually coming to your store for seed? __________
    a. Is the demand increasing or decreasing?_____________________________

Annex 3: Variables included in selected recent studies of improved verity adoption

Variables	Frequency	Rank	Per cent use	Reference/sources (number)∗
Extension visit	19	1	95%	1,2,4, 5,6,7,8,9,10,11, 12, 13, 14,15, 16,17,18,19, 20
Age house hold head	18	2	90%	2,3,5,6,7,8,9,10,11,12,13,14,15, 16, 17,18,19,20
Education house hold head	15	3	75%	1,2,3,5,6,7,8,11,12,13,17,18,19, 20
size	13	4	65%	1,2,3,4,5,6,8,13,14,15,17,19,20
Livestock	9	5	45%	1,4,5,6,10,13,14,17,19
Credit access	9	5	45%	4,5,6,10,12,14,19,20
Household labor	8	7	40%	1,2,5,6,7,10,14,18
Off farm income	7	8	35%	1,2,3,5,6,14,19
Agro-Ecologic zone	7	8	35%	7,9,10,11,18,19,20
Gender	5	10	25%	6,9,13,14,19
Field day/workshop	5	10	25%	1,5,6,16,20
Hired labor	5	10	25%	1,4,14,19,20
Farmer Organization membership	4	10	25%	14,15,19,20
Experience of Household head	4	14	20%	1,5,6,17
Household size	4	14	20%	9,11,12,17
Proportion of farm land allocated to maize	4	14	20%	4,8,10,13
Market distance	4	14	20%	4,5,10,17
Contact farmer/demonstration host	4	14	20%	14,15,16,20
Group member farmer organization	4	20	10%	14,15,19,20
Climate perception/drought	3	19	15%	3,6,16
High yield perception/preference	2	20	10%	1,16
Income from cash crop (Chat, Coffee)	2	20	10%	3,20
Number of male household member	2	20	10%	4,9,
Number of female household member	2	20	10%	4,9
Wealth Index	2	20	10%	7,18
Commercial orientation	2	20	10%	8,11
Knowledge of new variety	2	20	10%	9,11
Winter Maize Growing or not	2	20	10%	12,13
Use of farm yard manure	2	20	10%	13,2o
Infrastructure/Road condition	2	20	10%	9,17
Others (mentioned only once)‡	1	31	5%	

‡NB. Land tenure, farm income, Improved seed availability, dependent household , extension intensity Index, Information Source, Attitude, Tribe, Farmers training course, Permanent Employment, membership of farmer Training, radio, proximity to Research Center, Development Enterprise, Contract seed producer ESE, Risk perception of about the technology, perception of adaptability to poor soil and perception of tolerance to striga.

Source: Adoption studies of miscellaneous years and countries (1995 to 2010)

[*]**Reference source (for Annex 3)**

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Annex 4: Promising maize seed source in high drought stress years

	ISM	ARDO	Relative living in different place	Another Farmer	ISM and ARDO	Relative live in different place and ARDO	ISM and Relative Living in Different place	Total
Number	106	103	17	7	27	8	9	277
Per cent share	38.3%	37.2%	6.1%	2.5%	9.7%	2.9%	3.2%	100.0 %

Source: Author field study, 2011

Annex 5: Description of improved maize varieties released in Ethiopia, 1973-2008 (n=42)

Variety	Release Year	Type	Altitude (100 masl)	Rainfall (100 mm)	Maturity (days)	On station yield (t/ha)	on farm yield (t/ha)	Observed in CRV in 2011
BH-140	1988(22)	hybrid	10-18	10-12	188	7.1	3.6	Not
BH-660	1993(17)	hybrid	16-22	10-150	172.5	10.5	7	Yes
BH-540	1995(15)	hybrid	10-20	10-20	145	9	5.8	Yes
Jabi	1995(15)	hybrid	nd	nd	133	8.4	na	-
Tabor	2001(9)	hybrid	16 - 20	8- 16	137	9.8	7.6	Not
Shindi	2001(9)	hybrid	15 - 19	80 - 160	137	8.6	6.9	Not
BH-670	2002(8)	hybrid	17- 24	10 - 15	165	10.8	7.5	Not
BH-541	2002(8)	hybrid	10 - 18	10 - 12	150	9.8	7	Not
BHQP-542	2002(8)	hybrid	10 - 18	10 - 12	145	8.5	5.5	Not
Beles (Pvt)	2005(5)	hybrid	10 - 20	10- 12	151.6	9.8	5.5	Not
Bereda(Pvt)	2005(5)	hybrid	10 - 20	10 - 12	148	9.5	6.3	Not
BH-543	2005(5)	hybrid	10 - 20	10 - 12	151	9.8	5.5	Yes
Hora	2005(5)	hybrid	17 - 24	10 - 12	172	7	5.8	Not
Argane	2005(5)	hybrid	17 - 24	10 - 12	175	7.5	6	Not
Bako-1	2006(4)	hybrid	10 - 20	10 - 12	157	10	5.5	Not
Wolel (Pvt)	2006(4)	hybrid	10 - 20	8 - 12	163	9	7.3	Not
Aba Raya (Pvt)	2006(4)	hybrid	10 - 20	10 -12	148	8	na	Not
Shone(Pvt)	2006(4)	hybrid	10 - 20	8 - 12	162	9	7.3	Not
Kello-1(Y)	2008(2)	hybrid	10 - 20	10 - 12	138	9.5	6.5	Not
Wonchi	2008(2)	hybrid	18 - 26	10 - 12	185	10	8	Not
Agar	2008(2)	hybrid	18 - 26	10 - 12	156	8.9	7.1	Not
Jibat	2009(1)	hybrid	18 - 26	10 - 12	180	10	8	Not
Zama (Pvt)	2009(1)	hybrid	6 - 17	4.5 - 12	135	11	6.5	Yes
Awassa-511	1973(1)	OPV	10 - 19	6 - 9	142	5.6	na	Yes
Alemaya Com	1973(37)	OPV	16 - 23	8 - 12	165	8.8	5	Not
Katumani	1974(36)	OPV	10-16	6-8	110	3.1	na	Yes
Guto	1988(22)	OPV	10-17	8-12	126	4	2.7	Yes
Kulani	1988(22)	OPV	17-22	10-15	150	6.6	4.3	Yes
Fetene (ACV3)	1996(14)	OPV	10-16	6-8	100	4.2	3	Not
Tesfa (ACV6)	1996(14)	OPV	10-16	6-8	108	4.3	3	Not
Rare-1	1997(13)	OPV	16 - 23	9 - 11	155	6.5	5	Not
Ghibe Comp.-1	2001(9)	OPV	10 - 17	9 – 12.5	145	7.4	4.3	Not
Melkassa-1 (Y)	2001(9)	OPV	5 - 16	4.5 – 7.5	85	4.5	3.5	Yes
Gambella Com.	2002(8)	OPV	5 - 10	100 - 12	110	6.8	4.5	Not
Melkassa-2	2004(6)	OPV	12 - 17	6 - 8	130	5	3.5	Yes
Melkassa-3	2004(6)	OPV	12 - 17	6 - 8	125	5	3.5	Not
Toga (C. white)	2005(5)	OPV	12 - 18	> 10	139	7.5	6.8	Not
Melkassa-4	2006(4)	OPV	10 - 16	5 - 7	105	4	3.3	Yes
Melkassa-5	2008(2)	OPV	10 - 17	6 - 8	125	4.5	3.3	Not
Melkassa-6Q	2008(2)	OPV	10 – 17.5	5 - 8	120	5	3.5	
Melkassa-7 (Y)	2008(2)	OPV	10 – 17.5	5 - 8	115	4	3.5	Not
Morka	2008(2)	OPV	16 - 18	10 - 20	165	9.5	5.5	Not

Note 1: Rx: Recommended; Pvt: private seed enterprises; na- not available; Y: yellow

Note 2: The figures in the bracket shows age from release at the time of data collection

Source: Author field study and miscellaneous documents

Annex 6: List of maize varieties and their seed sources in CRV of Ethiopia

Variety	Type	Maturity Type	Own	Another farmer	ISM	Formal	Per cent
Shaye	Local	Late	3	1	4	0	2.9
Melkassa-2	Improved	Medium	17	17	6	9	17.7
Melkassa-1	Improved	Early	3	1	2	2	2.9
Limat	Local	Late	4	1	1	0	2.2
Katumani	Improved	Early	4	7	7	1	6.9
Hararghe	Local	Late	1	-	-	0	0.4
Awassa-511	Improved	Late	18	13	17	3	18.4
Milisha	Local	Early	8	4	5	0	6.1
Filatama	Improved	na	1	1	5	0	2.5
Sinde	Local	Late	2	-	-	0	0.7
Melkassa-4	Improved	Early	-	2	1	1	1.4
Melkassa -6Q	Improved	Medium	1	1	-	0	0.7
Adii	Unknown	na	1	3	6	0	3.6
Bukuri	Improved	Medium	-	-	1	0	0.4
Kate	local	Late	-	-	1	0	0.4
'Maka' (mixed)	Unknown	na	1	-	-	0	0.4
BH-540	Improved	Medium	11	13	4	27	19.9
Marid	Local	Late	1	1	1	0	1.1
BH-543	Improved	Late	1	2	2	2	2.5
Pioneer	Improved	Late	-	-	3	1	1.4
Mogosse	Local	Late	-	-	1	0	0.4
Awassa- Gababa	Improved	Early	1	-	-	0	0.4
Zama	Improved	Medium	1	-	-	2	1.1
Ghibe	Improved	Late	-	1	9	0	3.6
Guto	Improved	na	1	-	-	0	0.4
Hisbawi Nuro	Local	Late	-	1	-	0	0.4
Kophisa	Unknown	Early	-	-	1	0	0.4
Unknown by name	Unknown	na	1	-	2	0	1.1
Total (n=277)			81	69	79	48	100
Number of varieties			20	16	20	4	28

Note: The number of different maturity group users early=18.1%, Medium= 39.8%, late=34.4% and unknown 8%

Source: Author field study, 2011

Annex 7: Farmer maize selection criteria for seed from own farm

Selection criteria	Number	Percent
Big head	131	60.9
Multiple ears	17	7.9
Early Maturity	8	3.7
Big head and Multiple ears	59	27.4
Total	215	100.0

Source: Author field study, 2011

Annex 8: The first reason for buying FRG member produced improved maize seed

Reason	Number	Percent
high yield	11	42.3
tolerance to drought	5	19.2
early maturity	10	38.5
Total	26	100.0

Note: the number of respondents was 26 in year 2008

Source: Author field study

Annex 9: Perception of farmers about seed quality of maize purchased from FRG seed producer farmers

	Excellent	Very	Good
How do you rate the purity of the seed as compared to your own maize seed	(7.6%)	(77%)	(15.4%)
How do you rate the germination capacity of the variety	15.4%	84.6%	-
How was the resistance of the variety to drought	(3.8%	(73%)	(23.2%)

Note: the number of respondents was 26, in year 2008

Source: Author field study, 2008

Annex 10: List of Kebeles obtained improved maize seed from seed producer FRG farmers

		Seed Source		
No.	*Kebele*	Farmers	Research	Research and Farmer
1	Aneno Shisho			x
2	Bulbula	x		
3	Urija	x		
4	Abayo Deneba	x		
5	Goba Jecho Asebo	x		
6	Awara Iftu	x		
7	Dodicha	x		
8	Hizbawi Betele	x		
9	Jido	x		
10	Sedicho	x		
11	Suro Kudesa	x		
12	Weransa	x		
13	Weyiso Mecho	x		
14	Abjata	x		
15	Jido Kombolcha		x	
16	Mareko	x		
17	Weyiso	x		
18	Dengore Tiyo			x
19	Haleku	x		
20	Urgo Machafera	x		
21	Arba	x		
22	Jelo Aluto Aluto	x		
23	Gerbi Boramo	x		
24	Oda Anshura			x
25	Bochesa	x		
26	Awash Melkassa		x	
27	Adulala Hate Haroreti		x	
28	Dibibbisa Wacul Lafa			x
29	Dongore Furda		x	
30	Negalign			x
31	Dongore Chale	x		
32	Wolinchiti	x		
33	Bato Degaga	x		
34	Merti	x		

Source: Author field study, 2010

Annex 11: Comparison between FRG and Non-FRG Kebeles in their access to improved varieties, field days participation and awareness about improved variety planting rates

Item			FRG *Kebele*	
			No	Yes
Major maize variety grown	Improved	Std. Residual	-.8	1.7*
	Local	Std. Residual	1.1	-2.1**
	Unknown	Std. Residual	1.1	-2.2**
Have you tried/planted a new maize variety in the last five years?	No	Std. Residual	1.1	-2.1**
	Yes	Std. Residual	-1.2	2.4**
Have participated on improved maize demonstration field in the last five years?	No	Std. Residual	.5	-1.0
	Yes	Std. Residual	-1.0	2.0**
Number of Varieties grown in the last 10 years	3 or less	Std. Residual	.5	-1.0
	More than 3	Std. Residual	-.9	1.8*
Awareness of improved maize variety seed planting rate for maize per hectare is 25 to 30 kg.	No	Std. Residual	.9	-1.7*
	Yes	Std. Residual	-.6	1.2

Std. Residual is the Z-score (standardized value) and it compared to the probability of z score for one tailed chi- distribution. Accordingly, (*) and (**) show significant difference at 10% and 5% respectively. The negative sign with significant figure shows under representation while the positive sign shows over representation in the specified activity. For example, 1.7 in “major maize variety grown” farmers in FRG *Kebeles* were over represented from expected values while -2.1 indicates that they are underrepresented in local variety use.

Source: Author field study, 2011