Farmers' Wheat Seed Sources and Seed Management in **Chilalo Awraja, Ethiopia**

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August 1998

IAR ETHIOPIA

Funded by the European Union

CIMMYT
International Maize and Wheat Improvement Center

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Financial support for CIMMYT's research agenda currently comes from many sources, including the governments of Australia, Austria, Belgium, Canada, China, Denmark, France, Germany, India, Iran, Italy, Japan, the Republic of Korea, Mexico, the Netherlands, Norway, the Philippines, Spain, Switzerland, the United Kingdom, and the USA, and from the European Union, the Ford Foundation, the Inter-American Development Bank, the Kellogg Foundation, the OPEC Fund for International Development, the Rockefeller Foundation, the Sasakawa Africa Association, UNDP, and the World Bank.

Printed in Mexico.

Correct citation: Regassa Ensermu, W. Mwangi, H. Verkuijl, M. Hassena, and Z. Alemayehu. 1998. *Farmers' Wheat Seed Sources and Seed Management in Chilalo Awraja, Ethiopia*. Mexico, D.F.: IAR and CIMMYT.

Abstract: This study describes the Ethiopian wheat seed system, identifies how farmers acquire and exchange wheat seed, explores problems related to farmers' acquisition and transfer of wheat seed, documents the status of previously released bread wheat varieties, and examines the effectiveness of the seed testing and release mechanism. A multistage stratified sampling design was used in selecting farmers for a formal survey in Chilalo Awraja, a major wheat-growing area. Logit analysis was used to establish relationships and draw conclusions about farmers' seed management and adoption of improved wheats. The formal sector produces and distributes only 15% of the improved seed requirement of the country. Most farmers rely on other farmers and local markets to replace seed, obtain new seed, and obtain information on wheat varieties. The weighted average age of more than 10 years for varieties in the study area reflects a poorly developed seed industry and ineffective extension service. Seed industry reform, as well as support from research and extension, could rectify this situation. The extension system should pay more attention to informing farmers about the precise characteristics of their varieties and their correct adaptation zones. Varieties must be diversified over time and space and targeted carefully to production zones. Breeders should maintain older varieties, which appear to possess some desirable traits that new varieties lack. The current stringent variety release mechanism needs to be reviewed, and the release committee should include farmers and representatives of the private sector. Before the economic reform of 1991, publicly owned and collective farms obtained most of the limited certified seed that was available, and they also received new seed more quickly. This preferential treatment limited the impact of breeding gains for farmers and the national economy at large. Recent changes in the seed industry, such as the entry of private firms, creation of the National Seed Industry Agency, and strengthening of the national extension service should improve farmers' access to improved seed. These changes would be even more effective if policies and an institutional and legal framework could be developed to link the formal and informal seed sectors so that they could function in a complementary way.

ISBN: 970-648-008-0
AGROVOC descriptors: Ethiopia; wheats; seed; varieties; seed industry; seed production; socioeconomic environment; human population; input output analysis; economic analysis; farming systems; cropping patterns; crop management; technology transfer; innovation adoption
AGRIS category codes: E21 Agro-industry
E14 Development Economics and Policies
Dewey decimal classification: 338.16

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ACRONYMS

AADE	Arsi Agricultural Development Enterprise
AAU	Addis Ababa University
AID Bank	Agricultural and Industrial Development Bank
AISCO	Agricultural Input Supply Corporation
AON	Advanced Observation Nursery
ARDU	Arsi Rural Development Unit
AUA	Alemaya University of Agriculture
BSI	Breeder Seed Increase
CADU	Chilalo Agricultural Development Unit
CVAT	Cooperative Variety Adaptation Trial
DMRT	Duncan's multiple range test
DZARC	Debre Zeit Agricultural Research Center
ESE	Ethiopian Seed Enterprise
HW	Hectoliter weight
IAR	Institute of Agricultural Research
ISTA	International Seed Testing Association
MOA	Ministry of Agriculture
MSFD	Ministry of State Farm Development
NGO	Non-governmental organization
NVT	National Variety Trial
PA	Peasant Association
PGRC	Plant Genetic Resource Center
PNVT	Pre-National Variety Trial
PYT	Preliminary Yield Trial
SC	Service Cooperative
SD	Standard deviation
SG-2000	Sasakawa-Global 2000
TKW	Thousand kernel weight
VVT	Variety Verification Trial

ACKNOWLEDGMENTS

Many people were involved in the actual field survey and development of this publication. We are particularly grateful to Ato Eshetu Lemma for his effort in entering the data into the computer. Our driver, Ato Kebede Teka, was patient enough to tolerate the difficulties of driving on very inconvenient roads joining villages to villages and fields to fields. We are also grateful to the enumerators for their conscientious efforts in administering the questionnaires to farmers. We thank Aklilewerk Bekele for typing the paper. Mulugeta Mekuria made valuable suggestions concerning content and structure. The financial support from the CIMMYT/EU Project on Strengthening Economics and Policy Research in NARSs in Eastern Africa, and the invaluable facilitation by Kulumsa Research Center, which enabled us to conduct the study, are immensely appreciated. Thanks to Miguel Mellado and the CIMMYT designers for producing this report, and to Kelly Cassaday for editorial assistance. Last but not least, we would like to extend our thanks to farmers in the Etheya, Tiyo, Lemmu-na-Bilbilo, and Asasa areas for sparing time to answer our questions. The same goes to the extension workers in the study area who assisted us in the implementation of the questionnaires.

EXECUTIVE SUMMARY

Despite the crucial importance of improved seed in bettering the livelihoods of small-scale farmers, in Ethiopia access to this invaluable technology is still constrained by many factors. One important factor is the underdeveloped seed industry. Independent studies have estimated a large annual demand for seed, which is never met or (in the case of hybrid maize and sunflower) is met only through imports. Consequently, the government has increased its efforts to develop plant breeding research networks and a complementary seed production, multiplication, processing, storage, marketing, and distribution system. The private sector, including non-governmental organizations (NGOs), has been encouraged to participate in the development of the national seed industry.

This study was initiated in Arsi Administrative Zone of Oromia Regional State to 1) describe the seed system in Ethiopia and assess the effectiveness of the seed testing and release mechanism; 2) identify how farmers acquire and transfer seed of bread wheat varieties; 3) explore problems related to farmers' seed acquisition and transfer mechanisms; and 4) document the use of released bread wheat varieties.

Methods

This study used a multistage stratified sampling design. Based on informal assessment and secondary data, the major wheat-growing woredas of Chilalo Awraja of Arsi were purposively classified into three strata (Tiyo/Etheya woredas, Asasa, and Lemu-na-Bilbilo). Six peasant associations (PAs) were selected from each stratum using a probability proportional to the sample size. From each PA, 10 farmers were randomly selected. Descriptive statistics and logit analysis were used to establish relationships and draw inferences and conclusions about farmers' adoption of improved wheats and their seed management strategies.

The Seed Industry

The Ethiopian seed industry is composed of formal and informal sectors as well as public and private organizations. The formal sector includes federal and regional agricultural research establishments, universities, Ethiopian Seed Enterprise (ESE), and a few private companies. The informal sector embraces millions of farmers who continue to practice seed selection and preservation just as their ancestors did centuries ago. Today, the bulk of national seed demand is met through this informal system of local seed maintenance and exchange.

The bread wheat seed industry comprises two sequential processes: varietal development, testing, and release; and seed multiplication, processing, certification, marketing, and distribution. At a minimum, seven years are required to release a variety. Release may be unnecessarily delayed because of the stringent varietal release mechanism.

Farmer Characteristics and Wheat Production in the Study Area

The study area is located in Arsi, southeastern Ethiopia. The area's prevailing temperatures, rainfall, soil, and elevation make it especially suitable for wheat production, and Arsi produces about 75% of Ethiopia's bread wheat crop. Arsi is also the home of the first integrated rural development project, financed by the government of Sweden, and so has benefited from more than two decades of sustained effort to disseminate improved agricultural technologies. The wheat technologies used by farmers are quite advanced relative to those used in other wheat-growing areas of the country.

Middle-aged farmers dominate the farming population because younger farmers cannot acquire land. Few off-farm employment opportunities exist. The mean land holding in the study area in general is about 17 timmad (1 timmad = 0.25 ha), with significant variation from locality to locality. Women head about 9% of the households. Reported literacy levels are high compared to similar areas of the country, although the literacy of those who participated in the literacy campaigns of the Derg is probably questionable.

For several reasons, the area planted to wheat by sample farmers more than doubled between 1992 and 1995. First, the policy reform of 1991 discouraged collective farming and liberalized the grain market. Second, combine hiring services, which reduced the drudgery of manual harvesting and yield losses at harvest, became available. Third, land of some state farms was redistributed among smallholders, particularly in Asasa area. Fourth, tractor hiring services became available on relatively good terms. During this same period, production trends of the different wheat varieties varied. Production of Pavon-76, Dashen, and Batu has increased, whereas that of Enkoy and K6295-4A decreased. The unexpected increase for Dashen reveals the time lag in farmer-to-farmer dissemination of information about varieties from one location to another. The increase in production of Dashen was caused by its expansion in Lemu-na-Bilbilo, a relatively isolated area.

Seed Issues

Farmers in the study area recognized about 47 varieties, although the proportion of farmers knowledgeable about the varieties differed from the proportion of farmers who had actually grown them. Seed of many varieties that farmers grew was no longer produced because the varieties were no longer recommended, mainly because of disease susceptibility, susceptibility to desiccating wind at a critical growth stage (which caused grain to shrivel), deterioration in yield potential, and availability of better varieties. Farmers reported that the advantages of the discontinued varieties included better food quality or flavor in indigenous dishes, better performance on poor soils, and white grain color, which is in high demand in the market.

The majority of farmers either did not know the names of the new varieties available at the time of the survey or did not have enough information about them. Some farmers considered varieties released more than 15 years ago and no longer recommended as new.

The three categories of seed users in the study area — small-scale farmers, state farms (agricultural development enterprises), and contractual farmers — obtain seed from different sources. State farms rely mainly on formal seed channels, whereas farmers — especially smallholders — rely primarily on informal sources. During the 1995-96 cropping season, most farmers used seed saved from previous harvests. The next most common sources of seed were other farmers, MOA, ESE, and the local market. It is difficult to evaluate farmers' knowledge of formal seed suppliers and their exact locations, but most farmers generally could not differentiate between the extension service, ESE, and the research system.

The majority of the farmers (87%) cleaned or at least winnowed seed at planting, whereas a more limited number (19%) maintained separate fields for seed production. Fields were selected for seed production if farmers perceived them to be more fertile, less weedy, and better for plowing. Moreover, farmers who produced seed on special fields gave more attention to managing the crop during the growing season. Special management practices included more intensive weeding and rouging.

Wheat seed quality was tested in the field and in the laboratory. Seed samples were analyzed for viability, purity, off-types, and grain size. Except for Tikur Sinde, all varieties met the minimum germination requirement of 85% seed set, which is the Ethiopian standard for certified seed. Most seed samples met the Ethiopian purity standards for commercial seed (95% pure) and certified seed (97% pure). Fields planted with seed from Arsi Agricultural Development Enterprise and Ethiopian Seed Enterprise had fewer weeds than fields planted with farmers own seed or seed obtained from other farmers. The average percentage of off-types in farmers' wheat fields was about 3.5%, which is higher than the percentage permitted in Ethiopian standards for certified and commercial seed (0.1%-0.5%). The highest thousand kernel weight (TKW) was recorded for Israel, followed by Batu.

Prices of seed of new varieties were generally higher than the grain price, and prices of new varieties from informal sources in 1995/96 were about 32% higher than prices of seed from formal sources. Wheat seed prices also varied depending on whether a given variety was a new release or an old one, and by source of supply and location.

Factors Influencing Awareness and Adoption of Wheat Varieties

Farmers' sources of information about new wheat varieties were other farmers, (63%), extension agents (25%), and seed dealers (8%). Farmers' awareness of new wheat varieties was also influenced by such characteristics as age, level of literacy (education), contact with information sources (e.g., extension) in the year preceding the survey, serving as a contact farmer for extension, and location near a formal seed source. Some of these variables also significantly influenced the adoption of new varieties.

Varietal Turnover and Recommendations for Action

The weighted average age of wheat varieties is an indicator of the speed with which farmers replace their varieties with newer ones. The weighted average age of wheat varieties in Chilalo Awraja for 1995 was 13 years, surpassing the global average of seven years. This comparatively slow varietal turnover reflects a poorly developed seed industry and ineffective extension services.

From farmers' responses, it was estimated that the mean number of years that seed of a new variety could be used before problems arose was about four years. This implies that breeders have to maintain seed quality and distribute fresh seed stocks every four years to seed suppliers. Farmers reported that the major problems associated with repeated use of the same seed were reduced yields, loss of disease resistance, and increased weed infestation. This implies that farmers would be motivated to replace a variety only if it were threatened by disease or if its yield declined substantially for other reasons.

Slow varietal turnover in the study area may also be related to the more limited range of bread wheat varieties recommended for the high-altitude (>2,600 masl) areas of Chilalo compared to the midaltitude areas. Wheats for the high-altitude zone will require different characteristics, and future efforts at varietal development may need to be targeted more carefully for this zone.

The research system also has a role to play with respect to genetic diversity. Improved bread wheat varieties have to a large extent replaced landraces in the study area, and care must be taken to ensure that farmers do not grow varieties that share a narrow genetic base. Farmers must grow a more diverse array of varieties, both over time and space. Breeders should maintain the older varieties because they might possess desirable traits that are lacking in the new ones.

The stringent varietal release mechanism also may impede the adoption of newer improved varieties. The release committee should include not only breeders and officials from the public sector but also farmers and representatives of the private sector.

Finally, the research system is confronted with the need to increase the rate at which it releases varieties, as the disease resistance of recent releases has tended to deteriorate quickly. To be successful, however, such research efforts must be supported by the greater overall development of the seed industry.

Some farmers in the study area were not only producing their own seed but also selling seed to other farmers. Their efforts show that, given the necessary advice, farmers can produce and preserve replacement seed, once they obtain fresh stock of a new variety. The extension system should strengthen its advisory role to farmers, especially on how to produce and preserve replacement seed. Such an initiative will also require farmers' institutions, such as service cooperatives (SCs), to be strengthened.

Current changes in the seed industry, such as permission for private firms to participate, the creation of the National Seed Industry Agency, and strengthening of the national extension service, should improve this situation considerably. But the seed sector would become even more effective if policies and institutional and legal frameworks were developed to link the formal and informal sectors so they could work in a complementary fashion.

1.0 INTRODUCTION

1.1 The Potential of Improved Seed and Importance of the Seed Industry

The effectiveness of research results emanating from experiment stations is conditioned by the strength and efficiency of support services such as extension, credit, and input supply, including the supply of improved seed. The role of improved seed, particularly of wheat and rice, in alleviating poverty has been widely debated (see Dasgupta 1977; Singn 1990; DZARC 1995). Ellis (1993) outlined the social and economic impact of improved varieties in countries where they have been widely grown, and it is commonly observed that the dissemination of improved seed and complementary inputs has removed the shadow of famine from the lives of millions of poor farmers. Because improved seed embodies the plant's genetic potential, it determines the upper limits on yield and even the productivity of other inputs (Jaffee and Srivastava 1992).

Despite the crucial importance of improved seed in bettering the welfare of small-scale farmers, access to this invaluable technology can be constrained by many factors, including an undeveloped seed industry. A seed industry essentially consists of all enterprises that produce or distribute seed (Pray and Ramaswami 1991), and at a minimum the industry has four components: 1) plant breeding research, 2) seed production and multiplication, 3) processing and storage, and 4) marketing and distribution. The industry's overall performance depends on the efficiency of each component, and each component possesses different economic and technical characteristics that determine the roles that public and private organizations will play in the seed industry. These characteristics include economies of scale, externalities, excludability, and problems of information or quality.

The development of new varieties and hybrids can be profitable for specialized research and development firms. However, because of the high fixed costs of entering the industry, the externalities associated with plant breeding, and the difficulty of excluding non-paying farmers or firms from benefiting from new varieties of seed, the amount and direction of private sector investment in these activities may be insufficient or inappropriate to meet society’s objectives. The significance of these difficulties will vary, depending on whether the seed is of hybrid or self-pollinating plants. Because the desirable properties of hybrids are attenuated if hybrid seed is grown over successive generations, farmers must buy new seed to achieve undiminished yields. The originator of a new hybrid can therefore easily exclude competing seed firms and farmers from the benefits of the new hybrid if they have not paid for access. In contrast, breeders of new self-pollinated varieties may capture few of the benefits because others (including farmers) can easily duplicate the variety without paying for it.

The skills required to multiply seed of a new variety or hybrid and the technical and commercial risks associated with this activity are considerably lower than those associated with research to develop a new variety or hybrid. For this reason, there are fewer economic and technical barriers to private sector involvement in seed multiplication than in research. (Even so, in some instances excludability may be a serious problem because harvested grain of self-pollinated crops resembles commercial seed.) The private sector can profitably perform most seed distribution functions; public sector distribution of seed can be justified only in the early stages of seed industry development, when private channels are weak.

1.2 The Local Seed Industry

The origins of the seed industry in the Chilalo study area (located in Arsi Zone of Oromia Regional State) can be traced back to formal seed multiplication efforts during the Italian occupation (1936-41). Those efforts were the basis for continued seed multiplication and eventual wheat improvement at Kulumsa Research Center (Lexander 1968). By 1968, the Chilalo Agricultural Development Unit (CADU) had been established and initiated a wheat survey with the following objectives (Widerström 1968):

1. To collect and evaluate local wheat varieties.
2. To determine whether and to what extent there is confusion in local wheat varieties' names.
3. To develop a botanical description and classification of local wheat varieties.
4. To explore, and preserve for the future, the genetic variation in local wheat varieties.

Eighty-one samples of local wheat varieties were collected from throughout the area and classified into 30 different types. This was the first of several important studies focusing on the wheat varieties grown by farmers and farmers' sources of seed.

In 1986, wheat farmers were surveyed at planting (i.e., June to July) to determine which wheat varieties were being grown and to evaluate their quality. The majority of individual farmers used grain from their own crop as seed, whereas farmers who belonged to cooperatives obtained seed through formal sources. The most popular varieties, in order of importance, were Enkoy, Israel, K6295-4A, and K6290-Bulk. The survey grouped together some 12 varieties that may have been either indigenous materials or earlier releases.

A rapid rural appraisal of the seed supply system of Bale, Southern Shoa, and Northern Omo Regions was undertaken at the household, Peasant Association (PA), and Service Cooperative (SC) levels (Singh 1990). Most seed transactions took place between neighbors and relatives, as people felt they had more confidence in seed taken from a crop stand that they had seen themselves. Seed obtained in this manner was obtained free of interest and farmers could pay for it in a variety of ways. It was found that if a good local market was located nearby, it actually discouraged farmer-to-farmer seed transactions within a small geographical area.

In 1992, the Ethiopian seed production and supply system for the major food crops was studied (Hailu Gebremariam 1992). Using the recommended seed renewal rate of four years, estimated annual cultivated area of 380,500 ha at the reference time, and the recommended seed rate of 150 kg/ha, the potential annual demand for bread wheat seed was estimated to be 142,700 quintals (qt). Demand for durum wheat was estimated to be 123,700 qt. In total, at the recommended renewal rate for cereals, pulses, and oilseeds, potential annual seed demand was estimated to be 1.1 million quintals. Through contractual arrangements with the state farms, the Ethiopian Seed Enterprise (ESE) produced and distributed only 21% of this annual seed requirement.

In Ethiopia, and in Chilalo Awraja in particular, the use of improved wheat seed began in the late 1960s when CADU was established (Linden and Wellving 1985). According to one conservative estimate, the incremental production resulting from the use of certified seed in Arsi was 2-5 qt/ha (Linden and Wellving 1985). Despite the potential production increases that could result from farmers' use of newer improved seed, a continuous, dependable supply of certified seed is still lacking in Ethiopia. Farmers continue to "recycle" seed — that is, to save some of their harvested grain to use as seed in the following cycle. This practice can yield seed that has a low germination percentage and is contaminated with weed seed (Ayele and Lindeman 1987; Linden and Wellving 1985; MOA/SEAD 1986; Gavian and Gemechu Degefa 1996). The problem of recycled seed is serious in Ethiopia, where pathogens of the wheat rusts — serious diseases of wheat — evolve quite rapidly, rendering farmers' varieties less resistant to disease. To avoid yield losses from disease, farmers should replace their wheat varieties frequently and regularly.

1.3 Objectives of the Study

Without a stronger framework governing the development, testing, release, and distribution of new seed, farmers will be hard pressed to obtain superior seed and better, more stable yields. In this study, we test the hypothesis that few institutions are involved in local seed supply and that the performance of those institutions is weak, particularly in relation to serving smallholders. Specifically, this study was designed to:

- Describe the wheat seed system in Ethiopia.
- Identify how farmers acquire and exchange wheat seed.
- Explore problems related to farmers' seed acquisition and transfer mechanisms.
- Document the status of previously released bread wheat varieties.
- Explore the effectiveness of the current seed testing and release mechanism.

Before we proceed to describe the results of the study, however, we will present essential background information on the study area.

1.4 The Study Area

Chilalo Awraja is situated around Kulumsa Research Center (Figure 1) in southeastern Ethiopia. The elevation ranges from 2,000 meters above sea level (masl) to more than 3,000 masl. Figure 2 shows selected weather variables for the area.

Soils in the study area range from clay loam in Asasa to reddish brown, heavy clay at Bekoji. The pH ranges from acidic (5) at Bekoji to about neutral (6.5) at Asasa. Organic matter also varies, ranging from low (3) at Asasa to high (7) at Bekoji. For all soil parameters considered, Etheya is in between the two areas.

The farming system has evolved in response to both internal and external forces, and this evolution can be divided into three periods:

1. The period before the area was incorporated into Menilik's empire (before 1898), when livestock production dominated the farming system (Lexander 1968).

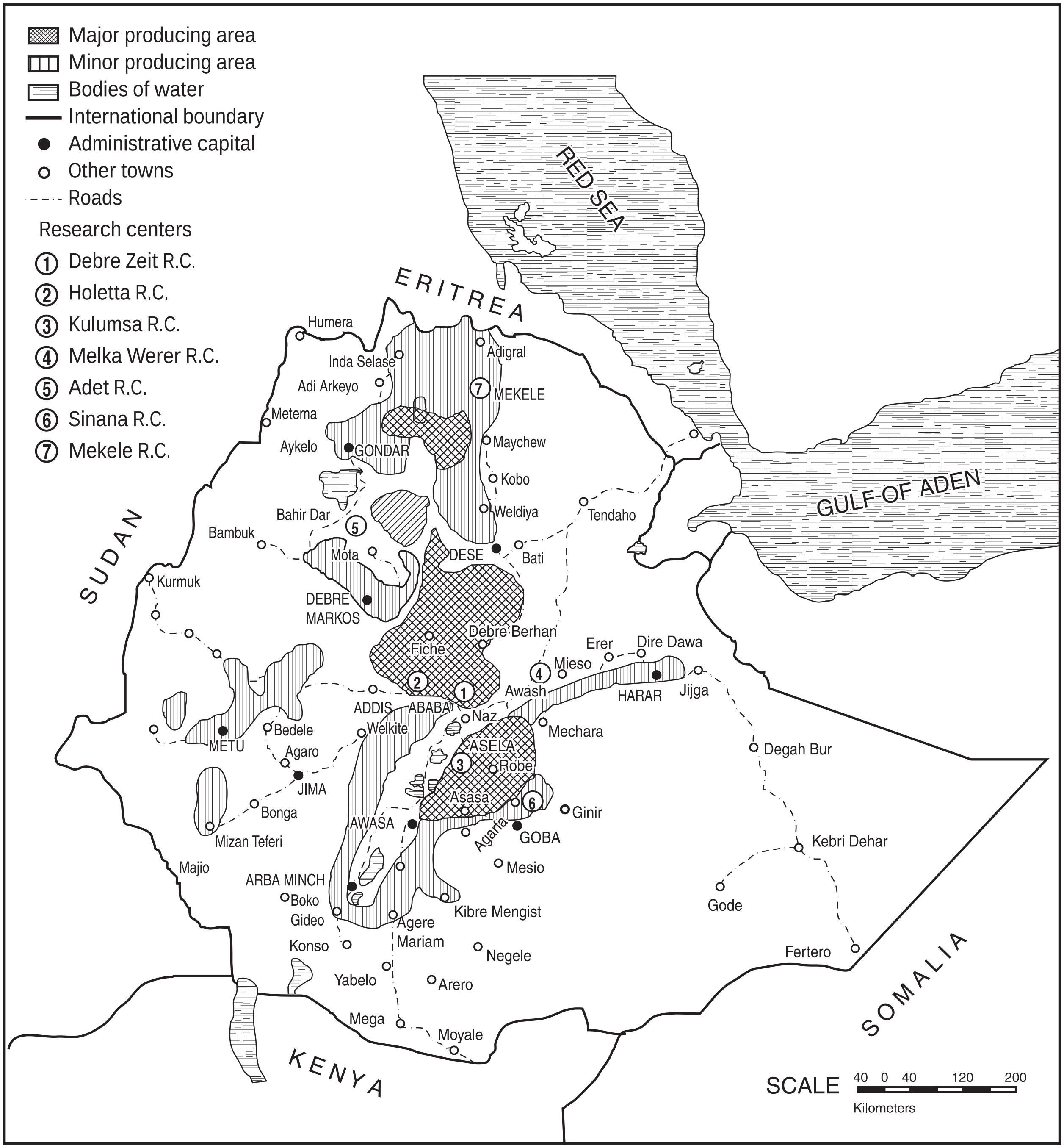

Figure 1. Major and minor wheat production areas in Ethiopia, including the study area.
Source: Land Use Planning and Regulatory Department, MOA.

2. The years from 1898 to the 1960s, when indigenous farmers experimented with crop production methods introduced by migrants from Shoa. During this period, farming practices were characterized by different rotational systems that included long fallows. The same fields were sometimes cultivated for four to five consecutive years and then left fallow for 10-15 years. Barley and wheat were the main crops, although peas, beans, and linseed were sown as well. Crop production was labor intensive (CADU 1966; CADU 1968; Lexander 1968; CADU 1969).

3. From 1966 to the present, small grain cereals have continued to dominate the farming system. Wheat area and yields have increased substantially, but farm sizes have diminished greatly as a result of population pressure, to the extent that some farms can be considered uneconomic (CADU 1971; CADU 1972; CADU 1973; Zena 1976; ARDU 1979).

In summary, farmers have shifted out of a livestock-dominated system to crop-livestock systems. The major crops in the area are now wheat, barley, faba bean, field pea, sorghum, and maize. Barley is dominant in the higher altitude areas, whereas wheat is the major crop in the midaltitude areas (Chilot Yirga et al. 1989). Besides being a subsistence crop, wheat is also a major source of cash for farmers.

About 75% of Ethiopia's total bread wheat area is located in Arsi, because the temperature, rainfall, soils, and elevation make the area especially amenable to wheat cultivation (Hailu Gebremariam, Tanner, and Hulluka 1991; Gavian and Gemechu Degefa 1996). Throughout Ethiopia, smallholders cultivate 82% of the wheat area and account for 76% of wheat production (Adugna Haile, Workneh Negatu, and Bisrat Retu 1991). Farmers' wheat management practices are advanced relative to other wheat-growing areas, chiefly because the area has benefited from more than two decades of sustained effort to disseminate improved agricultural technologies. (Arsi is the location of the first integrated rural development project in Ethiopia, financed by the Swedish government.) Moreover, the area is served by good roads that provide access to markets. Because of the area's proximity to research organizations and the formal marketing system, it provides an interesting opportunity for examining farmers' access to and use of improved seed.

Some information is already available on farmers' practices in the woredas that constitute Chilalo Awraja. For example, Gavian and Gemechu Degefa (1996) reported that in Tiyo woreda, 76% of farmers planted wheat on at least one of their plots and used 13% more seed than recommended. These high seed rates may reflect the impurity or limited germination ability of the seed. Farmers had retained most of their seed from the previous harvest. Only 6% of the seed had been purchased from ESE, which sold only K6295-4A in 1994. Herbicide was applied to about 38% of the wheat plots and the quantities applied were lower than the recommended rate for the region. In Arsi, it was found that about 87% of the farmers applied fertilizer to their wheat crop (the average application was 71 kg/ha), but there is considerable variation across the awrajas of Arsi. Almost half of the farmers in the region used 50 kg/ha of fertilizer or less, but the same proportion of farmers in Chilalo was found to use relatively higher rates (75-100 kg/ha) (Mulugeta 1996).

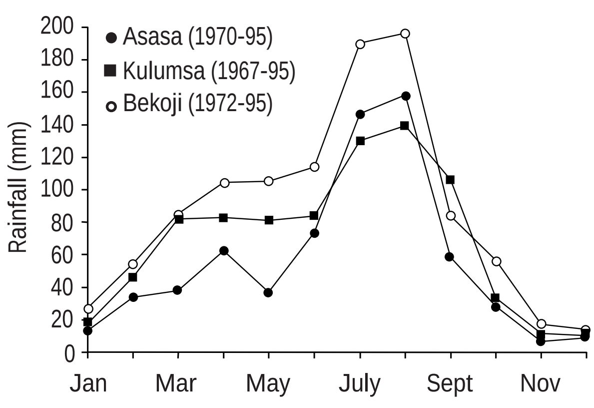

Figure 2. Average monthly rainfall at different research stations in Arsi, Ethiopia.

2.0 METHODOLOGY

2.1 Sampling Method

Based on an informal assessment and secondary data sources, the major wheat-growing woredas of Chilalo were classified into three strata. The major stratifying parameter was proximity to formal and informal seed suppliers (i.e., state farm, ESE farm, and the research center). Agroecological diversity (i.e., variation in elevation, rainfall, and temperature) and institutional factors (i.e., accessibility to input and output markets) were also considered.

Four woredas representing the three strata were purposively selected: Tiyo, Etheya, Lemu-na-Bilbilo, and Asasa. Because Tiyo and Etheya are relatively similar with respect to the parameters considered for stratification, a joint sampling frame was prepared for the two woredas, in which two PAs from Tiyo and four from Etheya were selected according to the procedure detailed in Table 1. For the purposes of this study, therefore, the two woredas form a single stratum. Six PAs from each remaining woreda were included in the sample. The PAs were selected using probability proportional to size, while simple random sampling was used to select farmers. The total sample size was 180 farmers.

The Tiyo/Etheya area encompasses the towns of Asala and Etheya (Asala is the capital of Arsi Administrative Zone). Two of the ESE farms, Gonde and Etheya, are also located in this area. Moreover, the area benefits from on-farm research and demonstrations by the Kulumsa Research Center, which is the National Wheat Research Coordinating Center. Privately and publicly owned enterprises provide tractor and combine hiring services for farmers in the area, and some privately owned shops sell agricultural chemicals.

Asasa woreda is the site of farms belong to the Arsi Agricultural Development Enterprise (AADE), which practices large-scale, mechanized wheat production. Tractor and combine hiring services are available. The Ardaita farmer training center is also located in Asasa woreda.

Compared to the other woredas, Lemu-na-Bilbilo woreda is farther away from formal and informal seed suppliers.

2.2 Analytical Model

The two most common functional forms used in adoption studies are the logit and the probit models. The advantage of these models is that the probabilities are bounded between 0 and 1. Moreover, they compel the disturbance terms to be homoscedastic because the forms of probability functions depend on the distribution of the difference between the error term

Table 1. Sampling method

	Woreda			
Stages	Tiyo/ Etheya	Lemu-na-Bilbilo	Gedab Asasa	Sampling procedure
Peasant Associations	6	6	6	PPS
Farmers	60	60	60	SRS
Probability	0.00063	0.00311	0.0011	

Note: PPS = probability proportional to size; SRS = simple random sample.

associated with one particular choice and another. Usually a choice has to be made between logit and probit models, although the statistical similarities between the logit and probit models make such a choice difficult (Amemiya 1981). The choice of model may be evaluated *a posteriori* on statistical grounds, although even here, in practice, there will usually not be strong reasons to choose one model over the other. We selected the logit model because it is computationally easier to estimate.

Following Pindyck and Rubinfeld (1981), the model is written as:

[1] $$\ln [P/(1-P)] = \beta_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + B_{10}X_{10} + e$$

where:

X_1 = 1 if farmer is near AADE farm, 0 otherwise;
X_2 = 1 if farmer is near ESE farm, 0 otherwise;
X_3 = 1 if farmer is near research station, 0 otherwise;
X_4 = farmer's age in years;
X_5 = 1 if farmer participated in basic literacy campaign or attended church school, 0 otherwise;
X_6 = farmer's level of education, in years;
X_7 = 1 if farmer hosted demonstration or on-farm trial, 0 otherwise;
X_8 = 1 if farmer had extension contact, 0 otherwise;
X_9 = cultivated land (timmad per person);[1]
X_{10} = 1 if farmer served as contact farmer, 0 otherwise; and
e = error term.

The dependent variable is the natural log of the probability of awareness of the new wheat variety (P), divided by the probability of unawareness ($1-P$). The model was estimated using the maximum likelihood procedure of the Statistical Package for the Social Sciences (version 6.1).

Formation of the model was influenced by a number of working hypotheses. Several variables were hypothesized to influence the adoption of new wheat varieties in the study area.

Nearness to the AADE farm (X_1): Farmers who are near the AADE farm are hypothesized to be more likely to receive information on the new wheat varieties that are available.

Nearness to the ESE farm (X_2): Farmers who are near the ESE farm are hypothesized to be more likely to receive information on the new wheat varieties that are available.

Nearness to the research center (X_3): Farmers who are near the research center are hypothesized to be more likely to receive information on the new wheat varieties that are being developed.

[1] 1 timmad = 0.25 ha.

Farmer's age (X_4): It is hypothesized that with increasing age a farmer will be less likely to be aware of new wheat varieties. Younger farmers may have greater access to information because they have had greater access to education, and thus they will be more aware of new wheat varieties. Older farmers might not have access to this information.

Participation in basic literacy campaign (X_5): Participation in the literacy campaign, which exposed farmers to information such as the availability of farming technologies, is hypothesized to increase the probability that farmers will be aware of new wheat varieties.

Farmer's education level (X_6): Formal schooling enhances a farmer's ability to perceive, interpret, and respond to new events in the context of risk. Hence education is hypothesized to increase the probability that farmers will be aware of new wheat varieties.

Farmer hosted demonstration or on-farm trial (X_7): Hosting a demonstration or on-farm trial gives the farmer access to information and is hypothesized to increase the probability that farmers will be aware of new wheat varieties.

Extension contact (X_8): Extension contact gives the farmer access to information and is hypothesized to increase the probability that farmers will be aware of new wheat varieties.

Cultivated land per person (X_9): Population pressure in the study area is causing a land shortage, and the scope for increasing land productivity will rely on increased cropping intensity. This in turn will require farmers to allocate their limited land to newer and better yielding wheat varieties. Hence, cultivated land per person is hypothesized to increase the farmer's awareness of the new wheat varieties.

Serving as contact farmer (X_{10}): Serving as a contact farmer gives a farmer access to information and should increase the likelihood that he or she will be aware of new wheat varieties.

3.0 THE SEED INDUSTRY IN ETHIOPIA

3.1 Seed Industry Structure

Douglas (1980), in his life cycle model of seed industry development, showed that seed supply systems in most countries pass through four evolutionary stages characterized by increasing technological and organizational complexity.

1. During the first stage, farmers save their own seed from crop to crop by selecting the most productive plants. They also exchange seed with a few farmers.

2. In the second stage, a specialized government agricultural department emerges under pressure from farmers and conducts plant breeding research and varietal development. A few farmers specialize in multiplying and distributing seed released by the government research stations.

3. During the third stage, private seed companies enter the seed industry and invest in plant breeding research and development and seed growing, processing, and marketing.

4. In the fourth stage, plant breeding and seed production and marketing become highly organized and technologically intensive. Both public and private organizations engage in seed production, marketing, and international trade.

The Ethiopian seed industry is in the second stage of seed industry development. Improved varieties are developed by national research systems and development programs or introduced from outside. Public institutions are responsible for producing and distributing seed to farmers, although some private companies are now entering the seed industry and have started research on hybrid seed production, marketing, and distribution.

The supply of seed is constrained by the inefficiency of public seed enterprises, poor seed promotion, poor transportation, and inappropriate agricultural and pricing policies. Moreover, because high yielding varieties perform well with fertilizers, the limited availability of fertilizers constrains demand for improved seed. As a result, in the peasant sector most seed is still produced by farmers themselves (Hailu Gebremariam 1992). The Ethiopian seed industry is thus characterized by formal and informal sectors. The formal sector includes research institutions, agricultural ministries, development projects, public and private seed enterprises, non-governmental organizations (NGOs), and relief agencies. The participants in the informal sector are farmers.

3.1.1 The formal sector

Varietal development is handled by the Institute of Agricultural Research (IAR), Alemeya University of Agriculture (AUA), Addis Ababa University (AAU), and regional state agricultural research establishments. Virtually all plant breeding has been done by public institutions, although Pioneer Hi-Bred International has done some varietal development.

Before a variety can be recommended for release, it must be evaluated in farmers' fields for disease resistance, productivity, stability, and quality. After on-farm verification and evaluation, varieties are officially released by the National Variety Releasing Committee (NVRC). This procedure is sometimes violated. For instance, in 1991, Pioneer tried to produce 144 ha of hybrid maize and 60 ha of sunflower using imported seed that had not been tested. The company harvested only 71.1 t of maize seed whereas the sunflower did not even set seed.

The Ministry of Agriculture (MOA), particularly Arsi Rural Development Unit (ARDU) and the Ministry of State Farm Development (MSFD), have undertaken a limited amount of seed production and distribution since the late 1960s. The MSFD produced seed to meet its own requirements, whereas ARDU produced different kinds of seed for peasant farmers in Arsi.

The Ethiopian Seed Enterprise (ESE) was incorporated in 1979 to produce, process, and market seed. Initially, ESE supplied improved varieties only for state farms and producers' co-operatives that were the foundation of the socialist economy. Now ESE is governed by an interministerial Seed

Board and has been given autonomous status to function as a profit-making enterprise. This organization was the only seed enterprise in Ethiopia until December, 1990, when it entered into partnership with Pioneer Hi-Bred International (Hailu Gebremariam 1992).[2]

The ESE is supplied with breeder and basic seed by IAR and AUA and multiplies this seed at two of its basic seed farms. The ESE also produces seed under contractual arrangements with state farms and private producers. The organization maintains five processing plants, from which it also distributes seed. From 1980 to 1991, on average, ESE produced and distributed 23,065 t of seed per year (Table 2). Although there are no supporting data, it is believed that ESE will presently distribute more than this amount of seed, given the high demand for improved varieties and the strong, government-supported extension program.

The seed required for the peasant sector is collected by the Agricultural Input Supply Corporation (AISCO) of MOA from the processing plants and distributed to farmers through the SCs and PAs. There has always been some discrepancy between the amount of seed ordered and purchased by AISCO. For example, between 1985/86 and 1990/91, AISCO annually ordered about 24,688 t of seed from ESE and purchased only about 21%. This left ESE with a large residual seed stock every year. Furthermore, AISCO actually distributed only part (60%) of what it had purchased. This discrepancy in production and distribution of seed to peasant farmers is caused by related problems in demand assessment, the seed distribution mechanism, seed quality, and the seed price and credit system (Hailu Gebremariam 1992). At present ESE distributes seed directly to SCs through district MOA offices. The ESE seed prices should be lower than those of AISCO because ESE services are less. AISCO used to charge 20 Birr/100 kg over the price it paid to ESE for its services (Hailu Gebremariam 1992).[3] There is no independent national seed quality control and certification scheme, although ESE has its own internal quality control facilities. As a result, none of the commercial seed distributed by ESE is certified, and farmers and development workers have sometimes disputed the purity and quality of seed supplied by ESE (Hailu Beyene 1993). Adugna Haile, Workneh Negatu, and Bisrat Retu (1991) have observed that very few improved wheat varieties released or recommended by the research system have reached farmers, mainly because of the poor seed dissemination mechanism.

Table 2. Seed distribution (000 t) by Ethiopian Seed Enterprise (1980-91)

Year	Wheat	Barley	Maize	Teff	Sorghum	Total
1980	19.08	0.26	1.16	0.02	0.20	20.72
1981	18.85	0.74	2.35	0.13	0.17	22.24
1982	16.43	0.29	1.42	0.27	0.15	18.56
1983	16.57	0.87	2.50	0.22	0.05	20.21
1984	12.25	1.65	1.30	0.13	0.26	15.58
1985	21.77	1.72	12.58	0.77	0.07	36.92
1986	25.54	1.83	11.78	0.56	1.12	40.83
1987	19.91	2.16	8.28	0.53	1.44	32.32
1988	18.81	4.12	4.51	0.57	2.15	30.17
1989	9.19	1.39	3.16	0.22	0.94	14.89
1990	8.81	0.71	3.87	0.74	0.61	14.74
1991	7.10	1.24	1.14	0.03	0.10	9.61
Total	194.31	16.98	54.05	4.19	7.26	276.79

Source: Hailu Gebremariam (1992).

In general, the formal sector's contribution to supplying improved seed has been very low, but it is improving. Seed distribution by IAR-Debre Zeit Agricultural Research Center (DZARC) through on-farm testing, demonstration, and

[2] The joint venture was discontinued in December 1995 as part of the reform to liberalize the economy.

[3] 7 birr = 1 US$.

popularization, and through the Plant Genetic Resource Center (PGRC) and community level landrace conservation initiatives, is minimal. Even so, these efforts have contributed to the distribution of improved varieties through farmer-to-farmer seed exchange, although the distribution is limited to the immediate vicinity of the research centers.

3.1.2 The informal sector

The role played by NGOs and relief agencies in the seed industry is difficult to assess. Their activities are dispersed and uncoordinated, because their operations are mainly based on providing emergency relief and on replacing seed lost as a result of natural disasters or civil disorders. Initially NGOs were assumed to be responsible for acquiring and providing early generation seed to SCs at cost, including transport. In fact, the distribution of free seed by NGOs and relief agencies has had several negative effects, creating dependency on free services, disrupting the informal farmer-to-farmer seed exchange system, and weakening sustainable development in the seed subsector (Hailu Gebremariam 1992). Nevertheless, NGOs have tended to work well with small-scale, resource-poor farmers, who are mostly located in remote and inaccessible areas.

Ethiopian farmers have been practicing seed selection and preservation for centuries, and as we have noted, the bulk of the national seed requirement is still met through this informal system of local seed maintenance and exchange. Of the total annual seed requirement of about 0.42 million t, 15% is produced by the formal sector as improved seed stock, whereas local varieties from the informal farmer-to-farmer exchange system constitute 85% of the total seed requirement (Table 3).

3.1.3 Potential seed users

The potential seed users of the study area can be categorized into three groups: small-scale farmers, state farms, and contractual farmers (who are coming into the picture since the economic reform of 1991). Each group has slightly different seed sources (Figure 3); for instance, state farms depend mostly on formal seed channels.

3.2 Mechanisms of Wheat Seed Development and Supply

The bread wheat seed industry comprises several processes, beginning with varietal development, testing, and release and proceeding to processing, distribution, and marketing.

3.2.1 Varietal development, testing, and release

Bread wheat research in Ethiopia depends mainly on introduced germplasm, because the stock of local bread wheats is too limited in number and variability to constitute a viable, economic breeding program. Introduced materials may be used as parents for further breeding research or included in the Advanced Observation Nursery (AON). Materials evaluated in the AON are evaluated further (mainly for yield, disease resistance, and other desirable traits) in the Preliminary Yield Trial (PYT) and the Pre-National Variety Trial (PNVT) for two years. Promising genotypes are included in National Variety Trial (NVT) for further evaluation for two to three years.

At this stage, some of the promising lines in the NVT may be included in the Cooperative Variety Adaptation Trial (CVAT) and tested for three more years at more than 20 locations in major wheat-growing environments of the country. The best materials from the NVT and CVAT are included in the Variety Verification Trial (VVT), conducted both on-station and on-farm under recommended and farmers' levels of management for one to two years. The objectives of the VVT are to obtain farmers' pre- and postharvest assessment of varieties, to evaluate the performance of the varieties in a real production system, and to assist in the decision of the variety release committee. The committee is composed of professionals from different research and seed user organizations (e.g., IAR, MOA, ESE). The committee considers mostly biological factors in deciding to release a variety, and there is no guarantee that farmers' preferences and priorities are fully represented. In general, seven years are required to release a variety. Sometimes release of the variety may be unnecessarily delayed because of the stringent release mechanism.

After a variety is released, it is included in Breeder Seed Increase (BSI). Breeder seed is then provided to ESE for further multiplication on large plots.

Table 3. Annual harvested area, estimated area planted with improved varieties/hybrids, quantity of improved seed used, and share of area planted to landraces/local varieties and improved varieties of major food crops, Ethiopia

Crop	Harvested area (000 ha)	Area under improved varieties (000 ha)	Quantity of improved seed used (000 qt)	Percent area planted with local materials	Percent area planted with improved materials
Teff	1,389.2	27.8	8.3	98.0	2.0
Bread wheat	380.5	304.4	456.6	20.0	80.0
Durum wheat	396.0	15.8	19.7	96.0	4.0
Barley	987.2	39.5	43.4	96.0	4.0
Maize (OPVs, hybrids)	1,037.8	363.2	109.0	65.0	35.0
Sorghum	887.0	149.0	14.9	83.2	16.8
Finger millet	213.6	0.0	0.0	100.0	0.0
Emmer	37.4	0.0	0.0	100.0	0.0
Cereals	**5,317.7**	**899.7**	**651.9**	**83.1**	**16.9**
Faba bean	284.7	2.8	5.6	99.0	1.0
Field pea	131.0	0.0	0.0	100.0	0.0
Chickpea	126.2	0.0	0.0	100.0	0.0
Lentil	50.4	0.5	0.3	99.0	1.0
Grass pea	52.0	0.0	0.0	100.0	0.0
H. bean	45.1	33.8	20.3	25.0	75.0
Soybean	2.4	1.9	1.7	20.0	80.0
Pulses	**691.8**	**39.0**	**27.9**	**94.4**	**5.6**
Noug (Niger seed)	157.8	1.6	0.2	99.0	1.0
Linseed	87.8	1.8	0.4	98.0	2.0
Rapeseed	57.2	8.6	1.0	85.0	15.0
Sesame	7.7	0.0	0.0	100.0	0.0
Groundnut	5.2	1.0	0.8	80.0	20.0
Fenugreek	10.2	0.0	0.0	100.0	0.0
Sunflower	53.4	5.1	0.5	90.4	9.6
Oilseeds	379.3	18.1	2.9	95.2	4.8
Total	6,388.8	956.8	682.7	85.0	15.0

Source: Hailu Gebremariam (1992).

3.2.2 Seed imports

Aside from producing seed to meet local demand, ESE is also responsible for importing seed. Between 1986 and 1991, ESE imported nearly 3,000 t of seed (Table 4), mostly hybrid maize from Kenya and hybrid sunflower from Argentina. After ESE established a joint venture with Pioneer Hi-Bred International in 1990, it imported more seed. Continued increases in seed imports may have a negative impact on national efforts to develop adapted, high-yielding varieties and hybrids, on creating a sustainable seed supply that would foster self-sufficiency, and on the conservation and sustainable use of indigenous germplasm (Hailu Gebremariam 1992). On the other hand, increased imports reflect ESE's inability to meet domestic seed demand.

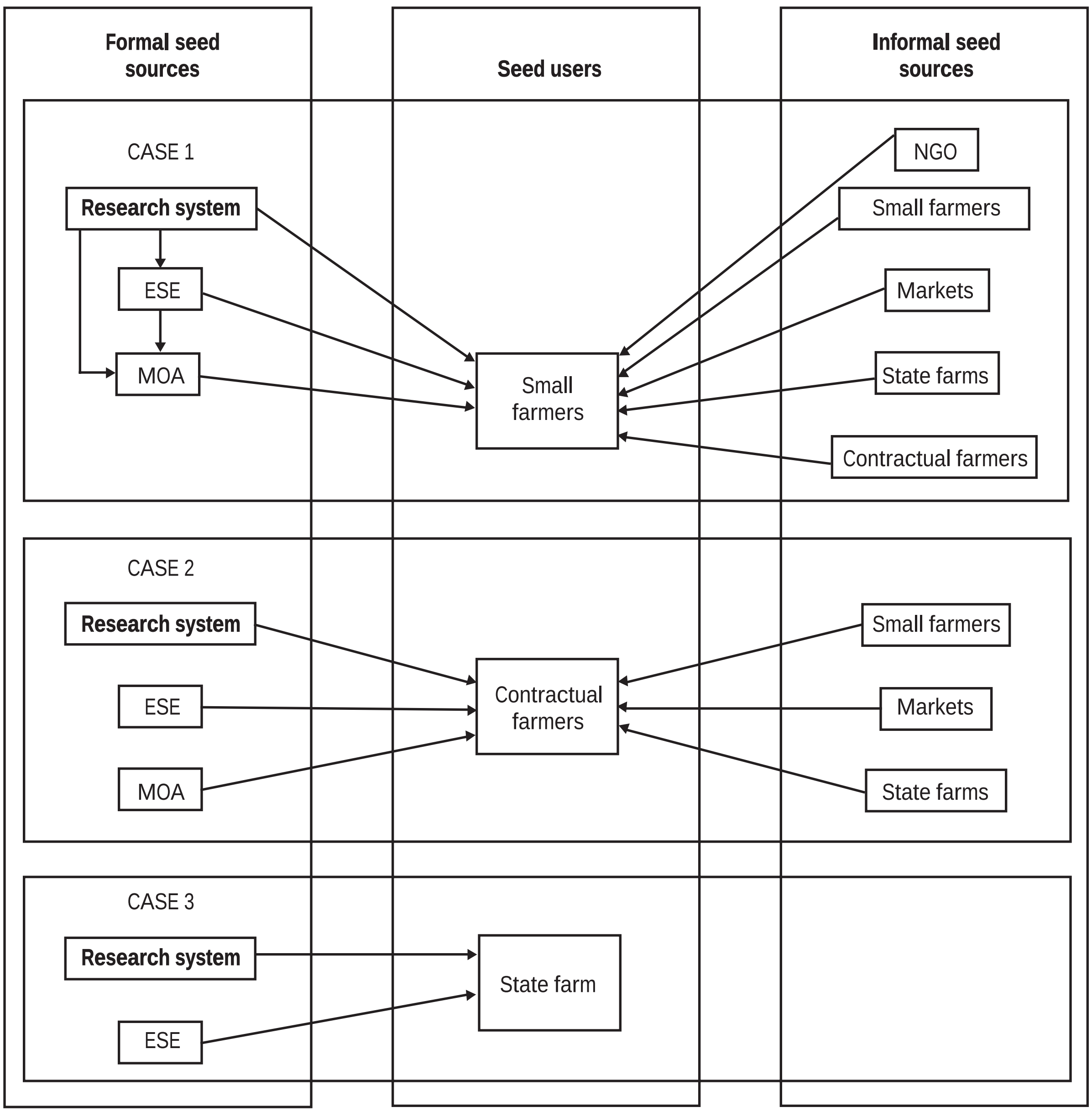

Figure 3. Mechanisms of seed supply in Chilalo Awraja, Ethiopia.
Note: ESE = Ethiopian Seed Enterprise; MOA = Ministry of Agriculture; NGO = non-governmental organization.

3.2.3 Seed distribution and marketing

The institutions involved in seed distribution and marketing are ESE, AISCO, AID Bank, Commercial Bank of Ethiopia, the SCs, and private organizations.

Commercial seed production and processing are handled by ESE. AISCO distributes seed through SCs, which receive loans from AID Bank and Commercial Bank of Ethiopia to purchase seed. Although it is envisaged that the private sector will play an important role in the seed industry in the future, the contribution of private firms in supplying seed of the major food grains is still small (Hailu Gebremariam 1992). Private companies such as Ethiopia Amalgamated Ltd., Ambassel, and Dinsho trading enterprises have recently entered the seed industry, buying seed from ESE and distributing it to a limited number of farmers on commission.

The promotion of improved seed by ESE has been limited. It also seems that sometimes ESE is not aware of the varieties that farmers want, because it has produced and distributed seed that farmers did not request. A better marketing effort could play an important role in the diffusion of new varieties. For example, a greater effort could be made to convince farmers to use improved varieties and differentiate between grain and improved seed.

Table 4. Seed imports by Ethiopian Seed Enterprise (1986-91)

Year	Crop	Country	Quantity (t)	Price (US$/t)
1986	Hybrid maize	Kenya	3.8	750.00
	Malt barley	Kenya	0.5	900.00
1987	Hybrid maize	Kenya	980.0	996.00
	Hybrid maize	Zimbabwe	120.0	834.70
	Malt barley	Spain	150.0	626.00
	Sunflower	Argentina	11.0	3,513.20
1988	Hybrid maize	Kenya	580.0	869.70
	Maize, basic	Kenya	30.0	899.80
	Sorghum	Kenya	10.0	869.70
	Maize, basic	France	2.03	22,434.10
	Sunflower	Zimbabwe	33.0	3,821.30
	Sunflower	Argentina	30.0	3,821.30
	Sunflower, basic	Argentina	0.15	84,000.00
	Pepper	Argentina	0.1	43,500.00
1989	Maize, basic	Zimbabwe	2.5	17,076.40
	Sunflower	Argentina	47.5	4,471.20
1990	Sunflower	Argentina	11.5	3,022.40
	Maize, basic	Malawi	0.3	21,866.70
	Cotton	Israel	0.6	10,225.00
1991	Hybrid maize	Kenya	900.0	1,000.00
Total			**2,957.4**	

Source: Hailu Gebremariam (1992).

4.0 SOCIOECONOMIC AND DEMOGRAPHIC CHARACTERISTICS

Socioeconomic and demographic characteristics of sample households for the four woredas in Chilalo Awraja are shown in Table 5. The mean age of farmers in Tiyo was about 59 years compared to about 46 years for Hetosa, 45 years for Lemmu-na-Bilbilo, and 38 years for Asasa. The mean age of the household head was about 45 years, with about 26 years of farming experience. Middle-aged farmers dominate the farming population in the area, mainly because young farmers have little opportunity to acquire land. Only a limited quantity of land is available and land redistribution has ended.

The mean years of farming experience in Asasa is about 18, compared to 29 years for Hetosa, 43 for Tiyo, and 26 for Lemmu-na-Bilbilo. The mean for Asasa is significantly (5% level) less than the mean for the other woredas, because farmers in Asasa woreda were predominantly cattle herders until quite recently.

Mean family size was about eight persons, with about an equal number of family members older than 17 and younger than 14 years (3.5 and 3.4, respectively). No significant differences in family size were observed across woredas. The number of family members between 14 and 17 years of age is on average 0.87, although the mean number of family members working off of the farm is only 0.09. As expected, the number of family members working off of the farm is higher in Tiyo woreda because it is close to the town of Asella, the capital of Arsi zone. However, the small number of family members working off of the farm indicates the limited opportunities for off-farm employment.

Average farm size in Chilalo Awraja is about 17 timmad. Mean farm size is about 11 timmad for Hetosa and 10 timmad for Tiyo, and the mean is significantly (5% level) smaller than the mean in Lemmu-na-Bilbilo and Asasa.

About 9% of households were headed by women. The proportion of female-headed households tended to be higher in Etheya and Tiyo woredas, although the degree of association between sex of

Table 5. Socioeconomic and demographic characteristics by woreda, Chilalo Awraja, Ethiopia

	Woreda				
Variables	Hetosa	Tiyo	Lemmu-na-Bilbilo	Asasa	Chilalo Awraja
Age of household head (yr)	46.4b	59.2a	45.0b	38.7c	44.70
Farming experience (yr)	29.5b	42.7a	26.2b	18.2b	26.10
Family size	7.1	9.2	7.7	7.9	7.80
Family size (age >17)	3.3b	4.9a	3.2b	3.5b	3.50
Family size (age 14-17)	0.7	1.5	0.8	0.8	0.90
Family size (age <14)	3.1	2.8	3.7	3.6	3.40
Off-farm workers	0.03b	0.4a	0.03b	0.08b	0.09
Farm size (timmad)	10.7a	10.1a	17.8b	23.2c	17.20

Note: Figures followed by similar letters are not significantly different from each other at the 5% level; 1 timmad = 0.25 ha.

household head and woreda was not significant (χ^2=4.13, P=0.25). Of the 17 female-headed households, about 41% reported that their husbands had died, 6% were divorced, and 6% were married to soldiers who lived off of the farm. The remaining 47% reported that their husbands lived in the village, but they were the ones registered in the PA. Widowhood was the main reason that women in Etheya and Tiyo woredas were heads of households, whereas the practice of polygamy was the main reason for the female-headed households in Lemmu-na-Bilbilo and Asasa woredas. About 18% of the male farmers in Lemmu-na Bilbilo and 37% in Asasa had two wives, compared to about 19% in Etheya and 11% in Tiyo.

Table 6 shows the levels of education by woreda. About 50% of the farmers were illiterate. Thirty percent had participated in a basic literacy campaign or church school, but this does not necessarily guarantee that they are literate. Twenty percent of the farmers are certainly literate; of these, about 56% had formal schooling from grades 1 to 6, about 42% reached grades 7 to 8, and only about 3% reached grades 9 to 12.

5.0 FARMERS' SOURCES OF SEED, SEED MANAGEMENT PRACTICES, AND SEED QUALITY

5.1 Varieties

5.1.1 Farmers' knowledge of wheat varieties and varieties grown

Seed samples of each bread wheat variety encountered during the survey were collected for further identification and laboratory analysis at Kulumsa Research Center. Chilalo farmers identified about 47 wheat varieties, although there was some disparity between the proportion of farmers who knew about varieties and the proportion of farmers who had actually grown them (Table 7).

Popular varieties include Enkoy, Dashen, Laketch, K6295-4A, Israel, Pavon-76, Supremo, Tikur-sinde, Bonde, Romany, Batu, ET-13, Inglizi, K6290-Bulk, Salamayo, Setakuri, and Abasha. About half of these varieties were released by the research system, whereas the rest are landraces or introductions of unknown origin (e.g., Israel). Some farmers have known about the landraces since childhood or learned about them from their parents, but only a few farmers have actually grown them. Except for growing a few local varieties/landraces such as Israel and Tikur-sinde, which have

Table 6. Differences in farmers' level of education by woreda, Chilalo Awraja, Ethiopia

Woreda	Illiterate N	Illiterate (%)	Basic literacy N	Basic literacy (%)	Grades 1-6 N	Grades 1-6 (%)	Grades 7-8 N	Grades 7-8 (%)	Grades 9-12 N	Grades 9-12 (%)	Church N	Church (%)	N
Etheya	18	(45)	13	(32.5)	7	(17.5)	1	(2.5)	1	(2.5)	-		40
Tiyo	10	(50)	7	(35)	2	(10)	-		-		1	(5)	20
Lemu-na-Bilbilo	40	(66.7)	9	(15)	5	(8.3)	6	(10)	-		-		60
Asasa	21	(35)	25	(41.7)	6	(10)	8	(13.3)	-		-		60
Total	**89**	**(49.4)**	**54**	**(30)**	**20**	**(11.1)**	**15**	**(8.3)**	**1**	**(0.5)**	**1**	**(0.5)**	**180**

Table 7. Wheat varieties known and grown by farmers, by woreda, Chilalo Awraja, Ethiopia

		Farmers knowing variety (%)				Farmers growing variety (%)			
No.	Variety	Tiyo/ Etheya	Lemmu	Asasa	Chilalo	Tiyo/ Etheya	Lemmu	Asasa	Chilalo
1	Batu	55.0	0.0	0.0	18.3	35.0	0	0.0	11.7
2	Dereselign	18.3	0.0	0.0	6.1	5.0	0	0.0	1.7
3	ET-13	16.7	8.3	66.7	30.6	0.0	8.3	26.7	11.7
4	HAR-710	0.0	0.0	5.0	1.7	0.0	0.0	1.7	0.6
5	HAR-1709	1.7	0.0	0.0	0.6	0.0	0.0	0.0	0.0
6	Israel	93.3	93.3	90.0	92.2	65.0	41.7	38.3	48.3
7	K6290-Bulk	16.7	18.3	71.7	35.6	3.3	6.7	21.7	10.6
8	K6295-4A	90.0	61.7	98.3	83.3	63.3	28.3	73.3	55.0
9	Inglizi	35.0	61.7	40.0	45.6	10.0	11.7	13.3	11.7
10	Bonde	50.0	85.0	45.0	60.0	18.3	33.3	5.0	18.9
11	Dashen	100	86.7	91.7	92.8	93.3	31.7	61.7	62.2
12	Enkoy	100	98.3	100	97.8	73.3	96.7	96.7	88.9
13	Laketch	95.0	91.7	88.3	91.7	71.7	46.7	55.0	57.8
14	Mamba	50.0	75.0	73.3	66.1	11.7	21.7	23.3	18.9
15	Pavon-76	91.7	20.0	85.0	65.6	66.7	3.3	56.7	42.2
16	Romany	35.0	58.3	36.7	43.3	10.0	21.7	6.7	12.8
17	Supremo	81.7	45.0	75.0	67.2	43.3	15.0	30.0	29.4
18	Sergegna	23.3	36.7	16.7	25.6	1.7	5.0	6.7	4.4
19	Setakuri	35.0	5.0	1.7	13.9	23.3	1.7	1.7	8.9
20	Tikur-sinde	45.0	66.7	21.7	44.4	33.3	36.7	15.0	28.3
21	Bokoke	23.3	1.7	6.7	10.6	11.7	0.0	1.7	4.4
22	Haibo	13.3	3.3	1.7	6.1	5.0	1.7	1.7	2.8
23	Manze	1.7	0.0	0.0	0.6	1.7	0.0	0.0	0.6
24	Didao	1.7	0.0	0.0	0.6	1.7	0.0	0.0	0.6
25	Butugi	1.7	0.0	0.0	0.6	0.0	0.0	0.0	0.0
26	Salamayo	23.3	43.4	1.7	18.3	0.0	26.7	1.7	0.4
27	Kenya	6.7	6.7	1.7	5.0	5.0	5.0	0.0	3.3
28	Abasha	6.7	0.0	0.0	2.2	18.3	0.0	0.0	6.1
29	Taliani	10.0	0.0	0.0	3.3	1.7	0.0	0.0	0.6
30	Wolde	5.0	0.0	0.0	1.7	5.0	0.0	0.0	0.0
31	Kentana Frontana	3.3	6.7	0.0	3.3	5.0	3.3	0.0	2.8
32	Buhe	25.0	0.0	0.0	8.3	1.7	0.0	0.0	0.6
33	Yaktana-54	0.0	8.3	0.0	2.8	1.7	5.0	1.7	2.2
34	G/Meskel	1.7	0.0	0.	0.6	1.7	0.0	0.0	0.6
35	Azaze	1.7	0.0	0.0	0.6	1.7	0.0	0.0	0.6
36	Abolse	1.7	0.0	0.0	0.6	0.0	0.0	0.0	0.0
37	Arabe	1.7	0.0	0.0	0.6	0.0	0.0	0.0	0.0
38	Shamame	1.7	0.0	0.0	0.6	0.0	0.0	0.0	0.0
39	Fatate	0.0	3.3	1.7	1.7	0.0	0.0	0.0	0.0
40	Goshginbar	0.0	1.7	0.0	0.6	0.0	0.0	0.0	0.0
41	Kanga	0.0	1.7	0.0	0.6	0.0	0.0	0.0	0.0
42	Dabule	0.0	5.0	1.7	2.2	0.0	0.0	0.0	0.0
43	FW-86	0.0	0.0	3.3	1.1	0.0	0.0	0.0	0.0
44	Shukare Kenya	0.0	1.7	0.0	0.6	0.0	0.0	0.0	0.0
45	HAR-416	8.3	0.0	0.0	2.8	10.0	0.0	0.0	3.3
46	Qore	8.3	0.0	0.0	2.8	1.7	0.0	0.0	0.6
47	Wolandi	15.0	3.3	6.7	8.3	0	0.0	1.7	2.8

stayed in production because of their valued food qualities and the market demand for their large, white grain and superior flavor, farmers have resorted almost completely to growing introduced/ improved varieties.

5.1.2 Sources of wheat varieties in 1995/96

In the 1995/96 cropping season, most farmers planted seed saved from their previous harvests (Table 8). The next most common sources of seed in 1995/96 were other farmers, MOA, ESE, and the local market. Additional seed sources included AADE, Sasakawa-Global 2000 (an NGO), and farmers' relatives.

Despite the belief that ESE and/or MOA are the main sources of seed for new varieties, this study shows the importance of other sources — especially other farmers and the local market — as potential sources of new seed for the majority of farmers. The diffusion of Green Revolution varieties of wheat and rice in Asia was also largely facilitated by farmer-to-farmer seed movement (Heisey 1990). In Ethiopia, a previous study has shown that most farmers (95.3%) obtain seed from informal sources (Bishaw et al. 1994).

Table 8. Farmers' sources of seed of wheat varieties grown in 1995/96, by woreda, Chilalo Awraja, Ethiopia

		Percentage farmers obtaining seed from:						
Variety	Woreda	Other farmer	MOA	ESE	Market	Self	Other source	N
Dashen	Tiyo/Etheya	20.6	8.8	–	5.9	64.7	–	34
	Lemu-na-Bilbilo	–	–	–	42.8	57.1	–	14
	Asasa	3.3	3.3	3.3	10.0	80.0	–	30
	Chilalo	10.3	5.1	1.3	14.1	69.2	–	78
Pavon-76	Tiyo/Etheya	16.7	5.6	8.3	5.6	61.1	2.8	36
	Lemu-na-Bilbilo		50.0	–	50.0	–	–	2
	Asasa	11.1	5.6	11.1	13.9	50.0	8.4	36
	Chilalo	13.9	6.8	9.7	9.6	55.6	5.6	74
Enkoy	Tiyo/Etheya	–	–	11.1	–	88.9	–	9
	Lemu-na-Bilbilo	–	–	–	18.2	78.8	3.0	33
	Asasa	–	–	–	–	100.0	–	7
	Chilalo	–	–	–	12.3	83.7	–	49
K6290-4A	Lemu-na-Bilbilo	15.4	30.8	–	7.7	46.2	–	13
	Asasa	5.9	29.4	29.4	17.6	17.6	–	17
	Chilalo	10.0	30.0	16.7	13.3	30.0	–	30
Batu	Tiyo/Etheya	–	5.6	–	5.6	83.3	5.6	18
ET-13	Lemu-na-Bilbilo	–	60.0	–	–	20.0	20.0	5
	Asasa	–	ñ	–	100.0	–	–	1
	Chilalo	–	50.0	–	16.7	16.7	16.7	6
Israel	Tiyo/Etheya	50.0	–	–	–	50.0	–	2
	Lemu-na-Bilbilo	25.0	–	–	25.0	50.0	–	4
	Chilalo	33.3	–	–	16.7	50.0	–	6
Tikur-sinde	Lemu-na-Bilbilo	–	–	–	50.0	50.0	–	2
	Asasa	–	–	–	100.0	–	–	1
	Chilalo	–	–	–	66.7	33.3	–	3
HAR-416	Tiyo/Etheya	25.0	–	–	–	75.0	–	4
K6290-Bulk	Asasa	–	–	–	100.0	–	–	1
HAR-710	Tiyo	–	–	–	–	–	100.0	1
	Asasa	100.0	–	–	–	–	–	1

5.1.3 Wheat varieties no longer grown, and the reasons for abandonment

From Table 7 we can see that the number of farmers who had actually grown a given variety was less than the number who knew about it, implying that farmers can be aware of a variety but not necessarily grow it. The recently released varieties HAR-1709 (1993) and HAR-710 (1994) are still not known by most farmers (only one farmer had obtained seed of HAR-710, from SG-2000).

Obviously, some varieties may have different names in different localities even though they are inherently the same variety; conversely, different varieties may be called by the same name (Workneh Negatu, Mwangi, and Tesfaye Tesema 1994). However, most of the old varieties listed in Table 8 are recorded in the literature, and attempts were made to characterize them phenotypically (Widerström 1968). Most of them were durum wheats.

The most important reasons that farmers gave for no longer growing certain varieties included susceptibility to disease, vulnerability to desiccating wind that shrivels grain, deterioration in yield potential, and the lack of varieties superior to those already available (Table 9). Farmers' secondary reasons for disadoption were specific to individual varieties; for instance, Romany was rejected because of threshing problems. Some of the reasons for abandoning a variety were not mutually exclusive. Farmers often confused the effects of frost with those of disease. They also confused the effect of frost with that of the September/October wind that results in shriveled grain. It is also important to note that some varieties (e.g., K6295-4A) have a low market price and poor quality for making *injera*, a staple food, but these considerations are overshadowed by superior yield.

Aside from the characteristics of the varieties themselves, there are other reasons why farmers no longer grow certain varieties. The organization of farmers into producers' cooperatives caused many farmers to stop growing landraces in favor of improved varieties, and members of cooperatives have accepted more improved varieties than private farmers. Farmers were asked to specify the advantages of abandoned varieties compared to those currently under production. The majority of the farmers reported that generally the abandoned varieties had no advantage over the current varieties. However, older varieties such as Tikur-sinde, Israel, and Laketch were still preferred for their food quality, white grain, and performance on infertile soils (Table 10).

Table 9. Varieties no longer grown by farmers, and farmers' reasons for abandoning these varieties, Chilalo Awraja, Ethiopia

	Percentage of farmers who have abandoned:											
Reason	**ET-13**	**Israel**	**K6295-4A**	**Inglizi**	**Bonde**	**Dashen**	**Enkoy**	**Laketch**	**Mamba**	**Romany**	**Supremo**	**Tikur-sinde**
Disease	36.4	18.4	22.1	–	36.6	22.7	42.2	33.6	12.5	10.7	12.9	18.0
Frost	13.6	6.9	9.1	8.3	19.5	11.4	11.1	20.3	35.0	17.8	3.7	2.0
Yield	45.5	56.3	45.5	41.7	31.7	22.7	27.4	25.8	30.0	10.8	62.9	24.0
Better variety available	–	8.0	7.8	16.7	2.4	6.8	6.7	10.9	2.5	10.8	5.6	28.0
Threshing problem	–	–	–	4.2	–	2.3	–	–	–	42.8	3.7	2.0
Poor *injera* quality	4.5	–	–	8.3	–	2.3	–	–	–	–	–	–
Other	–	11.4	15.5	20.8	9.8	31.8	12.6	9.4	20.0	7.1	1.2	26.0
Number of farmers	**22**	**87**	**77**	**24**	**41**	**44**	**135**	**128**	**40**	**28**	**54**	**50**

5.2 Wheat Production Patterns, 1992-95

Between 1992 and 1995, sample farmers' wheat area more than doubled (Table 11), probably for several reasons:

- The policy reform of 1991 discouraged collective farming and liberalized the grain market.
- The availability of combine hiring services reduced the drudgery of manual harvesting and reduced yield losses at harvest.
- Land belonging to some state farms was redistributed to smallholders, particularly in the Asasa area.
- Tractor hiring services became available on relatively good terms.

The popularity of individual varieties, measured by the number of farmers planting a given variety and the area it occupies, has changed over the year (Tables 11 and 12). Dashen has been grown on a wider area and by more farmers, despite its susceptibility to stripe rust. Area planted to Enkoy declined consistently over the four-year period, although the relative rate of decline has varied. Use of this variety has diminished primarily because its reduced resistance to stem rust caused yields to fall. The area planted to Pavon-76 has increased substantially. This variety was originally intended for the irrigated lowlands and was introduced to the study area by state farms, not by the formal extension channel. Farmers adopted the variety and it is gaining in popularity. Of the local varieties/ indigenous landraces, only a few have remained in production: Israel, Tikur-sinde, Inglizi, and Buhe. The other varieties (e.g., K6295-4A, K6290-Bulk, ET-13) showed no remarkable changes over 1992-95.

Table 11. Wheat production pattern from 1992 to 1995 in Chilalo Awraja, Ethiopia

	Percentage of farmers growing the variety in each year			
Variety	1992 (N=156)	1993 (N=163)	1994 (N=174)	1995 (N=177)
Dashen	47	54	76	78
Batu	8	13	15	20
Pavon-76	12	26	52	72
ET-13	5	4	6	6
K6295-4A	19	26	21	26
Enkoy	100	93	76	53
Israel	7	2	5	6
HAR-710	–	–	–	1
HAR-416	4	7	4	3
Tikur-sinde	–	–	2	4
K6290-Bulk	–	1	2	1
Buhe	–	1	–	–
Inglizi	1	–	–	–

Table 10. Advantages of varieties that farmers have abandoned compared to current varieties, Chilalo Awraja, Ethiopia

	Percentage of farmers who have abandoned:											
Advantage of abandoned variety	ET-13	Israel	K6295-4A	Inglizi	Bonde	Dashen	Enkoy	Laketch	Mamba	Romany	Supremo	Tikur-sinde
Yield	—	16.5	19.1	23.8	11.4	44.2	42.0	45.5	12.8	33.3	1.5	12.7
Food quality	33.3	24.2	11.8	9.5	22.9	18.6	9.8	18.8	33.3	3.0	7.7	41.8
Weed suppressant	6.6	11.0	1.5	4.8	11.4	2.3	1.8	2.7	5.1	3.0	17.3	—
No advantage	53.3	26.4	63.2	47.6	42.9	20.9	43.8	26.8	25.6	41.7	51.9	34.5
Market price	—	11.0	—	—	—	2.3	0.9	—	5.1	—	5.8	3.6
Other	6.6	11.0	4.4	14.3	11.4	11.6	1.8	6.3	17.9	16.7	5.8	7.3
Number of farmers	**15**	**91**	**68**	**21**	**35**	**43**	**112**	**112**	**39**	**24**	**52**	**55**

The area sown to different varieties has varied not just over the years but also across geographical areas (Table 12). Batu and HAR-416 are almost exclusively produced in Tiyo/Etheya, perhaps because of the influence of ESE farms. Pavon-76, which is spreading rapidly in other woredas, is scarcely grown in Lemu-na-Bilbilo, where older varieties such as Israel and Enkoy still cover a substantial area. This shows how the remoteness of Lemu-na-Bilbilo causes adoption of improved varieties to lag behind that of the other woredas. In addition, this woreda lies mostly above 2,600 masl, and the adaptation zone for most varieties in Table 9 is around 2,600 masl. Only a few varieties, such as ET-13, Dashen, and Enkoy, are suitable for Lemu-na-Bilbilo, and Dashen is highly susceptible to stripe rust, which is more prevalent at higher elevations.

Farmers tended to reduce the area sown to a given variety more rapidly in Tiyo, Etheya, and Asasa compared to Lemu-na-Bilbilo. This is the result of the relative slowness with which information about varieties diffuses to Lemu-na-Bilbilo. The case of Dashen in particular highlights this conclusion. Area planted to Dashen expanded in Lemu-na-Bilbilo and Asasa woredas. (The area increase in Asasa may result from the fact that some farmers in this woreda cannot distinguish between Pavon-76 and Dashen.) However, the increased area sown to Dashen in Lemu-na-Bilbilo runs contrary to expectations. In the other woredas, Dashen is losing popularity because of its susceptibility to stripe rust. The incidence of stripe rust is higher in Lemu-na-Bilbilo because of its higher elevation, and during the survey, certain fields planted to Dashen in Lemu-na-Bilbilo were highly infected with stripe rust. Farmers in Lemu-na-Bilbilo rely on farmers in lower altitude areas for their information about varieties, but this is risky, because a variety that performs well at lower elevations may not do so at higher elevations.

If the seed market were perfect, every grower would have perfect information about the available varieties (i.e., their yield potential, level of disease resistance, adaptation, and other desirable traits). Moreover, the varieties required by farmers would be available in the quantity demanded. However, the seed market in the study area is distorted by supply constraints and lack of information. In any given year, farmers are expected to decide which variety to grow based on expected yield and other desirable characteristics. The relative weights attached to these characteristics in the decision process

Table 12. Area (timmad) under various varieties by woreda and year

	Tiyo				Etheya				Lemu-na-Bilbilo				Asasa				Total			
Varieties	**1992**	**1993**	**1994**	**1995**	**1992**	**1993**	**1994**	**1995**	**1992**	**1993**	**1994**	**1995**	**1992**	**1993**	**1994**	**1995**	**1992**	**1993**	**1994**	**1995**
Dashen	14.5	11.0	19.5	19.0	113.9	107.4	110.0	82.5	0.0	27.0	47.0	117.0	33.0	45.5	191.0	351.0	161.4	190.9	367.5	569.5
Batu	0.0	0.0	0.0	0.0	28.0	40.5	56.8	82.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	28.0	40.5	58.8	82.0
Pavon-76	11.5	3.1	35.0	50.0	13.0	29.0	54.5	62.0	0.0	0.0	0.0	3.0	5.0	15.0	109.0	257.5	27.5	75.0	198.5	372.5
ET-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	8.5	22.0	22.0	36.0	1.0	22.0	22.0	37.0	9.5
K6295-4A	5.0	6.5	3.0	0.0	0.0	2.0	0.0	0.0	7.0	11.0	12.0	6.6	55.5	75v	107.0	79.0	67.5	94.5	122.0	105.6
Enkoy	34.0	2.7	2.7	19.0	5.0	5.0	1.0	0.0	97.5	82.5	74.5	64.8	22.8	329.0	114.0	28.5	364.5	443.5	216.5	112.2
Israel	4.0	0.0	0.0	1.5	0.0	0.0	0.0	1.0	4.5	1.5	8.0	3.5	15.0	0.0	4.0	0.0	23.5	1.5	12.0	6.0
HAR-710	-	-	-	0.0	-	-	-	2.0	-	-	-	0.0	-	-	-	4.0	-	-	-	6.0
HAR-416	-	0.0	0.0	0.0	-	21.0	14.0	11.0	-	-	0.0	0.0	-	0.0	0.0	1.0	-	21.0	14.0	12.0
Tikur-sinde	0.0	-	0.0	0.0	0.0	-	0.0	0.0	1.0	-	0.8	0.5	0.0	-	0.0	2.0	1.0	-	0.8	2.5
K6290-Bulk	-	0.0	0.0	0.0	-	0.0	0.0	0.0	-	0.0	0.0	0.0	-	4.0	6.0	2.0	-	4.0	6.0	2.0
Total	**69.0**	**75.5**	**84.5**	**89.5**	**159.9**	**204.9**	**236.3**	**240.5**	**110.0**	**122.0**	**143.3**	**223.9**	**358.5**	**490.5**	**559.0**	**726.0**	**595.4**	**892.9**	**1,033.1**	**1,279.8**

Note: One timmad = 0.25 ha.

may, however, vary among farmers. To gain some insight into this process, we asked farmers about the yields they obtained in the three years preceding the survey and in the year of the survey itself (Table 13). Mean yields of Batu, Pavon-76, and Dashen were the highest; those of Enkoy, K6295-4A, and K6290-Bulk were the lowest. Although the lowest yield was obtained from K6295-4A, which was susceptible to disease and rejected by farmers, ESE still supplied seed of this variety during 1994-95.

5.3 Farmers' Use and Knowledge of New Varieties

5.3.1 General knowledge of wheat varieties

Only 8% of the farmers interviewed correctly identified or had information about new varieties. Some farmers identified varieties that had been released more than 15 years ago and banned by breeders as "new" (Table 14). Only about 2% of farmers had actually grown one or the other of the newly released varieties HAR-710 (1.1%), HAR-1685 (0.5%), and HAR-1709 (0.5%), and this was because their farms had been used for demonstrations.

5.3.2 Adoption of new varieties

Varietal adoption and disadoption curves for Chilalo Awraja are given in Figure 4. The curves represent net cumulative adoption (number of farmers growing a variety in a given year), which is the difference between cumulative adoption and disadoption in any given year as measured by the number of farmers. The plausibility of these curves was verified by counter checking with the results of earlier studies.

As we have noted, in the 1960s, traditional landraces were widely grown, along with introductions such as Kenya-I, Yaktana-54, and Kentana-Frontana (Widerström 1968). In the 1970s, these materials were superseded by the improved varieties Laketch, Supremo, and Romany (Aregay Waktola 1980). Popular varieties during the 1980s included Enkoy, Israel, K6295-4A, and K6295-Bulk (Ayele and Lindeman 1987). By the beginning of the 1990s, Enkoy and Dashen were the major varieties (Mulugetta Mekuria 1996). In the 1994 cropping season, the major wheat varieties grown in Chilalo were Pavon-76, Enkoy, and K6295-4A (Gavian and Gemechu Degefa 1996).

Table 13. Yields (kg/ha) of popular varieties grown from 1992 to 1995 in Chilalo Awraja, Ethiopia

Variety	1992	1993	1994	1995
Dashen	2,263	2,402	1,973	2,155
Batu	2,530	2,900	2,679	2,518
Pavon-76	2,525	2,156	2,421	3,159
HAR-416	1,800	2,505	2,590	1,583
ET-13	2,360	1,550	1,348	2,500
Tikur-sinde	1,600	ñ	2,400	–
Israel	1,590	2,600	1,320	–
Enkoy	1,698	1,558	1,611	1,338
K6295-4A	1,525	–	1,521	1,380
K6290-Bulk	–	2,600	1,200	1,200

Table 14. Varieties that farmers consider new, by woreda (%)

Varieties	Tiyo	Lemu	Asasa	Chilalo	Year released
Dashen	8.2	47.1	18.5	25.9	1984
Pavon-76	26.2	11.4	29.6	21.6	1982
HAR-710	14.8	0.0	0.0	4.9	1994
HAR-1709	1.6	0.0	0.0	0.5	1993
HAR-1685	1.6	0.0	0.0	0.5	1994
Batu	9.8	0.0	0.0	3.2	1984
HAR-416	1.6	0.0	0.0	0.5	1987
K6295-4A	0.0	14.3	3.7	6.5	1980
ET-13	0.0	8.6	1.9	3.8	1980
Enkoy	0.0	0.0	1.9	0.5	1974
K6290-Bulk	0.0	0.0	1.9	0.5	1977
Don't know the name	36.1	18.6	42.6	31.4	

To date, about 42 bread wheat varieties have been released for commercial production in the study area, but only a few have been successful. An interesting phenomenon in the study area is that when a variety is endangered by disease, farmers tend to re-adopt varieties they had discarded. For instance, now that Enkoy has become vulnerable to disease, farmers are replacing it with K6295-4A and Dashen.

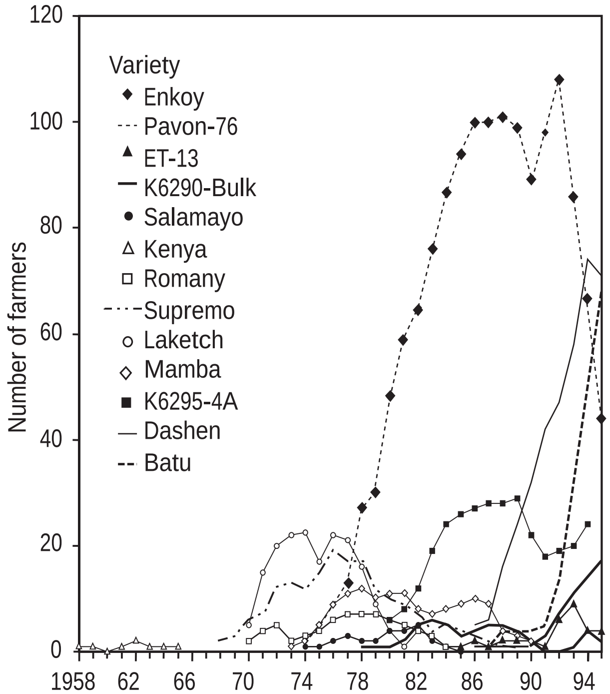

Figure 4. Adoption curves for improved wheat varieties, Chilalo Awraja, Ethiopia.

5.3.3 Farmers' sources of information and seed for new wheat varieties

Respondents' sources of information about new varieties are presented in Table 15. They include other farmers (63%), extension agents (25%), and seed dealers (8%). Normally the extension system would have been the main supplier of information about new varieties, but extension agents are occupied with input distribution and other activities aside from providing information to farmers. Twenty-one percent of the farmers who supplied information on new wheat varieties to other farmers had farm sizes greater than those of the recipient farmers.

The most important sources of seed of new varieties were not the formal sources, such as ESE or MOA (Table 16). The most important medium for diffusing seed continued to be the local market and farmer-to-farmer diffusion. One farmer had multiplied seed of HAR-710 by collecting it from a neighboring farmer's wheat field after the owner of the field had finished harvesting. This indicates farmers' level of appreciation for new seed.

Table 15. Farmers' sources of information on new wheat varieties, by woreda, Chilalo Awraja, Ethiopia

	Percentage of farmers			
Information source	**Tiyo/ Etheya**	**Lemmu-na-Bilbilo**	**Asasa**	**Chilalo**
Extension agent	23.4	30.8	17.9	24.6
Other farmers	55.3	61.5	74.4	63.0
Seed dealer	17.0	3.8	2.6	8.0
Sasakawa-Global 2000	2.1	1.9	2.6	2.2
Local traders	—	1.9	—	0.7
PA assembly	2.1	—	—	0.7
Ardaita	—	—	2.6	0.7

Farmers who obtained new seed from other farmers were asked whether they knew the original seed source. Most (63%) did not know. Twenty-three percent responded that the original source of seed had been MOA and ESE. Other sources included participation in a demonstration, distant markets, access through membership in a producers' cooperative, other farmers, and state farms. The farm size of the source farmer is not necessarily greater than that of the recipient farmer, because about 58% of recipient farmers reported having larger farms than the those of the farmers who provided the seed.

Table 16. Farmers' sources of seed of new wheat varieties they were currently growing, by woreda, Chilalo Awraja, Ethiopia

	Percentage of farmers						
	Tiyo/Etheya		Lemmu-na-Bilbilo		Asasa		
Source	Dashen	Pavon-76	Dashen	Pavon-76	Dashen	Pavon-76	HAR-710
Bought from other farmers	20.7	15.8	–	–	18.2	14.3	–
Exchanged with other farmers	6.9	18.4	–	–	–	7.1	–
Local market	44.8	34.2	90.0	50.0	36.4	42.8	–
MOA	3.4	13.2	–	50.0	9.1	14.3	–
ESE	10.3	5.3	–	–	18.2	14.3	–
Other source	10.2	13.2	10.0	–	9.1	7.1	100.0

5.3.4 Amount and price of new wheat varieties

The price of wheat seed varied depending on source of supply, location, and whether the variety was an old or new release. For instance, the price of Dashen was low near the ESE farm and higher in distant areas such as Asasa. The opposite was observed for Pavon-76. New varieties generally cost more than wheat grain (Table 17). However, prices of old varieties regarded as new in some areas (e.g., Dashen and Pavon-76) were almost half the price of the truly new releases (e.g., HAR-1709, HAR-1685, and HAR-710). In 1995/96, the price of recent HAR varieties from informal seed sources was about 32% higher than the price of these varieties from formal seed sources. Again, this price differential reflects the limited availability of improved seed in the study area.

5.3.5 Funds for purchasing new wheat seed

As Table 18 shows, farmers rely mainly on crop and livestock sales to obtain the cash to purchase new wheat seed. Credit is not an important source of funds for new seed. However, in 1995/96, MOA distributed “certified seed” on credit to a limited number of farmers for 226.5 Birr/qt, with a 25% down payment at the time of the purchase.

Table 17. Quantities and prices of purchased wheat seed of new varieties, 1995/96, Chilalo Awraja, Ethiopia

Variety	Average quantity purchased (kg)	N	Average price per qt (Birr)	N
Dashen	234	21	147.0	20
Pavon-76	150	27	148.0	26
HAR-1709	–	–	302.0*	1
HAR-1709, 1685, and 710	–	–	226.5**	–

Note: * indicates the price of new wheat seed from informal seed sources for the 1995/96 crop season; ** indicates the price of certified wheat seed from formal sources for the same cropping season.

Table 18. Farmers' sources of funding for purchased seed, Chilalo Awraja, Ethiopia

	Varieties		
Source	Dashen	Pavon-76	Mitike
Credit	2	4	–
Own cash	1	–	–
Crop sale	11	16	1
Livestock sale	9	1	–

5.4 On-farm Seed Management

5.4.1 Varietal replacement[4]

Although there are various measures of the rates at which farmers replace the varieties they grow, we have used the weighted average age (WA) because it is simple and unambiguous (Brennan and Byerlee 1991). This measure is based on the average age of varieties grown by farmers in a given year (measured in years since release), weighted by the area planted to each variety in that year. This measure, WA_t, is computed for a given year, t, as follows:

$$WA_t = \sum_i P_{it} R_{it}$$

where P_{it} is the proportion of area sown to variety i in year t, and R_{it} is the number of years (at time t) since the release of variety i.

The WA of wheat varieties in Chilalo Awraja for 1995 was 13 years. Brennan and Byerlee (1991) found that the WA of wheat varieties varied from less than four years in the Yaqui Valley in Mexico to over 10 years in the Punjab of Pakistan, with a global average of seven years. The slow varietal turnover in Chilalo Awraja reflects a poorly developed seed industry and ineffective extension services, which in turn explain why farmer-to-farmer seed exchange is the common practice in the study area and Ethiopia in general. Similar findings have been reported by Bishaw et al. (1994), who found that 21% of wheat farmers saved seed for 6-10 years and 14% saved seed for 11-15 years.

Table 19 lists problems associated with continuous use of saved seed. The major problems are reduced yield and loss of disease resistance. About 91% of farmers indicated that they replaced old varieties with new ones only if the new varieties yielded more. For this reason, genetic deterioration of saved seed, resulting in a breakdown of disease resistance and in yield losses, increases farmers' need to replace their varieties. From farmers' responses, it was estimated that the mean number of years a new variety stays in production before problems occur is about four years (standard deviation = 2.11 years).[5] Figure 5 shows the distribution of farmers' estimates of the longevity of new varieties.

Table 19. Problems associated with recycling seed, Chilalo Awraja, Ethiopia

Problem	N	Percentage of farmers
Weeds	82	45.6
Diseases	128	71.1
Yield decrease	158	87.8
Seed purity (mixture)	3	1.7
Color change	1	0.5
Drought-prone	1	0.5
Stunted growth	1	0.5
Insects	1	0.5

The longevity of wheat varieties after release depends on the variety and the environment. According to Brennan and Byerlee (1991), the optimal seed retention period depends on the yield gain of the new variety, yield losses from old varieties, and the risk involved in changing from one variety to another. The responses depicted in the uppermost tail of Figure 5 may refer to Enkoy, which has remained in production without losing its disease resistance

4 Farmers' decision to change the variety they have already adopted is termed "varietal replacement," whereas farmers' decision to obtain a fresh seed stock of a variety they already grow is called "seed renewal."

5 For purposes of comparison, in Pakistan the useful life of a wheat variety before disease resistance breaks down averages five to six years (Heisey 1990).

for almost 20 years. The lowest portion of Figure 5 represents wheat varieties that have succumbed to disease shortly after release (e.g., HAR-416).

5.4.2 Farmers' seed selection and storage

Most farmers (87%) clean or at least winnow seed at planting, and 57% store wheat seed separately from wheat used for consumption. Nineteen percent of farmers had separate fields for seed production, and about 21% threshed seed separately (Table 20). Of the farmers storing seed separately, about 53% stored it in wooden structures, whereas 40% kept it in sacks (Table 21). Of the farmers who maintained separate seed fields, 67% selected the fields before planting (Table 22). Fields were selected for seed production if farmers perceived them to be more fertile, less weedy, and better for plowing (Table 23). Farmers with special seed fields also gave more attention to managing the crop during the growing season; for example, these fields were weeded more intensively (Table 24).

5.4.3 Quality of farmers' seed

The quality of farmers' wheat seed was assessed in the field and in the laboratory. All wheat fields of the surveyed farmers were inspected for off-types and weed infestation. To determine the number of off-types, four 1 m^2 quadrants were randomly set out in each wheat field. Within each quadrant, the number of off-type and true-to-type wheat heads were counted. Weed infestation was assessed visually on a scale of 1 to 4, in which 1 denoted a very low level of infestation. The farmer's crop rotation sequences was also noted.

All of the inspected wheat fields (about 367) had a high percentage of off-types. The average percentage of off-type plants was about 3.5%, which is above the Ethiopian standard in certified

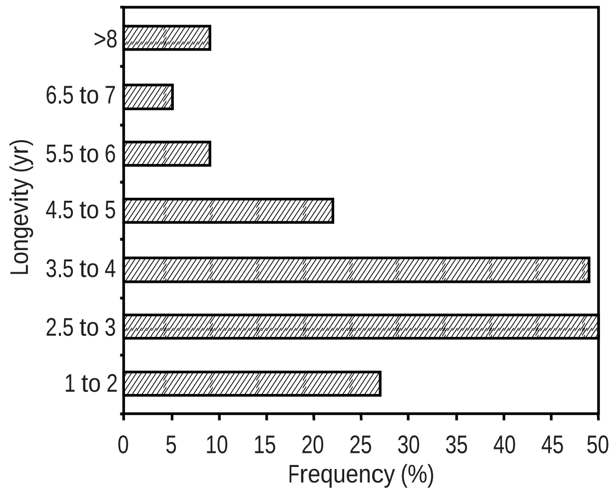

Figure 5. Frequency distribution of farmers' estimate of the longevity of wheat varieties in Chilalo Awraja, Ethiopia.

Table 20. Farmers' wheat seed management practices, Chilalo Awraja, Ethiopia

Practice	Percentage of farmers
Store seed separately	57
Own separate field for seed	19
Thresh seed separately	21
Clean seed at planting	87

Table 21. Farmers' methods of storing wheat seed, Chilalo Awraja, Ethiopia

Storage method	Percentage of farmers storing seed separately
Sack	40.2
Storage unit made of wooden material	52.9
Storage unit made of mud	16.7
Pot	1.0
Just store separately	1.0

Table 22. Time when farmer selects field for seed production, Chilalo Awraja, Ethiopia

Time	Percentage of farmers[a]
Before planting	67.0
Before the crop is ripe	11.8
At harvesting	14.7
At planting	8.8
Before plowing	2.9

[a] Of the farmers who reserved special field for seed production.

and commercial wheat seed of 0.1-0.5%. The highest percentage of off-types was observed in wheat fields planted with Israel, followed by fields planted with HAR-416, Enkoy, and Dashen. These figures roughly parallel the age of the varieties.

Farmers' source of wheat seed had a significant influence on the expected percentage of off-types in their wheat fields (Table 25). Fields sown with wheat seed obtained from ESE or AADE had the lowest percentage of off-types, whereas fields planted with the farmer's own seed or seed obtained from other farmers had the highest percentages of off-types.

After the wheat crop was harvested and stored, the surveyed farmers were visited again. From each variety and field inspected during the initial survey, a 1 kg sample was collected in exchange for 5 kg of a recently released variety with adaptation to the farmers' agroecology. The quality of the seed samples was analyzed using standard procedures developed by the International Seed Testing Association (ISTA 1976). Laboratory tests were performed for viability, seed purity, and grain size.

Except for Tikur Sinde, all varieties tested fulfilled the minimum germination requirement of 85%, which is the Ethiopian standard for certified seed. Moreover, six of the varieties met the minimum germination standard for breeders' (pre-basic) seed and basic seed of 90%, indicating the high quality of farmers' seed with respect to germination (Table 26).

Table 23. Characteristics farmers use when selecting fields for seed production, Chilalo Awraja, Ethiopia

Field characteristic	Percentage of farmers	Indication
Proper crop rotation	15.9	Fertility, weed population
Weed free	25.0	Weed population
Good plowing	9.1	Fertility, weed population
New field	27.3	Fertility
Herbicide used in previous year	2.3	Weed population
Fallow land	9.1	Fertility
Fertile land (*areda*)	6.8	Fertility
Yield obtained from field in previous year	4.5	Fertility

Table 24. Special management practices applied to fields used for seed production, Chilalo Awraja, Ethiopia

Management practice	N	Percentage of farmers[a]
Weeding	31	91.2
Rouging	16	47.1
Good tillage	6	17.6
Better fertilization	9	26.5
Herbicide application	2	5.9

[a] Of the farmers who reserved special field for seed production.

Table 25. Quality of farmers' wheat seed, by source of seed, Chilalo Awraja, Ethiopia

		Off-types		Purity	
No	Seed source	%	SD	%	SD
1	Own	3.7a	4.9	96.3	3.1
2	Other farmer	4.0a	4.8	96.4	3.5
3	ESE	1.9b	1.8	96.1	3.9
4	AADE	2.0ab	0.9	97.1	2.1
	Mean	3.5	4.6	96.3	3.3
	F prob.	P<0.05		NS	

Note: NS = not significant. Figures followed by the same letter are not significantly different at the 5% level (DMRT).

Most of the seed samples also satisfied Ethiopian purity standards for commercial seed (95% purity) and certified seed (97% purity) (Table 26). The purity of the seed samples was influenced by the crop rotation pattern (p>0.05). Seed taken from fields in which the precursor crops were faba beans, field peas, or sorghum had a purity level of more than 98%, which is the minimum purity level for breeders' and basic seed (Table 27). The relationship between seed source, weed infestation, and seed purity is depicted in Tables 25, 28, and 29. No significant relationship was found between seed source and level of purity.

As noted previously, weed infestation in wheat fields was scored and fields were divided into four groups: very low, low, high, and very high infestation. Fields with very low to low weed infestation had the highest measured seed purity levels (Table 28). Moreover, the different wheat seed sources were indirectly evaluated for their weed seed contamination level (Table 29). Fields planted with seed

Table 26. Laboratory and field assessments of seed quality of selected wheat varieties, Chilalo Awraja, Ethiopia

		Germination		Purity		Off-types		Thousand kernel weight		Test weight	
No	Variety	%	SD	%	SD	%	SD	(g)	SD	(kg/hl)	SD
1	Pavon-76	93.6	5.5	95.7	4.2	2.8a*	2.7	31.4	3.7	69.9	3.4
2	Dashen	93.0	6.7	96.4	3.1	3.9a	4.7	31.7	3.3	69.8	1.9
3	K6295-4A	91.0	6.0	97.3	2.1	2.7a	3.7	28.7	3.7	69.5	4.3
4	Enkoy	86.2	12.2	97.1	2.7	4.0a	5.3	27.9	3.5	69.9	2.5
5	Batu	94.2	3.9	96.8	2.1	2.9a	2.4	33.3	2.7	72.6	2.4
6	ET-13A2	86.9	6.4	97.3	2.5	0.9a	0.7	29.2	4.3	69.3	2.1
7	Israel	91.4	8.5	97.1	1.6	16.0b	10.9	35.5	1.8	68.1	2.7
8	HAR416	94.0	2.6	97.3	1.3	4.8a	3.4	32.4	1.7	72.1	0.8
9	HAR1709	72.9	-	96.0	-	0.0a	-	31.2	-	72.9	-
10	Tikur Sinde	81.0	12.7	94.1	4.2	1.1a	1.4	32.7	7.4	68.8	1.0
	Mean	91.4	8.2			3.5	4.5	30.9	3.9	70.0	2.9
	F prob.	<0.0001		NS		p<0.0001		P<0.0001		P<0.003	

Note: NS = not significant. Figures followed by the same letter are not significantly different at the 5% level (DMRT).

Table 27. Effect of rotation pattern on wheat seed quality parameters

		Purity		Off-types		Thousand kernel weight		Test weight	
No	Precursor crop	%	SD	%	SD	(g)	SD	(kg/hl)	SD
1	Wheat	96.1	3.4	3.6	3.8	30.8	3.7	69.8	3.1
2	Barely	96.2	3.5	3.2	4.1	30.0	3.6	69.7	2.8
3	Teff	96.6	0.9	2.9	2.2	32.1	3.1	72.6	1.1
4	Faba bean	98.1	1.0	3.6	6.2	32.2	4.9	70.5	3.0
5	Field pea	98.3	0.8	1.5	1.0	34.0	4.1	71.9	2.0
6	Maize	96.9	5.2	4.4	8.2	33.7	2.8	71.5	2.2
7	Sorghum	98.9	-	1.3	0.8	29.6	-	70.5	-
8	Potato	96.5	0.7	4.3	2.2	29.2	1.7	69.8	3.0
9	Linseed	96.5	3.3	3.7	3.6	29.5	3.2	69.1	2.2
10	Fallow	97.0	1.9	5.0	7.1	30.0	5.3	68.9	4.2
	Mean	96.5	3.3	3.5	4.6	30.8	3.9	69.9	2.9
	F prob.	NS		NS		p<0.002		p<0.05	

Note: NS = not significant.

from AADE and ESE had very low to low levels of weed infestation. However, this generalization may not be fully valid, because the level of weed infestation in a field is also influenced by farmers' weed management practices.

The highest thousand kernel weight (TKW) was recorded for Israel, followed by Batu (Table 26). Batu had the highest hectoliter test weight (HW). The rotation pattern influenced both TKW and HW. The highest mean TKW (34 g), which is above the standard, was recorded for samples taken from fields whose precursor crop was field peas, followed by maize, faba beans, and teff (Table 26). This result may be related to a fertility effect. Faba beans and field peas have the ability to fix nitrogen, while the effect of teff and maize on TKW and HW in the subsequent wheat crop may result from a residual effect of the relatively high rates of fertilizer applied to these crops and to the reduced weed population. Very high weed infestations were also associated with relatively lower TKW and HW.

5.4.4 Farmers' contact with the seed industry

It is difficult to evaluate farmers' knowledge of formal seed suppliers and their exact locations, because ESE, as the government parastatal entrusted with seed production, processing, and marketing, operates through AISCO. Nevertheless, farmers were asked about the existence of seed suppliers and their location. Fifty-eight percent of the farmers knew about seed supplying or marketing organizations. Of these farmers, about 11% correctly identified the location of the seed farm (these farmers were all located near the seed farm). Most farmers cannot differentiate between the MOA extension service, ESE, and the research center (Table 30).

Table 28. Quality of farmers' wheat seed, by weed status, Chilalo Awraja, Ethiopia

		Purity		Thousand kernel weight		Test weight	
No	Weed status	%	SD	(g)	SD	(kg/hl)	SD
1	Very low	97.0a	2.4	30.8	3.6	70.0	3.0
2	Low	96.8a	3.1	31.0	4.1	70.0	3.1
3	High	95.8ab	4.1	30.7	3.7	70.2	2.7
4	Very high	95.6b	3.5	29.6	3.8	69.5	2.8
	Mean	96.4	3.3	30.6	3.8	70.00	2.9
	F prob.	P<0.05		NS		NS	

Note: NS = not significant. Figures followed by the same letter are not significantly different at the 5% level (DMRT).

Table 29. Weed infestation in wheat, by source of seed, Chilalo Awraja, Ethiopia

	Level of weed infestation				
Seed source	Very low	Low	High	Very high	Sample size
Own seed	28.7%	31.7%	19.5%	20.1%	164
Other farmer	35.1%	28.1%	22.8%	14.0%	114
ESE	39.6%	22.9%	25.0%	12.5%	48
AADE	-	71.4%	28.6%	-	7

Table 30. Farmers' perceptions of locations of seed suppliers, Chilalo Awraja, Ethiopia

Location	N	Organization operating
Kulumsa	18	Research Center
Etheya Shaki	6	ESE
Etheya town	4	Extension office
MOA	6	Extension office
Gonde	5	ESE
Hexosa	1	Extension office
Lemu Sirba	4	Extension office
Bekoji	9	Extension office
Meraro	1	Extension office
Asasa	45	Extension office

The majority of farmers (90%) said they have problems obtaining seed of the new wheat varieties they learn about. Of these farmers, about 42% reported that seed is not available, and 35% reported that the price is too high (Table 31).

6.0 FACTORS INFLUENCING FARMERS' AWARENESS AND ADOPTION OF NEW WHEAT VARIETIES

Adoption of wheat varieties was analyzed as a two-stage process in which farmers first become aware of a new variety and then adopt it. A "new wheat variety" is a variety that was released or introduced into the study area between 1990 and 1995 (the year of the survey).

Many variables can influence farmers' awareness of new wheat varieties: human capital variables such as literacy; farm size; information sources such as agricultural extension or the research station; and distance from seed sources. The variables used in the analysis are defined in Table 32. Since these variables are unlikely to operate independently, a variable-by-variable analysis of relationships with farmers' awareness of new wheat varieties is likely to be misleading (Feder, Just, and Zilberman 1985). Hence logit analysis, which uses a number of independent variables, has been used to predict the probability of these factors in influencing farmers' varietal awareness and adoption.

Table 31. Farmers' perceptions of seed supply problems, Chilalo Awraja, Ethiopia

Problem	Number of farmers	Percentage of farmers
Seed not available	75	41.7
Price too high	63	35.0
Seed not distributed in sufficient amount	39	21.7
Seed not available on time	15	8.3
Needs new land	4	2.2
Seed distribution biased in favor of better-off farmers	3	1.7

Table 32. Variables used in logit analysis of farmers' awareness and adoption of new wheat varieties, Chilalo Awraja, Ethiopia

PROXIMIT 1	If PA or farmer is near AADE farm
PROXIMIT 2	If PA or farmer is in the vicinity of ESE farm (Gonde and Etheya)
PROXIMIT 3	If the PA or farmer is near research station
PROXIMIT 4	If PA is not near (1), (2), or (3), and the most significant source of influence is the normal extension activity of the MOA
AGE	Farmer's age (yr)
SQAGE	Quadratic specification for age
EDUCAT1	If farmer participated in basic literacy campaign or attended church school
EDUCAT2	If farmer had 1-6 years of formal education
EDUCAT3	If farmer had 7-12 years of formal education
EDUCAT4	If farmer is illiterate (reference category)
HHDAOF	Dummy variable = 1 if farmer hosted demonstration or on-farm trial, 0 otherwise
DEAVTY	Dummy variable = 1 if farmer met extension agent in year previous to survey, 0 otherwise
TAO95	Total area operated in 1995 (timmad)
DSACF	Dummy variable = 1 if farmer served as contact farmer, 0 otherwise

The variables PROXIMIT and EDUCAT are original variables with four levels each initially. The extracted indicator variables to be included in the model are 4-1 = 3 (i.e., Proximit 1 = 1 PA near to AADE, 0 otherwise; Proximit 2 = 1 PA near ESE, 0 otherwise; and PROXIMIT3 = 1 PA near research station, 0 otherwise). The reference category is a PA far from the above locations, which is coded zero in each of the three locations. EDUCAT1 = 1, basic literacy or church, 0 otherwise; EDUCAT2 = 1, 1-6 years of education, 0 otherwise; and EDUCAT3 = 1, 7-12 years of education, 0 otherwise. The reference category here is "illiterate," which is coded zero in each of the three categories.

Some explanatory variables were omitted from the model because they were highly correlated with other variables: radio ownership, participation in vocational training, membership in a producers' cooperative, and participation in field days.

- **Radio ownership:** Radio ownership was included in the study originally as a proxy for wealth, but subsequent analysis showed that this variable is highly correlated with the level of education. Farmers who own radios do not necessarily have a better resource endowment, but Chilot Yirga, Shapiro, and Demeke (1996), using ownership of a metal-roofed house and/or radio as proxy of the farmer's wealth, showed that wealth positively and significantly influenced adoption of improved wheat seed.
- **Participation in vocational training and membership in a cooperative:** Participation in vocational training is assumed to increase the likelihood that a farmer will know about new wheat varieties. Similarly, it was hypothesized that farmers who belonged to a producers' cooperative were better able to gather and synthesize information about varieties. When the Derg ruled, these farmers received preferential access to training, inputs, and other resources. These variables were omitted from the model, however, because they were jointly and significantly correlated with farm size (or area operated in 1995). Former members of producers' cooperatives had significantly larger farms than the rest of the sample, and they had received the bulk of the vocational training. Moreover, when the questionnaire was under preparation, questions about training were not worded well to include reference to time.
- **Participation in field days:** Participation in field days, particularly in the year preceding the survey, was assumed to have a positive impact on farmers' awareness of new varieties. In the analysis, this variable was highly correlated with level of education. Farmers who had participated in field days in the previous year also had more formal education, perhaps because officials at various levels usually participate in field days, and extension agents take maximum care in selecting which farmers will participate. They tend to recruit farmers who can communicate better with visitors and defend the position of the development agents. Hence, this variable was dropped from the analysis.

The variables included in the model were those with the most predictive power, in that more of the coefficients were significant with the expected signs (Table 33). Some results of the logit analysis are consistent with expectations. The age specification is significant, implying that as a farmer's age increases (up to the early sixties), so does the likelihood that the farmer will know about new wheat varieties; after the early sixties, increasing age reduces the probability that a farmer will know about new wheat varieties. The level of literacy and education, though not significant, had the expected signs. Generally, literate farmers were more likely to be aware of new wheat varieties. When the literate group was divided into three categories (Table 32) and each category was compared to illiterate farmers, it was found that the marginal contribution of education to the level of awareness increased up to the sixth grade. Thus farmers in the grade 1-6 category were more likely to be aware of new varieties compared to farmers who had been to a basic literacy program and church school. However, with respect to varietal awareness, farmers in the grade 7-12 category are not in a better position than farmers in the grade 1-6 category. Farmers who had attained grades 7-12 were military returnees and high school dropouts. They were not serious farmers; they engaged in agriculture because they lacked other employment opportunities, and they did not have as much land as other farmers.

Other important variables increasing the likelihood of farmers' varietal awareness are related to information. Two factors significantly influenced farmers' awareness of new varieties: serving as a contact farmer and receiving an extension visit in the year preceding the survey. Participation in a demonstration or on-farm research had the expected sign, although it was not significant. However, given that most farmers first learned about new varieties from other farmers, it is unlikely that extension contact caused varietal awareness; rather, farmers who actively sought agricultural information through these and other channels were more likely to know about new wheat varieties. Close scrutiny of farmers who had extension contact the preceding year revealed that those farmers were better educated. Over 90% of the farmers who had extension contact were literate. Literate farmers were active information seekers, and their level of education influenced both their awareness of new varieties and their use of other media as sources of information. The majority of those farmers who served as contact farmers could also read and write.

Table 33. Parameter estimates of a logistic model for factors affecting farmers' awareness and adoption of new wheat varieties, Chilalo Awraja, Ethiopia

	Parameter estimates for awareness		Parameter estimates for adoption	
Explanatory variable	**β**	**Wald-statistic**	**β**	**Wald-statistic**
Intercept	-3.156*	3.21	1.3182	0.31
Household head age	0.153**	4.05	-0.078	0.62
Household head age, squared	-0.0013*	3.58	0.0007	0.53
Farmer near AADE	1.8603***	14.06	2.2644**	5.46
Farmer near ESE	2.4449***	18.27	3.9564***	13.50
Farmer near research station	2.8952***	12.50	4.5828***	13.48
Literacy campaign	0.6091	1.59	0.699	1.58
Primary education	1.1924	2.11	-0.0203	0.00
Secondary education	1.1054	2.03	0.5385	0.27
Hosted demonstration plot	1.2368	1.62	-1.0603	1.74
Extension visit	1.8577**	5.87	1.4873*	3.34
Farm size	0.0096	0.23	0.0352	2.30
Contact farmer	1.6969*	3.19	1.4014	1.65
Model Chi-square	53.0***		30.7***	
Overall cases correctly predicted	76.5%		74.3%	
Sample size (N)	180		113	

Note: * indicates significance at the 10% level; ** indicates significance at the 5% level; *** indicates significance at the 1% level.

The proximity of PAs to important seed sources affected farmers' knowledge of varieties significantly. Compared with farmers from Lemu-na-Bilbilo, which is isolated from most seed sources except the normal extension activity of MOA, farmers in the vicinity of AADE farms, ESE farms, and Kulumsa Research Center are more likely to know about new wheat varieties. As expected, farmers around the research center had a higher probability of being aware of new wheat varieties than those who lived near seed farms and AADE farms. Farmers in the vicinity of seed farms had a higher likelihood of knowing about new wheat varieties than those around state farms.

Some of the variables influencing farmers' awareness of new varieties also significantly influenced the actual adoption of the varieties (Table 33). Age and its quadratic specification were not significant, indicating that even though young farmers are aware of new varieties, they may not necessarily have the financial means to adopt them. The hosting of demonstration and on-farm research activities increased the likelihood of varietal awareness but decreased the likelihood that a new variety would be adopted. This result can be explained by the nature of the new variety considered here. The major "new" variety was Pavon-76, which did not come to the area through formal extension channels. At the time of the survey, extension personnel were discouraging production of Pavon-76 in favor of new releases such as HAR-1685, HAR-1709, and HAR-604. The extension system (including Sasakawa-Global 2000) included Pavon-76 in demonstrations only very recently, considering its potential for the area. The level of literacy did not significantly influence the adoption of new varieties.

The predicted probabilities of awareness of new wheat varieties for changes in significant factors were calculated keeping other variables at their mean levels. A farmer in Lemu-na-Bilbilo had a probability of about 78% of knowing a variety and a 46% probability of adopting it. Proximity to any seed source profoundly affected the probability of awareness and adoption of the improved varieties (Table 34); thus the extension services should focus on the more remote areas. Proximity to a seed source was the major factor affecting the probability of adopting an improved variety, except in the Bekoji area in Lemu-na-Bilbilo, where extension services increased the probability of adopting an improved variety from about 46% to 79%.

Table 34. Impact of significant factors on the predicted probabilities of farmers' awareness and adoption of improved wheat, Chilalo Awraja, Ethiopia

	Change in probabilities (% for adoption of improved variety)		Change in probabilities (% for awareness of improved variety)			
	Extension services		Extension services		Contact farmer	
Factor	No	Yes	No	Yes	No	Yes
Bekoji	45.8	78.9	77.9	95.8	77.9	95.1
AADE	89.0	97.3	95.8	99.3	95.8	99.2
ESE	97.8	99.5	97.6	99.6	97.6	99.6
Kulumsa Research Center	98.8	99.7	98.5	99.8	98.5	99.7

7.0 SUMMARY AND IMPLICATIONS

The farming system in the study area — one of Ethiopia's most important wheat-producing areas — is changing from land-extensive, labor-intensive system to a land-intensive and more mechanized system (particularly for harvesting, threshing, and — to a limited extent — plowing). The size of the current land holding per household is already so small as to be uneconomic, but occasional land reallocation (the basic mechanism for acquiring cultivable land, especially for new farmers) ceased in 1991, and the desirability of future land reallocation is questionable.

Consequently, there is a concerted effort to promote land-augmenting, labor-intensive technologies such as improved varieties and fertilizer. However, disparities in the rates of adoption of improved varieties of wheat have been observed. These disparities are related to variability in biophysical conditions such as altitude, soil, and temperature, which influence the incidence and severity of diseases; to socioeconomic differences among farmers; and to difficulties with farmer support services, including the supply of improved seed.

This study, which has focused mostly on seed issues, has shown that most farmers rely on other farmers and occasionally on local markets to replace seed or obtain new seed. Farmer-to-farmer diffusion remains the most important seed diffusion mechanism. Moreover, farmers' main source of information about varieties is other farmers. The WA of more than 10 years for varieties in the study area reflects a poorly developed seed industry and ineffective extension service, and there are several ways that research, extension, and the larger seed industry structure could be changed to improve this situation.

The extension system should pay greater attention to informing farmers about the precise characteristics of their varieties and their correct adaptation zones. This will decrease the adoption lag by enabling farmers to avoid experimenting with one or more varieties.

The research system can also contribute in important ways to improving the likelihood that farmers will adopt newer releases. For example, in some areas, the research system can widen the range of varieties open to farmers. The range of bread wheat varieties recommended for high altitude (>2,600 masl) areas of Chilalo is limited compared to the materials that are available for the midaltitude areas. These production zones differ in their varietal adaptation, and thus there is a need to target future varietal development efforts differently.

In addition, it is important for the research system to conserve and promote genetic diversity for traits that are valued by farmers. Improved bread wheat varieties have largely replaced traditional landraces in farmers' fields. The genetic and phenotypic diversity of local varieties investigated in the 1960s was quite substantial, and the current trend is disturbing. If farmers grow only the "best" varieties, particularly with respect to yield potential, and if these varieties represent a narrowing of genetic diversity, farmers and the nation at large could become increasingly vulnerable to the vagaries of a disease outbreak. There is a need to diversify varieties both over time and across geographical areas.

Moreover, the research system should seek to maintain older varieties, because they possess desirable traits that may not be found in the new varieties.

Finally, the research system is confronted with the need to increase the rate at which it releases varieties, as the disease resistance of recent releases has tended to deteriorate quickly. To be successful, however, such research efforts must be supported by the greater overall development of the seed industry.

One positive step would be to review the current stringent variety release mechanism. The release committee should include not only breeders and officials from the public sector but also farmers and representatives of the private sector.

Before the economic reform of 1991, publicly owned and collective farms benefited most from the limited certified seed that was available, and they also tended to receive new seed more quickly. This preferential treatment has generally limited the impact of breeding gains for farmers and the national economy at large. Recent changes in the seed industry, such as the entry of private firms, creation of the National Seed Industry Agency, and strengthening of the national extension service, should bring about considerable positive change. These changes would be even more effective if policies and an institutional and legal framework could be developed to link the formal and informal seed sectors so that they could function in a complementary way.

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