Adoption of Improved Bread Wheat Varieties and Inorganic Fertilizer by Small-scale Farmers in Yelmana Densa and Farta Districts of **Northwestern Ethiopia**

Tesfaye Zegeye

Girma Taye

Douglas Tanner

Hugo Verkuijl

Aklilu Agidie

Wilfred Mwangi

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Aklilu Agidie

Wilfred Mwangi *

* Tesfaye Zegeye is Head, Socio-economics Department, Ethiopian Agricultural Research Organization (EARO). Girma Taye is Biometrician, EARO. Douglas Tanner is Senior Scientist and Agronomist for East Africa with the Wheat Program of the International Maize and Wheat Improvement Center (CIMMYT). When this paper was written, Hugo Verkuijl was Associate Scientist with the CIMMYT Economics Program. Aklilu Agidie is Socio-economist, Adet Research Center, Amhara Region Institute of Agricultural Research (ARIAR). Wilfred Mwangi is Principal Economist, CIMMYT Economics Program, on secondment to the Government of Kenya. The views expressed in this paper are the authors' and do not necessarily reflect policies of their respective institutions.

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Abstract: A study was initiated in Yelmana Densa and Farta Districts of northwestern Ethiopia to assess the adoption of improved wheat varieties and inorganic fertilizer, factors affecting adoption, and ways in which research, extension, and policy could improve adoption. The study relied on primary data obtained from a random sample of 200 farmers and on secondary data on agricultural production and the study area. Adoption of improved wheat varieties increased from less than 1% in 1981 to 72% in 1998 and grew rapidly after the new national extension package program commenced. Adoption of chemical fertilizer had increased in the study area from less than 1% in 1976 to 77% in 1998 and had also grown markedly since the national extension package program came into effect. Over 93% of adopters of improved wheat varieties also used chemical fertilizer on their farms. The adoption of an improved wheat variety and use of chemical fertilizer were systematically related. Results of a logistic model showed that adoption of improved wheats was positively and significantly affected by farm size, farmers' participation in on-farm demonstrations, and contacts made with extension agents, service cooperative representatives, or peasant association chairmen. Attendance at an agricultural training course, radio ownership, membership in a producer cooperative, farm size, total livestock units owned, and access to credit exerted a significant influence on the adoption of chemical fertilizer. To increase the flow of information to farmers (and the adoption of new technologies), the extension package program needs further strengthening. An efficient marketing system for inputs and outputs would benefit farmers by facilitating higher prices for marketed wheat and reducing the cost of fertilizer. The agricultural research system should put more emphasis on solving the problems of wheat producers and increase the frequency with which it releases new varieties that resist diseases and pests, yield well, and tolerate drought. To make the research effort more successful, seed of new varieties must be produced in sufficient quantities and quality for producers. To achieve this goal, the government must provide incentives and support to public and private seed companies, including infrastructure and credit. The formal credit system must address the credit constraints of small-scale farmers and increase awareness about the types of credit available for agricultural production. In addition, the government should encourage farmers to form service cooperatives or farmers' groups to reduce transaction costs and improve loan recovery rates.

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Acronyms and Abbreviations

ANRS	Amhara National Regional State
BOA	Bureau of Agriculture
BOPED	Bureau of Planning and Economic Development
CDE	Center for Development and Environment (University of Bern)
CIMMYT	International Maize and Wheat Improvement Center
CSA	Central Statistical Authority
DA	Development Agent
DAP	Diammonium phosphate
EARO	Ethiopian Agricultural Research Organization
ESE	Ethiopian Seed Enterprise
ETB	Ethiopian birr
GDP	Gross Domestic Product
IAR	Institute of Agricultural Research
masl	Meters above sea level
MEDAC	Ministry of Economic Development and Cooperation
MOA	Ministry of Agriculture
NCRS	National Crop Research Strategy
PADETES	Participatory Agricultural Demonstration and Training Extension System
PAs	Peasant Associations
SG-2000	Sasakawa-Global 2000
SPSS	Statistical Package for the Social Sciences
TLU	Tropical Livestock Unit
UNECA	United Nations Economic Commission for Africa
WRS	Wheat Research Strategy

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Executive Summary

Wheat is one of the most important cereal crops in Amhara National Regional State (ANRS) of Ethiopia, representing a source of both food and cash. The mean area (1996-99) under wheat cultivation in the region was 225,540 ha, constituting 10% of the total cereal area in the ANRS. The Ethiopian government aims to increase both the extent and intensity of wheat production by expanding the area planted to the crop and improving crop productivity. Studies to develop improved wheat varieties and cultural practices were initiated during the 1950s and 1960s by the Institute of Agriculture (IAR) (now the Ethiopian Agricultural Research Organization, EARO) and Alemaya University of Agriculture, with the assistance of international research centers and foreign donors. Since the 1950s, 48 bread and 14 durum wheat varieties have been released with their respective agronomic recommendations. Since the national extension package program was launched in 1994, significant efforts have been made to raise the adoption of production technology packages for wheat and other crops.

For new wheat technologies to be adopted, they must be appropriate to the biophysical and socioeconomic conditions of the producers. It is well known that the generation and transfer of technology is not an end in itself. The goal of increasing wheat productivity and production will be realized if and only if the ultimate users, namely the farmers, adopt the technologies developed through research. Because the reasons for low or no adoption of new agricultural technologies may be technical, socioeconomic, and/or institutional, it is relevant to determine the current rate and pattern of adoption and to identify specific factors that affect or determine adoption.

A study was initiated in two major wheat-growing districts of ANRS, Yelmana Densa and Farta, in West Gojam and South Gonder Zones. The objectives of the study were to investigate and document adoption of improved wheat varieties and inorganic fertilizer, to determine the factors affecting their adoption, and to determine ways in which research, extension, and policy could improve their adoption.

Farmers were selected in a two-stage sampling procedure. First, a random sample of peasant associations (PAs) was selected; second, a random sample of 200 farmers was drawn from the PAs using a sampling frame developed in conjunction with development centers and/or PA offices.

Data were collected from primary and secondary sources. Secondary sources included published and unpublished information about agricultural production in particular and the study area in general. Primary data on farming practices during 1998 were collected from sample farmers through a structured questionnaire during April and October of 1999 in Farta and Yelmana Densa Districts, respectively. The data were analyzed using descriptive statistical procedures and the logistic econometric model.

The mean age of household heads for adopters of improved varieties and nonadopters was 41 and 42 years, respectively. The mean farming experience of adopters was 20.7 years and that of nonadopters about 25.7. The mean household size of adopters was 5.83 persons, consisting of 30% children under 8 years, 20% children between 8 and 13 years, 26% adult males, 22% adult females, and 2% aged dependents.

The majority of the adopters of improved wheat varieties were literate: 16% attained an elementary education, 48% attended a literacy campaign, and 3% and 8% reached junior and senior high school, respectively. No systematic association was found, however, between the farmer’s level of education and adoption of improved wheat.

The mean size of land holding per household was 5.13 *eka* (one eka is equivalent to 0.25 ha), of which 75% was cultivated, 6.6% was for grazing, 1.8% was fallow, and 16% was homestead. Nonadopters possessed significantly more land than adopters in terms of total land holding and cultivated land. The area of land allocated by adopters and nonadopters for wheat production is 1.33 and 0.83 eka, respectively. In terms of area covered, tef, wheat, barley, and maize are the most important crops grown. In terms of the number of growers (i.e., the frequency of production), barley ranked first, followed by wheat, tef, and maize.

About 77.4% of adopters and 66.7% of nonadopters reported that they faced labor constraints. To overcome this problem, 47.3% and 26.4% of adopters and 25% and 12.5% of nonadopters use community and hired labor, respectively, for wheat production.

Mean animal numbers per household were 3.73 cattle, 0.94 equines (i.e., mules, horses, and donkeys), 1.97 small ruminants, and 2.01 chickens. Each household also had a mean number of 0.53 beehives. Only 15% of households owned beehives, 64% owned chickens, 18% mules, 26% horses, and 36% donkeys. On the other hand, 22.5% of households did not own oxen, 43.5% owned one ox, 32% owned two oxen, and only 2% owned 3 oxen; no household owned more than 3 oxen.

Access to information or extension messages was one of the institutional characteristics hypothesized to influence a farmer's decision to adopt a new technology. One can gain access to information about new technologies through various means, such as attending field days, visiting demonstration fields, participating in formal training, listening to agricultural programs on the radio, and communicating in various ways with neighbors, relatives, and community leaders. Of all these sources of information, the main source for wheat production technologies is the extension service of the BOA at the regional, zonal, and districts levels.

About 42.7% and 32.6% of adopters reported attending demonstrations and field days, respectively, whereas 20.1% of adopters reported attendance at a formal training course on improved wheat production. The chi-square analysis showed a systematic association for both participation in demonstrations and attendance at a formal training course with the adoption of improved wheat varieties. The types of contacts made by extension agents with farmers were identified as individual or group: 21.6% and 68.9% of adopters were visited individually and as a group, respectively, during the survey year.

About 20.6% of adopters and 6.3% of nonadopters owned a radio. No systematic association was found, however, between the adoption of improved wheat varieties and listening to agricultural programs on the radio.

Access to credit was hypothesized to be a major institutional factor influencing the farmers' adoption decisions. In the study area, 73.6% of the adopters of improved wheat varieties and 46.7% of nonadopters reported obtaining credit from the state (i.e., the Bureau of Agriculture at all levels). The chi-square analysis showed a systematic association between adoption of improved wheat varieties and access to credit, indicating that farmers with access to credit are more likely to adopt improved wheat varieties than farmers without access. The main purpose for which both categories of farmers take credit is to purchase chemical fertilizer.

About 86% of nonadopters and 63% of adopters obtained credit from other, non-State sources, primarily relatives and local moneylenders. The main purpose for obtaining credit through the informal sector is for domestic requirements (food, consumer goods, and cash expenses). It is important to note, however, that almost 67% of nonadopters partially fulfill their fertilizer requirement by borrowing from the informal sector. The most important credit problems cited in the study area were the unavailability of loans from either formal or informal sources, high interest rates, and unfavorable loan repayment terms.

The rate of adoption of improved wheat varieties increased from less than 1% in 1981 to 72% in 1998. Adoption dramatically increased over the six years since the national extension package program had commenced. The preferred improved wheat varieties were ET-13, Dashen, Enkoy, HAR-1685, and HAR-1709 (in descending order of importance). About 98% of the farmers included in the study knew about improved wheat varieties. In addition, 98% practiced crop rotation and only 17% fallowed their wheat fields, mainly due to a shortage of cultivated land. The major actors in the dissemination of information on improved wheat varieties were extension agents and neighbors. Other sources of information included relatives, researchers, traders, and producer and service cooperatives (in decreasing order of importance).

The most important initial source of seed of improved wheat varieties in the study area was the District Department of Agriculture. The reasons cited for adopting improved wheat varieties were many, but the most frequently cited reason was that improved wheat varieties yielded better with fertilizer.

Ninety percent of respondents reported using chemical fertilizer at least once during their farming experience. Chemical fertilizer had been used in the study area since 1973. The analysis indicated that the rate of adoption for chemical fertilizer increased from less than 1% in 1976 to 77% in 1998. The adoption of fertilizer had also increased markedly over the six years since the national extension package program came into effect. Prior to that program, fertilizer use was at about the 5% level.

Over 93% of adopters of improved wheat varieties also used chemical fertilizer on their farms. The major crops to which chemical fertilizer was applied for the first time were tef, wheat, and barley. During the survey year (i.e., the 1998 cropping season), nearly 70% of adopters and 27% of nonadopters of improved wheat varieties applied chemical fertilizer on wheat. The analysis of the relationship between the adoption of an improved wheat variety and use of chemical fertilizer showed that the two factors are systematically related.

The major source of chemical fertilizer reported by 40% of adopters and nonadopters was the Bureau of Agriculture at all levels. Few respondents mentioned the Amalgamated and Ambassel companies as sources of chemical fertilizer. About 87% and 63% of adopters and nonadopters reported obtaining chemical fertilizer on time. The study revealed that receiving fertilizer on time is significantly associated with the adoption of improved wheat varieties.

Each of the explanatory variables hypothesized to potentially influence adoption of improved wheat varieties was fitted into a logistic model. Farm size influenced the adoption of improved wheat varieties positively and significantly. Participation of farmers in on-farm demonstrations also positively and significantly affected the adoption pattern of respondents. Attendance at training courses, access to credit, and the farmer's educational level contributed to adoption positively, but the relationship was weak (i.e., not significant at the 10% level). Contacts made with extension agents, service cooperative (SC) representatives, or PA chairmen contributed significantly and positively to adoption. Other variables such as radio ownership contributed very little, suggesting that information about improved wheat production technologies is more effectively diffused among farmers through other methods such as extension contact and demonstration of an improved wheat variety. Number of livestock units, distance to a development center, and years of farming experience did not contribute to the adoption of improved wheat varieties.

Attendance at an agricultural training course, radio ownership, membership in a producer cooperative, farm size, total livestock units owned, and access to credit exerted a significant influence on the adoption of chemical fertilizer. The optimal logistic model developed to explain fertilizer adoption contained only participation in demonstrations and access to credit.

To increase the flow of information to farmers (and the adoption of new technologies), the extension package program (PADETES) needs further strengthening. More demonstration sites for improved technologies, including wheat varieties and fertilizer application, should be organized to increase awareness of the new technologies among farmers in the study area. The contact between extension agents and farmers must be strengthened by reducing the ratio of farmers to development agents. The extension program should enhance transport facilities for development agents to increase their capacity to travel within their mandated area. In addition, frequent training must be organized for development agents and supervisors about existing and newly developed improved agricultural technologies and practices. This training would bolster the agents' confidence and ability to transmit appropriate and useful information to farmers.

Research on bread wheat has established that the improved varieties released to date are responsive to fertilizer and that farmers obtain an economic benefit by applying fertilizer. The mean fertilizer application rate is lower than the recommended rate, however, despite the dramatic increase in fertilizer use since the PADETES extension program was implemented. As observed by the authors of this study, fertilizer application is constrained by a perceived high price of fertilizer and by farmers' lack of knowledge about how to use it. An efficient marketing system for inputs and outputs would benefit farmers by facilitating higher prices for marketed wheat and reducing the cost of fertilizer. Since the input and output markets for crops, including bread wheat, have been liberalized, there is a need to obtain updated information on the economics of using improved seed and fertilizer. The government should provide the necessary support to develop rural roads and other infrastructure such as storage facilities, which should enable inputs to be transported to farmers more efficiently and at a lower unit transport cost.

The agricultural research system should put more emphasis on solving the problems of wheat producers and increase the frequency with which it releases new varieties that resist diseases and pests, yield well, and tolerate drought. To make the research effort more successful, seed of newly developed varieties must be produced in sufficient quantities and quality for producers in the study area, the region, and the nation at large. Steps taken by the government to establish the National Seed Industry Agency and allow the private sector to participate in seed production, processing, and distribution are expected to increase the volume of seed produced. However, to achieve this goal, the government must provide incentives and support to public and private seed companies, including infrastructure and credit.

The most important credit constraints cited in the study area were the unavailability of loans from formal and informal sources, high interest rates, and unfavorable loan repayment terms. It has been noted that with rising input prices, improved access to credit for peasant farmers becomes indispensable. The formal credit system must address the credit constraints of small-scale farmers and increase awareness about the types of credit available for agricultural production. In addition, the government should encourage farmers to form service cooperatives or farmers' groups to reduce transaction costs and improve loan recovery rates.

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1. Background and Objectives of the Study

Ethiopia has a total land area of about 111.5 million hectares (ha), of which 73.6 million (66%) are estimated to be potentially suitable for agricultural production. Of the total land area suitable for agriculture, 16.5 million hectares (22%) are estimated to be under cultivation, with about 14.6 million under annual crop production and the remainder under perennial crops. Of the total area under major food crops in 1998/99, 88.7% was under cereals, 8.7% under pulses, and 2.6% under oilseeds.

The agricultural sector—the principal engine of growth of the Ethiopian economy—employs 85% of the labor force, contributes about 90% of exports and 50% of gross domestic product (GDP), and provides about 70% of the country's raw material requirement for large-and medium-scale industries (MEDAC 1999). To exploit the potential that exists in the agricultural sector, the nation has developed a strategy of "Agriculture Led Industrial Development" (ALID), which emphasizes enhanced productivity in smallholder agriculture and industrialization based on the utilization of domestic raw materials by adopting labor-intensive technologies. The agricultural component of ALID is designed to provide commodities for export, to overcome problems of domestic food sufficiency, to produce and supply adequate amounts of industrial raw materials, and to expand domestic markets for goods and services produced by local industries.

The agricultural sector is the basis of domestic food production and the major sector involved in food security. Small-scale producers operating under rainfed conditions in low-input, low-output mixed farming systems and using traditional technologies dominate the sector. Small-scale farmers account for 95% of the total area under crop cultivation and more than 96% of total agricultural output. The total number of farmers involved in small-scale agricultural production is estimated at about seven million (MEDAC 1999). The major crops grown by the small-farm sector include cereals (tef, maize, sorghum, wheat, barley, millet, and oats), pulses (faba beans, field peas, lentils, chickpeas, and haricot beans), and oil crops (flax and noug) (CSA 1999).

Ethiopia is the largest wheat producer in sub-Saharan Africa (Hailu 1991). The total area under both durum and bread wheat was about 0.987 million hectares (14.6% of total cereal area) in 1998/99 (Table 1). Statistical data and wheat literature reveal that Ethiopia produced surplus wheat and also exported wheat during the 1960s and early 1970s (EARO 2000). In terms of area and total production on a national basis, wheat ranks fifth following tef, maize, barley, and sorghum (CSA 1999).

Wheat is also one of the most important cereal crops in the Amhara National Regional State (ANRS), where it is grown as a source of food and cash. The mean area of wheat under cultivation in the region during 1996-99 was 225,540 ha, constituting 10% of the total cereal area.

The Ethiopian government aims to increase wheat production extensively by expanding cultivated area and intensively by improving the productivity of the crop. Studies to develop improved wheat varieties and cultural practices were initiated by the Institute of Agricultural Research (IAR), presently the Ethiopian Agricultural Research Organization (EARO), and the Alemaya University of Agriculture, with the assistance of international research centers and foreign donors. From the 1950s, 48 bread wheat and 14 durum wheat varieties were developed and released (Annexes 1 to 3) with their respective agronomic recommendations. Since the national extension package program was launched in 1994, significant efforts have been made to raise the level of adoption of technology packages for wheat and other crops.

For new wheat technologies to be adopted, they must be appropriate to the biophysical and socioeconomic conditions of the producers. From the relevant literature, we note that many agricultural technologies have been developed and transferred to the farming community in various

Table 1. Area, yield, and production of wheat and all cereals, Ethiopia, 1988-98

	Wheat					All cereals		
Year	Area (000 ha)	Percentage of total cereal area	Yield (qt/ha)	Production (000 qt)	Percentage of total cereal production	Area (000 ha)	Yield (qt/ha)	Production (000 qt)
1988/89	647.0	13.9	13.4	799.9	14.0	4,848.5	11.6	56,859.0
1989/90	605.1	12.3	13.2	798.8	13.1	4,915.5	12.1	60,888.0
1990/91	506.6	11.8	14.0	7,112.4	12.8	4,295.2	13.1	55,779.0
1991/92	559.9	13.1	13.5	7,556.7	15.3	4,263.3	11.5	49,290.5
1992/93	555.5	14.0	15.4	8,577.3	16.7	3,954.1	13.1	51,487.7
1993/94	722.8	13.7	10.8	7,833.2	15.3	5,287.4	9.7	51,052.6
1994/95	801.1	12.4	9.1	7,270.6	12.4	6,448.6	9.1	58,484.9
1995/96	932.4	12.2	11.9	11,119.8	12.0	7,670.5	12.1	92,654.0
1996/97	819.0	11.0	12.7	10,424.8	11.1	7,436.8	12.6	93,591.5
1997/98	831.8	13.2	13.7	11,427.0	15.9	6,312.7	11.4	71,974.4
1998/99	987.1	14.6	11.3	11,137.8	14.5	6,744.7	11.4	76,829.9

Source: CSA (1990, 1992, 1995, 1997, 1998, 1999).
Note: One quintal (qt) = 100 kg.

regions of the world. Only a small proportion of farmers tend to adopt all components of these technology packages, however. Epoug (1996) indicated that only 10% of farmers in Africa had adopted new technologies. It is well known that the generation and transfer of technologies is not an end in itself. The goal of increasing productivity and production of wheat will be realized if and only if the ultimate users, namely farmers, adopt the technologies that are developed by research.

The reasons for low or no adoption of new agricultural technologies can be technical, socioeconomic, and/or institutional. It is therefore relevant to determine the current rate and pattern of adoption of improved bread wheat varieties and fertilizer and to identify specific factors that affect their adoption. This information should suggest interventions that may help improve the efficiency of agricultural research and extension.

The International Maize and Wheat Improvement Center (CIMMYT) pointed out that adoption studies can provide research and extension staff, rural development institutions, and policymakers with valuable information to improve the efficiency of communication among them (CIMMYT 1993). Such studies can also play an important role in demonstrating the impact of research and extension and in justifying continued support from funding sources. Additionally, adoption studies can contribute to improving the efficiency of agricultural research, technology transfer, input provision, and agricultural policy formulation.

With this background and rationale, the Socio-economics Division of Adet Research Center, in collaboration with the Department of Socio-economics Research of EARO and the CIMMYT office in Ethiopia, initiated a wheat adoption study in ANRS. The study was undertaken in West Gojam and South Gonder Zones, specifically in Yelmana Densa and Farta Districts where the rate and pattern of wheat technology adoption had not previously been investigated.

This report is organized in ten sections. In this first section, we provide the background, outline the rationale and objectives of the study, and also describe very briefly the status of wheat production and its importance in the national economy. Section two provides background information about the study area. Section three provides details on wheat technology generation and transfer. Section four elaborates the methodology used to execute the field study and analyze the data. Sections five to nine present the findings of the study. Section ten discusses the conclusions and recommendations arising from the study.

The overall objectives of the study in Yelmana Densa and Farta Districts were to investigate and document adoption of improved wheat varieties and inorganic fertilizer, determine which factors affected adoption, and develop recommendations for research, extension, and policy to improve adoption in the future. Specific objectives of the study were to:

- Investigate the rate and pattern of adoption of improved wheat varieties and fertilizer (both use and application rates);
- Examine the characteristics of technology-adopting and nonadopting farmers;
- Identify the socioeconomic and institutional factors that affect the adoption of improved wheat technologies; and
- Draw implications of the findings for research, extension, and policy.

2. The Study Area

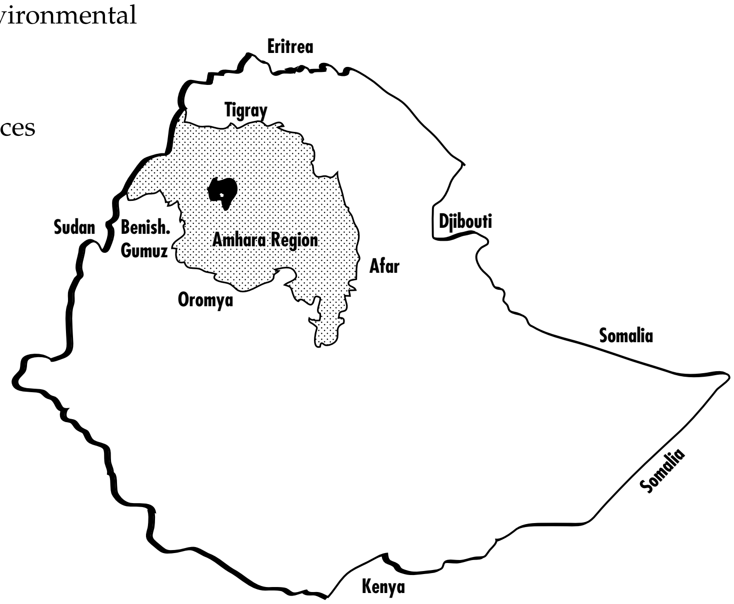
2.1 Amhara National Regional State

Amhara National Regional State (ANRS) is one of the constituent states of the Federal Democratic Republic of Ethiopia. The ANRS is located in the northwestern part of the country (Map 1) between 8°45′ and 13°45′ North latitude and 35°46′ and 40°25′ East longitude. The boundaries of the ANRS adjoin Tigray in the north, Oromia in the south, Afar in the east, Benishangul Gumuz in the southwest, and Sudan in the northwest. The state is divided into 11 administrative zones, including the capital city of the region, Bahir Dar. The other 10 administrative zones are East Gojam, West Gojam, Awi, North Gonder, South Gonder, Wag Himra, North Wollo, South Wollo, Semien Shewa, and Oromia (BOPED 1999). The region consists of 101 districts and 5,300 rural and urban associations (UNECA 1996).

The total area of the region is 170,752 km^2. Topography is divided mainly into plains, mountains, valleys, and undulating lands. The high- and mid-altitude areas (about 65% of total area) are characterized by a chain of mountains and a central plateau. The lowland part, constituting 33% of the total area, covers the western and eastern parts of the region; these are mainly plains that are large river drainage basins. Of the total area of the region, 27.3% is under cultivation, 30% is under grazing and browsing, 14.7% is covered by forest, bush, and herbs, and 18.9% is currently not used for productive purposes. The remaining 9.1% represents settlement sites, swampy areas, and lakes (UNECA 1996).

The population of the region was estimated to be 15 million in 1998/99. Of these, 90.3% live in rural areas. Mean population density is 91 persons/km^2 and ranges between 39 persons/km^2 in Wag Himra to 151 persons/km^2 in West Gojam (BOPED 1999). Persons below 25 years of age form more than 65% of the population. A large proportion of the population in ANRS depends upon crop and livestock farming. Cropping systems are predominantly rainfed. Because of population pressure and poor land husbandry, the level of land degradation and environmental depletion is worsening over time.

The region has fertile farmland and water resources suitable for crop production and livestock husbandry. High-potential areas include the western lowlands and the densely populated, surplus-producing areas of Gojam and Gonder (UNECA 1996). Farmers produce a combination of cereals, pulses, and oilseeds. Cereals account for the largest percentage of cultivated area (84.3%) and total production (85%). As noted, this study was undertaken in Yelmana Densa District of West Gojam Zone and Farta District of South Gonder Zone.



Map 1. Amhara National Regional State, Ethiopia.
Source: MOA and CDE (1999).

2.2 The Study Districts

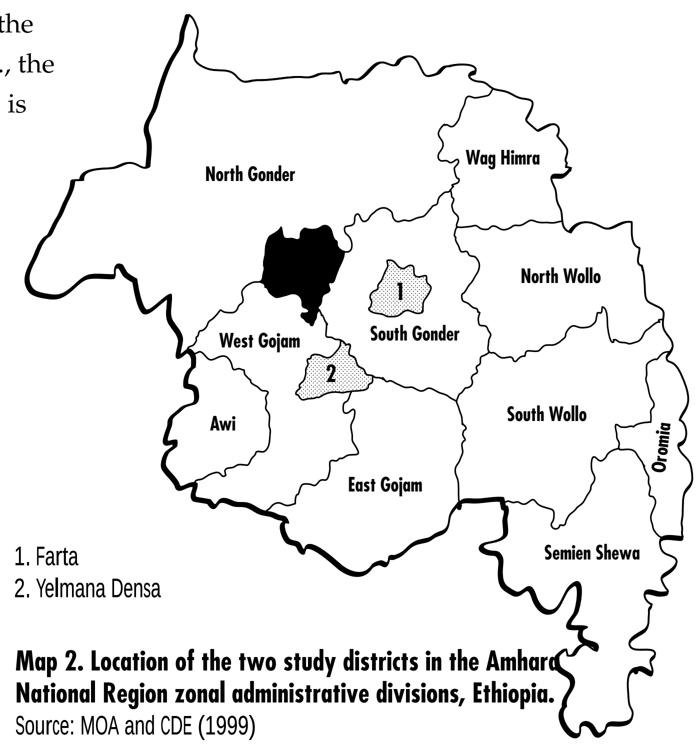
The location of Yelmana Densa District in West Gojam Zone is shown in Map 2. District boundaries are Bahir Dar in the north, East Gojam in the southeast, South Gonder in the east, Mecha in the west, Sekela in the southwest, and Kuarit in the south. According to the Department of Agriculture of Yelmana Densa District, the topography and terrain of the district consists of plateaus, hills, and flat lands. Total land area of the district is estimated to be 144,707 ha, accounting for about 10.6% of the total area of West Gojam Zone. Generally, Yelmana Densa District comprises altitudes ranging from 1,500-3,200 meters above sea level (masl). The district is classified into three traditional agroclimatic zones: *dega* (high altitude) covers 24% of the area and ranges between 2,400-3,200 masl, *woina dega* (mid-altitude) at 1,800-2,400 masl encompasses about 57% of the area, and *kolla* (lowland) at 500-1,500 masl covers 19% of the area.

Farta District contains the city of Debre Tabor; the district boundaries are Libo Kemkem and Ebinat Districts in the north, Estie to the south, Fogera and Lai Gaint in the east, and Fogera District in the west. Farta District comprises altitudes ranging between 1,500 and 4,135 masl. The study area includes medium- and high-altitude areas of Farta District, lying between 1,500 and 2,800 masl.

The mean maximum temperatures in Yelmana Densa District range from 22.1ºC in August to 28.8ºC in April. The mean minimum temperatures range from 5.2ºC in January to 11.6ºC in September. The rainfall pattern in the study area is unimodal. According to data from the Adet Research Center meteorological station, the mean annual rainfall ranged from 860 mm in 1986 to 1,771 in 1998: the long-term mean annual rainfall is about 1,291 mm. Rain usually starts in March, but the effective rainy season is from May to October with the peak in July—receiving a monthly mean of 331 mm of rainfall. The mean seasonal rainfall during the growing period (May to October) is 1,193 mm. From mid-October to January, dry weather prevails and extends to May.

The mean annual rainfall measured at the Debre Tabor meteorological station (i.e., the capital city of Farta and South Gonder) is 1,651 mm. The mean annual rainfall during the main rainy season (June to September) is 1,337 mm. These data indicate that the amount and seasonal distribution of rainfall are sufficient for crop production. Data from the meteorology station at Debre Tabor reveal that air temperatures exhibit monthly mean maxima of 18.4ºC and minima of 4.9ºC.

According to the 1994 census, the total population of Yelmana Densa District is 275,004, or 13.8% of the total population of West Gojam



Map 2. Location of the two study districts in the Amhara National Region zonal administrative divisions, Ethiopia.
Source: MOA and CDE (1999)

(Table 2). The census reported that 14,891 persons resided in urban areas and 260,113 in rural areas of the district (CSA 1994), and population is growing by 2.23% in rural areas and 4.11% in urban areas. The majority of the people of the district are from the Amhara ethnic group and the dominant religion is Ethiopian Orthodox Christian.

According to the 1994 population census, Farta District has a population of 247,101 or 12.9% of the population of South Gonder. The rural population comprises 12.7% and 98.2% of the population of the zone and of Farta District, respectively. The majority of the population of Farta District is Amhara and the dominant religion is Ethiopian Orthodox Christian.

Yelmana Densa and Farta Districts comprise mixed farming zones where crops are grown for food and cash, and animals are kept for complementary purposes and to meet farmers' cash needs. The most important crops grown in the two districts are tef, barley, maize, wheat, sorghum and millet; other pulse and oil crops are also grown (Table 3).

Table 2. Rural and urban populations of Farta and Yelmana Densa Districts and South Gonder and West Gojam Zones, Ethiopia

	West Gojam		South Gonder		Farta		Yelmana Densa	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Rural								
Male	939,513	50.3	904,849	51.1	124,391	51.3	130,568	47.5
Female	927,915	49.7	864,570	48.9	118,286	48.7	129,545	49.8
Subtotal	1,867,425	93.5	1,769,419	92.6	242,677	98.2	260,113	94.6
Urban								
Male	62,315	48.1	68,118	48.3	2,177	49.2	6,760	45.4
Female	67,240	51.9	72,911	51.7	2,247	50.8	8,131	54.6
Subtotal	129,555	6.5	141,029	7.4	4,424	1.8	14,891	5.4
Grand total	1,996,982		1,910,448		247,101		275,004	

Source: CSA (1990, 1992, 1995, 1997, 1998, 1999).

Table 3. Area and production of various crops in Yelmana Densa and Farta Districts, Ethiopia

	Yelmana Densa					Farta				
Crop	Area (ha)	Percentage of area	Production (qt)	Percent of total production	Yield (qt/ha)	Area (ha)	Percentage of area	Production (qt)	Percentage of total production	Yield (qt/ha)
Cereals	41,778	73.8	592,152	83.4	14.0	55,501	79	476,385	83	9
Tef	17,178	30.3	188,479	26.5	11.0	8,786	12	47,746	8	5
Barley	8,842	15.5	139,146	19.6	15.7	24,094	38	209,699	36	9
Wheat	4,682	8.2	74,059	10.4	15.8	17,793	25	176,619	31	10
Maize	5,478	9.7	115,177	16.2	21.0	1,364	2	16,640	3	7
Sorghum	3,796	6.7	49,059	6.9	12.9	978	1	9,257	2	12
Millet	1,802	3.1	26,232	3.7	14.5	2,486	3	16,424	3	10
Pulses	11,618	20.5	100,173	14.1	8.6	13,177	18	84,310	15	6
Oil crops	3,225	6.0	18,103	2.5	5.6	1,934	3	7,750	1	4

Source: CSA (1990, 1992, 1995, 1997, 1998, 1999).
Note: One quintal (qt) = 100 kg.

Aleligne (1988) indicated that during the 1980s wheat production was scanty in Yelmana Densa and Farta Districts and was limited to high-altitude areas. Historically, farmers in the two districts grew a small area of local wheat varieties. An informal assessment made in the two districts in 1995 revealed that improved bread wheat varieties had mostly been introduced after 1988. Before this time, durum wheat (as reported by 48% of the farmers in the survey sample) was the dominant wheat crop produced in the two districts. During the intervening 12 years, many improved bread wheat varieties have been extended in northwestern Ethiopia in general and the study area in particular. Bread wheat varieties have been demonstrated and popularized by district agricultural offices through package demonstrations on the farms of producer cooperatives, and by demonstrations on the research station and farmers' fields by Adet Research Center (Aleligne 1988; Aleligne and Regassa 1992). On-farm variety trials showed that improved bread wheat varieties could significantly increase wheat grain yields relative to farmers' varieties (Asmare et al. 1997). The following varieties were extended to farmers: Dashen, Enkoy, ET13, HAR-1685, HAR-1709, HAR-604, and HAR-710. Optimal cultural practices have been recommended, including a seed rate of 150-175 kg/ha, application of 92-46 kg/ha of N-P_2O_5, control of weeds using 2,4-D (at 1 liter of product/ha) and supplemental hand weeding depending on the locality (Asmare et al. 1995).

Currently, Yelmana Densa and Farta Districts are among the major bread wheat growing areas of ANRS. Of the total land allocated to cereals, pulses, and oil crops, wheat accounts for 8.2% in Yelmana Densa and 25% in Farta District (Table 3). Despite the importance of wheat in these districts, the degree of adoption of improved bread wheat technologies and the current production status are not well known. As indicated in the previous section, this study was initiated to investigate and assess the technical, social, and economic factors affecting the adoption of improved bread wheat varieties and inorganic fertilizer and to draw implications for research, extension, and policy.

3. Wheat Technology Generation and Dissemination

Although the Debre Zeit Agricultural Research Center, established under the then Agricultural College of Alemaya, was the pioneer institution for wheat research in Ethiopia, an effective national wheat research program was organized in the country with the establishment of the IAR in 1966. In addition to a number of research centers and subcenters of IAR and Debre Zeit, other important agricultural research and development institutions which came into being in 1967 (i.e., the National Crop Improvement Conference, and the Chilalo and Wolita Agricultural Development Units) contributed directly or indirectly to wheat research in the country. Subsequently, a wide range of wheat germplasm was introduced to the country. Research on wheat focused on screening varieties and developing optimal cultural practices for seed rate, time of planting, fertilizer type and rate, and weed control (Hailu 1991).

Starting in 1987, bread wheat research was nationally coordinated from the Kulumsa Research Center. Durum wheat research was coordinated from Debre Zeit starting from the 1950s. Wheat research was carried out by a team composed of researchers with specializations in breeding, agronomy, pathology, entomology, weed science, soil science, and agricultural economics. The major objective of the wheat research program of IAR (now EARO) has been to develop high-yielding varieties with improved and appropriate management and protection technologies for different agroecologies. During the last 50 years, several wheat varieties were developed for the agroecologies of the country (Annexes 1 to 3). Agronomic and crop protection recommendations were also developed for both large- and small-scale farms.

In ANRS, three research centers were established in different agroecologies. Adet Agricultural Research Center (ARC) was established in 1986, as a center of the former IAR, with the main objective of improving the living standards of smallholder farmers in northwestern Ethiopia through research. Since its establishment, Adet ARC has generated a number of improved agricultural technologies, including crop varieties, agronomic practices, and crop protection practices. Adet ARC has no subcenters, but it conducts multilocation trials using 10 IAR/ADD (2.5 ha) testing sites that represent administrative zones rather than agroecologies.

Wheat research started at Adet in 1986 in collaboration with the national wheat research program of IAR (EARO) and the regional office of the CIMMYT Wheat Program (based in Ethiopia). Wheat research included variety development and adaptation, pest and disease control, crop management practices, and technology transfer. To date, one improved wheat variety has been released specifically for ANRS from the breeding program based at Adet ARC. Currently farmers use a range of improved wheat varieties developed by the Kulumsa, Debre Zeit, and Holetta research centers, which historically have been responsible for the introduction and distribution of germplasm and other breeding materials for wheat variety development and release.

The use of crop inputs such as fertilizer, pesticides, and improved farm implements is essential to realize the full genetic potential of high–yielding, improved wheat varieties. A strong and efficient national, regional, and district agricultural extension service that stimulates the adoption of recommended scientific farming techniques and ideas is a prerequisite for successfully diffusing technology.

The extension strategy known as the Participatory Demonstration and Training Extension System (PADETES), which has been implemented in the study area, encourages farmers to adopt such technologies in association with the appropriate complementary production inputs. This aggressive technology transfer program is filling the major gaps that existed in various previous extension systems. The PADETES approach facilitates access to agricultural technologies developed by EARO, improves access to inputs by providing credit, and includes intensive, practical training of extension staff (to the development agent level) and farmers. Furthermore, the mobility of extension workers is improved through the provision of vehicles, motorcycles, bicycles, and pack animals to facilitate the implementation of the program. The other strength of the program is the effort made to build stronger linkages between research, extension, and input distributors—a key issue for successful agricultural technology transfer. The extension program uses large demonstration plots, usually 0.25-0.50 ha, to demonstrate improved farming practices. Regular visits to demonstration plots provide ample opportunity to discuss problems encountered in the process with farmers. In this strategy, the most important recommendations for wheat production include seed of improved varieties, seedbed preparation, optimum seed rate, methods of fertilizer application, fertilizer type and rate, and use of pesticides.

The PADETES program includes farm households on the basis of accessibility, population density, and settlement pattern. At present, the Development Agent (DA) to farmer ratio is 1:800 in Farta and 1:1,078 (1999/2000) in Yelmana Densa District. The major tasks of DAs include organizing demonstration trials, assisting farmers in obtaining agricultural inputs, and channeling farmers' problems to the relevant organizations, particularly to the District Department of Agriculture. In 1999/2000, the Farta District Department of Agriculture distributed 2,553 quintals (qt) of diammonium phosphate (DAP) and 1,964 qt of urea. In Yelmana Densa, 19,019 qt of DAP and 11,418 qt of urea were distributed in the same year. The total amount of improved seed distributed in Yelmana Densa District by the Department of Agriculture in 1998 was 697 qt. Seed of improved wheat varieties accounted for 47% of the seed distributed. In Farta, the total amount of seed distributed to farmers in 1999 was 530 qt, and seed of improved bread wheat varieties accounted for about 75% of this seed (Table 4).

Table 4. Amount of improved seed (quintals) distributed in Yelmana Densa and Farta Districts, Ethiopia, 1995-99

District and year	Maize	Tef	Wheat	Total
Yelmana Densa				
1996	9	215	283	507
1997	24	153	275	452
1998	138	231	328	697
1999	271	221	54	546
Farta				
1995	–	9	105	114
1996	–	–	1,158	1,158
1997	4	36	245	285
1998	3	—	114	117
1999	10	120	400	530

Source: Yelmana Densa and Farta District Agricultural Departments.
Note: One quintal = 100 kg.

4. Methodology

4.1 Sampling Procedure

The study was conducted during 1999 in West Gojam and South Gonder, two administrative zones of ANRS. These zones were selected on the basis of their large wheat production area, number of growers, potential for wheat production, accessibility, and representativeness of the farming system. Once the zones were selected, the same procedure and selection criteria were used to select the study districts, namely Yelmana Densa and Farta.

A two-stage sampling procedure was used to select farmers for the study. Peasant associations (PAs) were selected using a random sampling procedure. In the course of selecting sample PAs, precaution was taken not to select inaccessible and non-wheat growing PAs in either district. Following the selection of the PAs, 100 sample farmers were randomly selected in each of the two districts using a sampling frame developed in conjunction with the staff of development centers and/or PA offices.

4.2 Data Collection

Data were collected from primary and secondary sources. Secondary sources included published and unpublished information about agricultural production in particular and the study areas in general. This information was collected from regional-, zonal- and district-level offices of agriculture, planning bureaus, and knowledgeable individuals. Primary data, which pertained to the 1998 cropping season, were collected from sample farmers using a structured questionnaire administered during April 1999 in Farta and October 1999 in Yelmana Densa. Before starting the actual data collection, the questionnaire was pre-tested, enabling the modification of some of the questions which were either irrelevant to the current situation or out of context. Experienced enumerators were hired to administer the questionnaire. They were trained in the content of the questionnaire, methods of data collection, and on the appropriate way to approach farmers.

4.3 Analytical Procedure

Small-farm families are in general conservative decision-makers. As they endeavor to adjust to the prevailing physical, social, and economic environment, they test and choose carefully among alternative technologies and production strategies and then adapt them to their particular farming conditions and needs.

Following data collection, the data were coded and entered into SPSS Version 9 computer software for analysis. Analytical techniques applied included t-test, chi-square test, and correlation analysis as well as logistic regression models. Frequency and means were computed for different variables. The t-test was run to detect statistically significant differences in the continuous variables representing the characteristics of farmers who adopted improved wheat varieties versus those who had not adopted. The chi-square test was run to detect any systematic association between adoption and specific farm characteristics. Of the two related multifactorial analysis techniques (logistic and probit analysis; see Amemiya 1981; Feder et al. 1985) that are particularly useful for analyzing data generated by adoption studies, a logistic adoption model was utilized to determine the factors affecting the adoption of improved wheat varieties and chemical fertilizer.

The logistic model used in this study estimated the probability of adoption of improved bread wheat varieties by using one of two values for adoption versus nonadoption. If the response of the i^{th} farmer to the question of adoption is denoted by a random variable z_i and a corresponding probability (i.e., probability of adoption or nonadoption) by p_i such that the probability of adoption $(z_i = 1) = p_i$ and the probability of nonadoption $(z_i = 0) = 1 - p_i$, the logistic model is specified by:

$$\text{Logit}\,(p_i) = \text{Log}\,(p_i / 1 - p_i) = B_0 + B_1 X_{1i} + B_2 X_{2i} + \ldots + B_n X_{ni} = h_i,$$

so that: $P = e^{\eta i} / (1 - e^{\eta i})$,

where $^{\eta i}$ is known as the logistic transformation of p_i.

Other transformations that are commonly used are probit or inverse normal transformation and complementary log transformation (Collet 1991). In many practical situations, probit and logit transformation give very similar results, both being characterized by symmetry about $h_i = 0$. The logistic model was used in this study because it is computationally simpler to estimate and interpret, particularly for the logarithm of the odds ratio. The logit model assessment is based on a maximized log likelihood, log L (B), from which a deviance is calculated. This is useful for comparing two nested models:

$$D = 2\,[L\,(B', Z) - L0\,(B', Z)]$$

Goodness of fit of the model is assessed by residual plots, which may help to identify outliers. In a binary data set, outliers correspond to misclassification of the observed response.

A farmer's decision either to adopt or reject a new technology is influenced by the combined effect of a number of factors related to farmers' objectives and constraints (CIMMYT 1993). In this study, three aspects were considered in the analysis of factors associated with the adoption of improved bread wheat varieties and chemical fertilizer:

1. Farmers' socioeconomic circumstances (e.g., age, formal education);
2. Farmers' resource endowments (e.g., amount of family labor, farm size, and livestock ownership); and
3. Institutional support systems available to farmers (e.g., credit, extension, and availability of inputs).

A number of variables were hypothesized to influence the adoption of improved bread wheat varieties and the use of inorganic fertilizer, as explained below.

Level of education (EDUCLEVL). Level of education is assumed to increase a farmer's ability to obtain, process, and use information relevant to the adoption of improved bread wheat varieties and fertilizer. Education was therefore expected to increase the probability of adoption of improved bread wheat varieties and fertilizer.

Farming experience (FARMEXP). The previous experience of farmers can be expected to either enhance or diminish their level of confidence. It is anticipated that with more experience, farmers could become risk-averse regarding the adoption of specific wheat varieties. Thus, this variable could have either a positive or a negative effect on farmers' decisions to adopt a specific wheat variety.

Access to credit (CREDSTS). Access to credit can relax farmers' financial constraints and, in some cases, is tied to a particular technology package. In this study, access to credit was expected to increase the probability of adopting improved bread wheat varieties and fertilizer.

Extension contact (EXTCONT). Agricultural extension services provided by the Department of Agriculture at all levels of ARNS represent the major source of information for farmers. Contact with extension agents (development agents) was hypothesized to increase a farmer's likelihood of adopting improved bread wheat varieties and fertilizer.

Total livestock units (TOTALTLU). The number of livestock owned by a farmer was hypothesized to be positively related to the adoption of an improved bread wheat variety. The total livestock unit (TLU) index aggregates livestock numbers using the following weighting factors: oxen = 1; cows, heifers, and bulls = 0.8; and goats and sheep = 0.4.

Distance to nearest development center (DISTCNTR). The further an extension office is located from farmers' homes, the less likely it is that farmers will have access to information. Thus, this factor could be expected to be inversely related to the adoption of an improved wheat variety and fertilizer.

Attend field day (ATTFDAY), participate in demonstration plot (PARTDEMO), and attend formal training (ATTECRS). Farmers who have attended field days, visited demonstration plots, and participated in formal agricultural training are expected to have a positive attitude to the adoption of improved wheat varieties and fertilizer. It was hypothesized that participation in the above-mentioned activities could be expected to be an exposure variable and would be positively related to the adoption of improved wheat varieties and fertilizer.

Farm size (FARMSZ). Land shortage caused by population pressure is acute in the study areas. Increasing the production and productivity of wheat depends on increased cropping intensity by using seed of improved wheat varieties and fertilizer. Therefore, farm size was hypothesized to be inversely related to the adoption of an improved wheat variety and fertilizer.

Distance to market center (DISTRMKT). Distance to market center was hypothesized to be negatively related to the probability of adoption of improved bread wheat varieties, since households near market centers tend to have easier market access to dispose of their production.

Use of chemical fertilizer (USEFERT). Use of chemical fertilizer was hypothesized to be positively related to the probability of adoption of an improved bread wheat variety because such varieties are known to exhibit superior response to chemical fertilizer.

Ownership of radio (RADIOWN). Radio ownership and the ability to receive broadcast agricultural programs was expected to influence a farmer's awareness and hence adoption of improved bread wheat varieties and fertilizer.

Timely delivery of fertilizer (FERTIME). Timely delivery of fertilizer was expected to influence the decision to adopt improved bread wheat varieties and fertilizer.

5. Demographic, Socioeconomic, and Institutional Characteristics of Wheat Farmers in the Study Area

5.1 Demographic Characteristics

Table 5 summarizes the demographic characteristics of wheat farmers in the study area. The mean age of adopters of improved wheat varieties was 41 years. Age was one of the demographic characteristics assumed to influence the decision to adopt new technologies, but this study found no significant difference in age between farmers who had adopted improved wheat varieties and those who had not. Level of education was also assumed to influence the adoption decision, since literate farmers would have a greater ability to obtain, process, and use information about improved technologies. However, no significant difference was found in the level of education between adopters and nonadopters of improved wheat varieties. The majority of the adopters of improved wheat varieties (75%) were literate, of whom 16% had elementary education, 48% participated in a literacy campaign, and 3% and 8% reached junior and senior high school, respectively. The chi-square analysis showed no systematic association between the level of education and the adoption of improved wheat varieties, however.

The average number of years of farming experience of adopters of improved wheat varieties was 20.7, whereas that of nonadopters was about 25.7 (Table 5). The magnitude of the standard deviation (S.D.) of farm experience indicated a considerable variability (i.e., some adopters have little experience while others have many years of farming experience). In this analysis, it was hypothesized that with more farming experience, a farmer can become more or less averse to the risk implicit in adopting a new technology. The study showed no significant difference, however, in years of farming experience between adopters and nonadopters of improved wheat varieties.

Table 5. Demographic characteristics of wheat farmers in Yelmana Densa and Farta Districts, Ethiopia

	Adopters		Nonadopters		
Characteristic	Mean	S.D.	Mean	S.D.	t statistic
Age of household head	41.02	12.39	41.88	14.03	0.261 NS
Experience of farming (yr)	20.69	15.98	25.69	20.50	1.231 NS
Total number of persons living in the household	5.83	2.18	6.44	2.03	1.076 NS
Children under 8 years	1.76	1.34	1.94	1.39	0.502 NS
Children between 8-13	1.14	1.07	1.56	1.26	1.478 NS
Adult males 14-60 years	1.53	0.80	1.56	0.96	0.163 NS
Adult females 14-60 years	1.31	0.60	1.19	0.54	−0.794 NS
Dependents 61 years and above	0.13	0.38	0.25	0.15	1.210 NS
	Percentage of adopters		Percentage of nonadopters		χ^2 statistic
Level of education					
Illiterate	25.0		50.0		5.895 NS
Read and write	48.0		31.0		
Primary school	16.0		19.0		
Junior high school	3.0		–		
Senior high school	8.0		–		

Note: NS = not significant.

The average household size of adopters was 5.83 persons, consisting of 30% children less than 8 years, 20% children between 8 and 13 years, 26% adult males, 22% adult females, and 2% aged dependents. As expected, children less than 13 years of age dominate the family composition, as in other parts of the country. The number of aged dependents is unusually small compared to numbers reported in similar studies. Family size was hypothesized to influence farmers' adoption behavior, in that farmers with a large family were expected to be more likely to adopt improved wheat technologies to increase productivity. The statistical analysis showed no significant difference, however, in the family size of adopters versus nonadopters of improved wheat varieties.

5.2 Socioeconomic Characteristics

5.2.1 Farm land. Mean farm size per household was 5.13 *eka* (one eka is equivalent to 0.25 ha), of which 75% was cultivated, 6.6% was for grazing, 1.8% was fallow, and 16% was homestead. Nonadopters possessed significantly more land than adopters in terms of total farm size and cultivated land (Table 6). The area of land allocated by adopters and nonadopters for wheat production was 1.33 and 0.83 eka, respectively. Tef, wheat, barley, and maize are the most important crops grown in terms of area covered (Table 6). In terms of the number of growers (i.e., the frequency of production), barley was the first-ranked crop, followed by wheat, tef, and maize.

5.2.2 Labor. Involvement in off-farm jobs was one of the socioeconomic characteristics hypothesized to influence the decision to adopt improved wheat technologies, in that households involved in off-farm jobs may be able to afford to invest in improved technologies. However, the chi-square analysis revealed that adoption of an improved wheat variety was not systematically associated with involvement in off-farm activities (Table 7). Petty trading is the major off-farm job for adopters of improved wheat varieties and nonadopters. About 32.7% of adopters and 35.1% of nonadopters reported off-farm work during the survey year. The average annual income earned by adopters and nonadopters from off-farm activity was about Ethiopian birr (ETB) 442 and ETB 1,100, respectively (Table 7).

About 77% of adopters and 67% of nonadopters reported that they faced a labor shortage during farm operations. To overcome this problem, 47.3% and 26.4% of adopters and 25% and 12.5% of

Table 6. Size of land holding (eka) of wheat farmers in Yelmana Densa and Farta Districts, Ethiopia

	Adopters			Nonadopters			
Characteristic	No.	Mean	S.D.	No.	Mean	S.D.	t statistic
Total farm size	180	5.00	2.38	15	6.95	2.41	3.037*
Cultivated land	171	3.87	2.25	14	5.86	2.73	3.134*
Area of tef	100	2.90	1.96	14	2.96	1.15	0.901 NS
Area of barley	150	1.29	0.77	16	1.28	0.60	0.985 NS
Area of maize	90	1.63	0.95	14	1.46	0.50	0.261 NS
Area of wheat	124	1.33	0.89	3	0.83	0.29	–0.962 NS
Fallow land	8	1.91	2.98	1	0.25	_	_
Grazing land	79	0.72	0.47	7	0.61	0.28	–0.604 NS

Note: * indicates significance at the 5% level. NS = not significant. One eka = 0.25 ha.

Table 7. Socioeconomic characteristics of wheat farmers in Yelmana Densa and Farta Districts, Ethiopia

Characteristic	Adopters		Nonadopters		χ^2 statistic
	No.	Percent	No.	Percent	
Do you face labor shortage?					
Yes	120	77.4	26	66.7	1.935 NS
No	35	22.6	13	33.3	
How do you overcome labor shortage?					
Community labor	70	47.3	2	25.0	4.902 †
Hired labor	39	26.4	1	12.5	
Community and hired labor	39	26.4	5	62.5	
Do you have off-farm work?					
Yes	50	32.7	13	35.1	0.81 NS
No	103	67.3	24	64.9	
If yes, type of work:					
Trading	27	58.7	5	38.5	10.67 NS
Laborer	4	8.7	2	15.4	
Carpenter	3	6.5	1	7.7	
Civil servant	6	13.0	2	15.4	
Weaving	1	2.2	1	7.7	
Trading carpenter	1	2.2	_	_	

	Adopters			Non-adopters		
	N	Mean	S.D.	N	Mean	S.D.
Community and hired labor used for different operations (person-days)	139	24.14	24.98	7	14.00	10.63
Estimated off-farm income/yr (ETB)	51	441.96	572.97	2	1100.00	1,272.79

Note: † indicates significance at the 10% level. NS = not significant.

nonadopters used community and hired labor, respectively, for wheat production. The chi-square statistic showed a systematic association between the adoption of improved bread wheat varieties and the use of community and hired labor (Table 7). The most important community labor arrangements are locally called *Wobera/Debo* and *Wonfel*. The total community and hired labor used for different operations were estimated at 24 and 14 work-days for adopters and nonadopters of improved wheat varieties, respectively (Table 7).

5.2.3 Livestock. The mean number of animals per household was 3.73 cattle, 0.94 equines (i.e., composed of mules, horses, and donkeys), 1.97 small ruminants, and 2.01 chickens. Households also owned a mean number of 0.53 beehives. In terms of ownership, only 15% of the households had beehives (ranging in number from 1 to 20), 64% had chickens, 18% had mules, 26% had horses, and 36% had donkeys. On the other hand, 22.5% of the households did not own oxen, 43.5% owned one ox, 32% owned two oxen, while only 2% owned 3 oxen, and no household owned more than 3 oxen. The t-test revealed that there is no significant difference in the number of oxen owned by farmers who have adopted improved wheat varieties and those who have not (Table 8). Mules and horses, which are wealth indicators in some areas of Ethiopia, are relatively abundant in the study area; nonadopters apparently own fewer horses than adopters (Table 8).

The number of livestock units owned by a farmer was hypothesized to affect the adoption of improved technologies, since tropical livestock units (TLUs) represent a ready source of cash for purchasing farm

Table 8. Number of livestock owned by adopters and nonadopters in Yelmana Densa and Farta Districts, Ethiopia

	Adopters		Nonadopters		
Livestock type	Mean	S.D.	Mean	S.D.	t statistic
Cows	0.92	0.92	0.69	0.69	–1.277
Oxen	1.13	0.80	1.19	0.66	0.263
Bulls	0.43	0.64	0.31	0.60	–0.723
Heifers	0.66	0.83	0.56	0.89	–0.425
Calves	0.65	0.69	0.50	0.52	–0.823
Goats	0.28	0.88	0.31	1.01	0.143
Sheep	1.73	1.85	1.00	1.41	–1.544
Chickens	2.01	2.67	2.19	2.20	0.264
Beehives	0.57	2.12	0.006	0.25	–0.960
Mules	0.19	0.43	0.006	0.25	–1.156
Horses	0.32	0.56	0.006	0.25	–1.858†
Donkeys	0.46	0.70	0.31	0.48	–0.805

Note: † = indicates significance at the 10% level. Number of adopters = 180; number of non-adopters = 16.

inputs. However, there was no significant difference between adopters and nonadopters with regard to most livestock types (Table 8). The mean estimated number of oxen, cows, and small ruminants was the same for both adopters and nonadopters; however, adopters seem to be superior to nonadopters with respect to the number of beehives, mules, and horses owned.

5.3 Institutional Characteristics

5.3.1 Access to extension. Table 9 summarizes the institutional characteristics of wheat farmers in the study area. Access to information or extension messages was one institutional characteristic hypothesized to influence a farmer's decision to adopt a new technology. One can gain access to information about new technologies through various means, such as attending field days, visiting demonstration fields, participating in formal training, listening to agricultural programs on the radio, and through communicating with neighbors, relatives, and community leaders. Of these, the main source of information for wheat production practices is the extension service of the Bureau of Agriculture at the regional, zonal, and district levels.

Table 9. Institutional characteristics in Yelmana Densa and Farta Districts, Ethiopia

Characteristic	Percentage of adopters	Percentage of non-adopters	χ^2 statistic
Participated in demonstration of wheat varieties?			9.219 **
Yes	42.7	–	
No	57.3	100.0	
Attended a field day?			0.222 NS
Yes	32.6	26.7	
No	67.4	73.3	
Attended a formal training course in agriculture?			3.946 *
Yes	20.1	–	
No	79.9	100.0	
Visited by extension agent in 1999?			0.418 NS
Yes	41.7	50.0	
No	58.3	50.0	
Own a radio?			1.924 NS
Yes	20.6	6.3	
No	79.4	93.8	
Member of a producer co-op?			0.243 NS
Yes	17.3	12.5	
No	82.7	87.5	
Contact farmer?			1.488 NS
Yes	29.6	14.3	
No	70.4	85.7	
Member of informal organization?			0.938 NS
Yes	93.8	87.5	
No	6.2	12.5	
Office bearer?			0.283 NS
Yes	28.0	21.4	
No	72.0	78.6	
Usual types of visits made by extension agents:			4.662 †
Individual contact	21.6	–	
Group contact	68.9	–	
Both	9.5	–	

Note: † indicates significance at *P*<0.1; * indicates significance at *P*<0.05; ** indicates significance at *P*<0.01; and NS = not significant.

About 43% and 33% of adopters reported attendance at demonstrations and field days, respectively, whereas about 20% of adopters reported attendance at a formal training course on improved wheat production practices. The chi-square analysis revealed a systematic association for both participation in a demonstration and attendance at a formal training course with the adoption of an improved wheat variety (Table 9). The types of contacts made by extension agents with farmers were identified as individual, group, and both individual and group: 21.6% and 68.9% of adopters were visited individually and as part of a group, respectively, during the survey year.

About 21% of adopters and 6% of nonadopters owned a radio. However, no systematic association was found between the adoption of improved wheat varieties and the ability to listen to agricultural programs on the radio.

Distance to a development center was hypothesized to influence the adoption of improved wheat technologies. Compared to households farther away, households near a development center are considered more likely to have access to development agents, new technologies, and information. However, no significant difference was observed in the distance to a development center from the residence of adopters versus nonadopters. The average time taken to reach the nearest development center was about 30 minutes; on average, it takes a farmer about 40 minutes to reach the nearest market center. Household members travel an average of 1.9 km to the nearest development center, an average of 2.9 km to the nearest market place, and 1.72 km to a main road.

5.3.2 Credit availability. Access to credit was hypothesized as one of the major institutional factors influencing the decision of a farmer to adopt new technologies. In the study area, it was found that 73.6% of the adopters of an improved wheat variety and 46.7% of nonadopters reported obtaining credit from the state (i.e., the Bureau of Agriculture at all levels). The chi-square analysis showed a systematic association between adoption of an improved wheat variety and access to credit (Table 10), indicating that farmers with access to credit have a higher probability of adopting improved bread wheat varieties than those households with no access to credit. The main purpose for which both categories of farmers take credit is to purchase chemical fertilizer (Table 10).

About 86% of nonadopters and 63% of adopters reported obtaining credit from other (i.e., non-State) sources, primarily from relatives and local moneylenders. The main purpose for taking credit from the informal sector is for home consumption. However, it is important to note that 66.7% of adopters partially fulfill their fertilizer requirement by borrowing from the informal sector. The most important credit problems cited in the study area were the unavailability of loans from either formal or informal sources, high interest rates, and unfavorable loan repayment terms.

Table 10. Credit availability in Yelmana Densa and Farta Districts, Ethiopia

Credit characteristic	Percentage of adopters	Percentage of non-adopters	χ^2 statistic
Obtained credit from the state?			4.923*
Yes	73.6	46.7	
No	26.4	53.3	
Purpose of credit obtained from the state:			2.576 NS
To purchase fertilizer	55.0	85.7	
To purchase seed and fertilizer	37.1	14.3	
Obtained credit from others?			2.889†
Yes	63.2	85.7	
No	36.8	14.3	
Other credit sources:			22.391*
Relatives	49.2	33.3	
Local moneylenders	10.2	33.3	
Purpose of credit from other sources:			9.107 NS
For home consumption	21.4	33.3	
For purchasing fertilizer	66.7	9.5	
Problems of getting credit?			7.819**
Yes	80.0	57.5	
No	20.0	42.5	
Nature of credit problems:			9.392 NS
Bank loan not available	7.4	11.1	
Ministry of Agriculture loan not available	8.8	33.3	
Loan from informal sources not available as required	22.1	–	
Repayment terms unfavorable	22.2	14.7	
Interest rates too high	17.6	11.1	

Note: † indicates significance at $P<0.1$; * indicates significance at $P<0.05$; ** indicates significance at $P<0.01$; and NS = not significant.

6. Adoption of Improved Wheat Varieties and Chemical Fertilizer

The logistic curve, which captures the historical trend of adoption over time, was constructed using data on the proportion of farmers adopting improved wheat varieties and chemical fertilizer over a given period. The basic assumption in constructing each logistic curve is that adoption increases slowly at first and then increases rapidly to approach a maximum level (CIMMYT 1993). Mathematically, the logistic curve can be expressed by the following formula:

$$Y_t = K/(1 + e^{-a-bt})$$

where:

Y_t = the cumulative percentage of adopters by time t;
K = the upper bound of adoption (percentage);
b = a constant related to the rate of adoption; and
a = a constant term related to the time when adoption begins.

6.1 Adoption of Improved Wheat Varieties

The rate of adoption of improved wheat varieties increased from less than 1% in 1981 to 72% in 1998. The adoption rate had increased dramatically in the six years since the national extension package program was started. The preferred improved wheat varieties are ET-13, Dashen, Enkoy, HAR-1685, and HAR-1709 (in descending order of importance). About 98% of the farmers included in the study knew about improved wheat varieties. In addition, 98% practiced crop rotation, but only 17% fallowed their wheat fields, mainly due to the shortage of cultivated land. The major actors in the dissemination of information on improved wheat varieties were extension agents (54%) and neighbors (20%). Other sources of information included relatives, researchers, traders, and producer and service cooperatives (in decreasing order of importance).

The most important initial source of seed of improved wheat varieties in the study areas is the District Department of Agriculture. The reasons cited for adopting improved wheat varieties were many, but the most frequent reason was that improved wheat varieties yield better with fertilizer (81%). Nonadopters have more cultivated land than adopters (Table 6); adopters might have been induced to adopt the improved technology package to overcome their shortage of land by increasing unit productivity.

Some of the institutional arrangements seemed to facilitate the adoption of improved wheat varieties. For example, a larger proportion of adopters than nonadopters had previously belonged to producer cooperatives (17% vs. 12%), were contact farmers (28% vs. 12%), were members of other informal organizations (93% vs. 88%), had obtained credit from the State (73% vs. 44%), and had participated in demonstrations (42% vs. 1%). The major reasons cited for ceasing production of improved wheat varieties were unavailability of seed of improved wheat varieties in sufficient quantity, expense of seed of new varieties, unavailability of credit, and poor yield performance compared to local varieties.

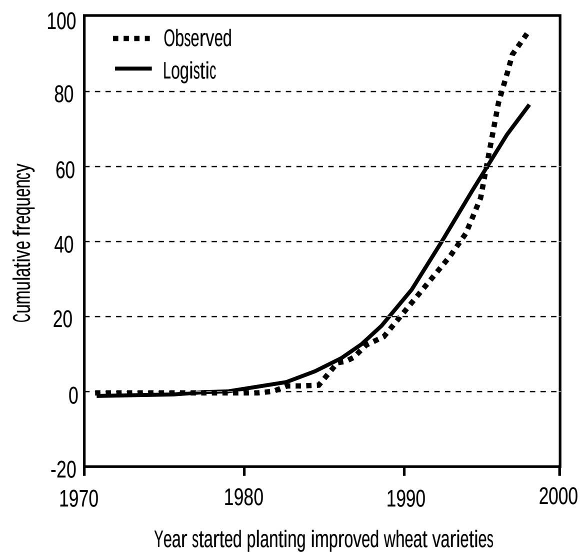


Figure 1. Adoption of improved bread wheat varieties in Yelmana Densa and Farta Districts, Ethiopia.

6.2 Adoption of Chemical Fertilizer

Ninety percent of the respondents reported using chemical fertilizer at least once during their farming experience. Use of chemical fertilizer in the study area dated to 1973. The logistic regression analysis indicated that the rate of adoption for chemical fertilizer had increased from less than 1% in 1976 to 77% in 1998. The adoption rate had increased markedly in the six years since the national extension package program was implemented.

Over 93% of adopters of improved wheat varieties also used chemical fertilizer on their farms. The major crops to which chemical fertilizer was applied for the first time were tef, wheat, and barley. During the survey year (i.e., the 1998 cropping season), 69.8% of adopters of improved wheat varieties and 27% of nonadopters applied chemical fertilizer on wheat. Diammonium phosphate (DAP) was the principal fertilizer used by both adopters and nonadopters. The analysis of the relationship between adoption of an improved wheat variety and use of chemical fertilizer showed that the two factors are systematically related ($\chi^2 = 11.485$; $P<0.01$).

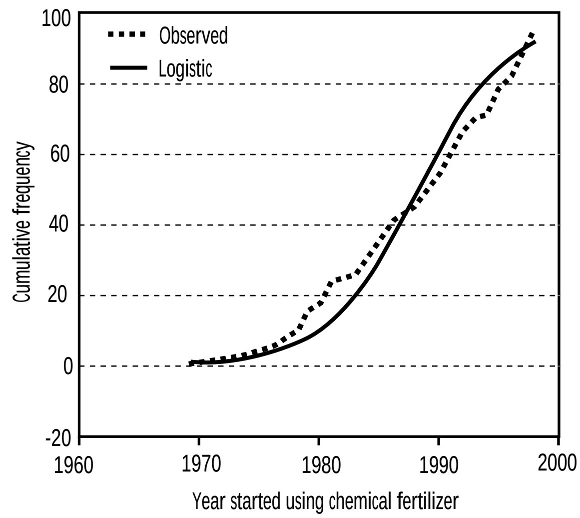


Figure 2. Adoption of chemical fertilizer in Yelmana Densa and Farta Districts, Ethiopia.

The major source of chemical fertilizer reported by 40% of both adopters and nonadopters was the Bureau of Agriculture at all levels. Only a few respondents mentioned the Amalgamated or Ambassel companies as the source of chemical fertilizer. Of those applying fertilizer, about 87% and 63% of adopters and nonadopters reported receiving chemical fertilizer on time. The study revealed that receiving fertilizer on time is significantly associated with the adoption of improved wheat varieties ($\chi^2 = 20.242$; $P<0.05$).

7. Factors Affecting Wheat Technology Adoption

7.1 Logistic Regression of Improved Bread Wheat Varieties

Each of the explanatory variables hypothesized (see section 4) to potentially influence adoption of improved wheat varieties was fitted into a logistic model (Table 11), and their individual contributions to the model were assessed on the basis of changes in deviance. Variables contributing significantly to the model were selected and the main effect and interactions were further investigated. The goodness of fit associated with adding each variable to the model was assessed by comparing the resulting change in deviance due to the addition of each variable in the model with the corresponding chi-square value. In this exercise, variables with multicollinearity were identified and dropped from the model. For example, farmer's age was found to be highly correlated with years of farming experience and was eliminated from the model.

Farm size influenced the adoption of improved bread wheat varieties positively and significantly. Although the mean farm size for adopters was less than that for nonadopters, as indicated in Table 6, there was a tendency detected in the logit analysis for the probability of adopting an improved wheat variety to increase slightly as farm size increased. Thus farmers with larger farms have a slightly higher probability of adopting an improved wheat variety. The estimation of the regression coefficient associated with farm size (Table 11) might have been influenced by the range of farm sizes: for adopters, farm size ranged from 2 to 16 eka; for nonadopters, farm size ranged from 3.5 to 11 eka. Thus in terms of the distribution of farm size, 92% of adopters had farm sizes equal to or greater than the minimum land-holding for nonadopters (i.e., 3.5 eka). The fact that the mean farm size of adopters was less than that of nonadopters (Table 6) might have been due to the 8% of adopters having less than 3 eka. Furthermore, the number of nonadopters identified in the survey was much less than the number of adopters (i.e., 15 compared to 180; see Table 6). Conversely, the logistic regression, which estimates an overall trend, might have been influenced by the 3% of adopters having a farm size greater than the maximum land-holding for nonadopters (i.e., 11 eka).

Table 11. Parameter estimates from the logit model for the adoption of improved wheat varieties

Source	Coefficient	S.E.
Intercept	-15.93	75.430
Use of chemical fertilizer	0.00396	0.039
Farm size	0.548**	0.203
Extension contact	21.68**	6.610
Participation in demonstration	5.94*	4.450
Attended agricultural training course	2.96	5.770
Access to credit	0.495	0.990
Illiterate	4.70	8.670
Elementary education	4.62	8.660
Junior high school education	0.84	22.100

Note: * indicates significance at $P<0.05$; ** indicates significance at $P<0.01$; and NS = not significant.

Participation of farmers in on-farm demonstrations also positively and significantly affected the adoption pattern of respondents, possibly because improved varieties of bread wheat would have been included in the demonstration. Attendance at training courses, access to credit, and the farmer's education level contributed positively to adoption, but the association was very weak (i.e., not significant at the 10% level). Contacts made with extension agents, service cooperative (SC) representatives, or peasant association (PA) chairmen contributed significantly and positively to adoption. Amount of DAP fertilizer used, although not significant at the 5% level, exhibited a slight association with the decision to adopt an improved bread wheat variety. By using forward stepwise regression (i.e., by successively adding variables to a model that already contained other significant variables, and by testing the resultant change in deviance with the relevant chi-square values), the final model contained participation in demonstrations, agricultural extension contact, and farm size with a deviance of 32.69 ($P < 0.01$).

Other variables such as radio ownership contributed very little to the logistic model, suggesting that information about agricultural technology is better diffused among farmers through other methods such as extension contact and demonstration of improved wheat varieties. Number of livestock units, distance to a development center, and years of farming experience, factors which were reported as significant in other studies (Chilot et al. 1996), did not contribute to the adoption of improved bread wheat varieties in the current study.

For the purpose of calculating the predicted probability of adopting improved bread wheat varieties, farm size was recorded as low and high. Using this classification, the fit of the model was improved (deviance = 40.5) as the classification gave a reasonable demarcation between poor, intermediate, and better-off farmers. Consequently, the probability of adopting improved wheat varieties was about 1 for farmers who are in contact with extension agents, whether they have a large or small farm size and whether or not they participated in demonstrations. Those farmers who are in contact with a PA chairman and those participating in demonstrations, whether poor or better off, also exhibited a higher probability of adopting an improved wheat variety. Participation in field demonstrations generally seemed to increase the probability of adoption regardless of the type of farmer considered.

7.2 Logistic Regression of Chemical Fertilizer Use

As with the logistic model for adoption of improved wheat varieties, variables related to the adoption of fertilizer that were significant at the 5% level were included in the model for fertilizer use. When these eight variables (Table 12) were simultaneously fitted, attendance at an agricultural training course, radio ownership, membership in a producer cooperative, farm size, total livestock units owned, and access to credit had significant influence on the adoption of chemical fertilizer at the 10% significance level or greater. Attendance at a training course, radio ownership, and membership in a producer cooperative were the major factors affecting fertilizer adoption in a positive manner (Table 12). However, participation in demonstrations and field days, although not significant at the 10% probability level, also appeared to contribute positively to the adoption of chemical fertilizer. Unfortunately, there may be conditions under which the adoption of an improved wheat variety and the use of chemical fertilizer did not coincide: some variables which were highly related to the adoption of improved wheat varieties did not appear to be related to the use of chemical fertilizer, and vice versa. For example, radio ownership contributed highly to fertilizer adoption but did not contribute to the adoption of improved wheat varieties.

Several combinations of variables were tested in the logit model using stepwise regression and assessing the resulting changes in deviance. Consequently, the final model selected to describe the adoption of fertilizer contained only participation in demonstrations and access to credit. The inclusion of other variables may improve the model but will not affect the level of significance. Participation in demonstrations and access to credit assumed major importance when fitted simultaneously, and the change in deviance was considerable. When fitted with the entire set of variables, however, these two factors did not contribute significantly to the model, presumably due to multicollinearity with the other variables. A model with fewer variables as components is preferred to simplify the calculation of the probability of adoption. The result showed that the probability of using chemical fertilizer for farmers who had attended demonstrations, regardless of their credit access, was the highest (0.999). For farmers who neither had access to credit nor had participated in demonstrations, the probability was 0.81, demonstrating once again the importance of the two factors in the adoption of chemical fertilizer.

Table 12. Parameter estimates from the logit model for the adoption of chemical fertilizer

Source	Coefficient	S.E.
Intercept	-77.2	5358.30
Farm size	-0.493†	0.30
Tropical livestock units owned	-1.219*	0.53
Participation in demonstration	17.08	3630.80
Attended field day	15.3	3940.70
Attended agricultural training course	16.2**	2.00
Radio ownership	17.2**	2.80
Membership in producer cooperative	14.78**	3.30
Access to credit	1.57†	0.89

Note: † indicates significance at *P*<0.1; * indicates significance at *P*<0.05; ** indicates significance at *P*<0.01; and NS = not significant.

8. Discriminate Analysis of the Adoption of Improved Wheat Varieties and Fertilizer

Discriminate analysis was performed to derive classification rules mathematically based on the categories of adopters and nonadopters and then to assign households into one of those two categories. The analysis therefore had two purposes: first, to see how adopting and nonadopting farmers could be separated based on the observed characteristics that were assumed to influence adoption; second, to classify new observations (i.e., those not included in the study) into adopter or nonadopter groups based on the criteria developed.

The theoretical basis underlying the use of discriminate classification is the formulation of decision rules that partition a given group—in this case, the farmers under study—into sub-groups. A considerable account of this work may be found in Fisher et al. (1996). In the case of a linear discriminate, the allocation rule will allocate household M to its group for which:

$$L_i\,(M) = \log q_i + \mu_i \Sigma^{-1}\,(M^{-1/2}\,\mu_i) \text{ is greatest,}$$

where:

L = discriminate function;
M = household;
q_i = prior probability;
μ_i = group mean; and
Σ^{-1} = common dispersion matrix.

This equation is, in fact, equivalent to saying that households are classified into group *i* if the posterior probability of belonging to group *i* is the greatest. In other words, the rule or the formula developed calculates the likelihood that a given farmer will be an adopter or a nonadopter.

Posterior probability is the probability of allocating a newly identified farmer into the adopter or nonadopter groups. Consequently, the posterior probability of being an adopter is more than that of being a nonadopter, probably due to the larger number of households in the adopter group. In this study, the classification rule works very well for both adopters and nonadopters, since about 83% of the households are classified correctly and the error rate is very small (Table 13). Based on these results and the fact that the households in the study were initially sampled at random, it may be inferred that newly identified farmers will have a 67% probability of being an adopter of an improved wheat variety. Parameter estimates for the discriminate function revealed that farm size (coefficient = 0.722) and participation in demonstrations (coefficient = –0.672) played a key role in distinguishing the two groups.

There is also strong evidence that the two groups are separated very well on the canonical scale. The overall variability was explained by just the first component, indicating that there is a relatively clear-cut classification between the two groups. There was also only a 5% overlapping of holdings (i.e., a few households tended to have a comparable posterior probability of being classified as an adopter or a nonadopter).

As in the case of the adoption of an improved wheat variety, the classification rule developed for adoption of fertilizer based on the observed data worked fairly well for both adopters and nonadopters, as the correct classification was about 84%. The error count rate is coincidentally small and similar to that for the adoption of wheat varieties (Table 13). The posterior probability (i.e., the probability that a randomly selected household in the study area uses chemical fertilizer) is about 71%, a slight improvement over that for the adoption of improved wheat varieties.

There is also a clear-cut separation between users and nonusers of fertilizer, as only 1% of the study farmers tended to have a comparable posterior probability of being allocated to either group. Such a clear separation was highly influenced by variables that exhibited the largest canonical coefficient, such as access to credit.

Table 13. Misclassification error rate estimates for adoption of improved wheat varieties and chemical fertilizer

	Improved wheat variety		Chemical fertilizer	
	Adopters	Nonadopters	Adopters	Nonadopters
Error count rate	0.17	0.10	0.16	0.18
Posterior probability of classification into a class	0.67	0.33	0.71	0.29

9. Multivariate Analysis of Variance (MANOVA)

The conventional approach of comparing two or more groups based on only one characteristic, say farm size alone, is known as univariate analysis of variance. Often the question of comparing groups requires a multivariate approach, however (Krzanowski 1988). In other words, the groups to be compared could normally be affected by more than one variable simultaneously. A simultaneous effect of, for example, farm size, household size, access to credit, and other variables may be reflected in the differences between adopters and nonadopters. This situation can be handled through multivariate analysis of variance.

Multivariate analysis of variance was therefore fitted to the data taking into account the continuous variables that were assumed to contribute to adoption, in order to fulfill the basic assumption of analysis of variance. The continuous variables included in the separate analyses of the adoption of improved wheat varieties and chemical fertilizer are distance from development center, distance from market center, amount of DAP, age of head of household, farm size, and TLUs owned. Consequently, all of the multivariate test statistics revealed significance, indicating considerable differences between adopters and nonadopters of improved wheat varieties. On the other hand, there was no significant difference between the chemical fertilizer users and nonusers in terms of the above-mentioned continuous variables.

10. Conclusions and Recommendations

The study revealed that the rate of adoption of improved bread wheat varieties has increased from less than 1% in 1981 to 72% in 1998. The adoption rate increased markedly over the last six years since the national extension package program commenced. About 98% of the farmers included in the study knew about improved wheat varieties. The major actors in the dissemination of information about wheat technology are extension agents and neighbors. Other sources of information included relatives, researchers, traders, producers, and service cooperatives.

As far as the adoption of chemical fertilizer is concerned, the study revealed that about 90% of the respondents had used chemical fertilizer at some point in their farming experience. The adoption rate for chemical fertilizer increased from less than 1% in 1976 to 77% in 1998. Ninety-three percent of adopters of improved bread wheat varieties used chemical fertilizer during the survey year. The source of fertilizer used by 98% of the adopters of improved bread wheat varieties and 14% of nonadopters was the Bureau of Agriculture. Few respondents mentioned the Amalgamated and Ambassel companies as sources of chemical fertilizer.

The agricultural research system should put more emphasis on solving the problems of wheat producers and increase the frequency of release of new varieties that resist diseases and pests, yield well, and tolerate drought. To make the research effort more successful, seed of newly developed varieties must be produced in sufficient quantities and quality for producers in the study area, the region, and the nation at large. The steps taken by the government to establish the National Seed Industry Agency and to allow the private sector to participate in seed production, processing, and distribution are expected to increase the volume of seed produced. To achieve this goal, the government must provide incentives and support to public and private seed companies, including infrastructure and credit.

Research on bread wheat has established that the improved varieties released to date are responsive to fertilizer and that farmers obtain an economic benefit from applying fertilizer. The mean fertilizer application rate is lower than the recommended rate, however, despite the dramatic increase in fertilizer use resulting from the implementation of the PADETES extension program. As observed by the authors of this study, fertilizer application is constrained by a perceived high price of fertilizer and by farmers' lack of knowledge about how to use it. An efficient marketing system for inputs and outputs will benefit farmers by facilitating higher prices for marketed wheat and reducing the cost of fertilizer. Since the input and output markets for crops, including bread wheat, have been liberalized, there is a need to obtain updated information on the economics of using improved seed and fertilizer. The government should provide the necessary support to develop rural roads and other infrastructure such as storage facilities, which should enable inputs to be transported to farmers more efficiently and at a lower unit transport cost.

To increase the flow of information to farmers (and the adoption of new technologies), the extension package program (PADETES) needs further strengthening. More demonstration sites for improved technologies, including wheat varieties and fertilizer application, should be organized to increase awareness of the new technologies among farmers in the study area. The contact between extension agents and farmers must be strengthened by reducing the ratio of farmers to development agents. The extension program should enhance transport facilities for development agents to increase their capacity to travel within their mandated area. In addition, frequent training must be organized for development agents and supervisors about existing and newly developed improved agricultural technologies and practices. This training would bolster the agents' confidence and ability to transmit appropriate and useful information to farmers.

The most important credit problems cited in the study area were the unavailability of loans from formal and informal sources, high interest rates, and unfavorable loan repayment terms. It has been noted that with rising input prices, improved access to credit for peasant farmers has become indispensable. The formal credit system needs to address the credit constraints faced by small-scale farmers and increase awareness about the types of credit available for agricultural production. In addition, the government should encourage farmers to form service cooperatives or farmers' groups to reduce transaction costs and improve loan recovery rates.

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Annex 1

Bread Wheat Varieties Tested and Released in Ethiopia since 1950

Decade and variety	Origin	Location where selected	Year released
1950s			
Kenya-1	Kenya	Paradiso	1953
Kenya-5	Kenya	Paradiso	1954
Kenya-6	Kenya	Paradiso	1954
1960s			
Kenya-Supremo x Yaqui 48	Mexico	Paradiso	1960
Anguilera - Kenya x Marroqui-Supremo x Yaqui-48	Mexico	Paradiso	1960
Yaktana-54	Kenya/Mexico	Debre Zeit	1967
Kentana - Frontana x Mayo-48	Kenya/Mexico	Debre Zeit	1967
Frocor x (YT x KT) sib	Kenya/Mexico	Debre Zeit	1967
Supremo - Kenya x Yaqui-48	Kenya/Mexico	Debre Zeit	1967
1970s			
Laketch	Mexico	Debre Zeit	1970
Romany	Kenya	Holetta	1970
Kanga	Kenya	Debre Zeit/Holetta	1971
Penjamo-62	Mexico	Debre Zeit/Holetta	1971
INIA-66	Mexico	Debre Zeit/Holetta	1971
Mamba	Kenya/Ethiopia	Holetta	1973
Salamayo	Colombia	Holetta	1973
Romany BC	Kenya/Mexico	Holetta	1974
Dereselign	Mexico	Debre Zeit	1974
Enkoy	Kenya/Ethiopia	Holetta/DZ	1974
Sonora-63	Mexico	Holetta	1975
CI-14393	Ecuador	Holetta	1975
K6290 Bulk	Kenya	Kulumsa	1977
K6106-8	Kenya	Debre Zeit	1977
Genet-71	Chile/Mexico	Holetta	1977
1980s			
K6295-4A	Kenya	Holetta/Kulumsa	1980
ET12.D4	Ethiopia	Holetta	1981
ET13.A2	Ethiopia	Holetta	1981
KKBB	CIMMYT	Holetta	1982
Pavon-76	CIMMYT	Werer	1982
Chenab-70	CIMMYT	Werer	1982
Blue Jay	CIMMYT	Werer	1982
K6106-9	Kenya	Holetta	1983
Batu	CIMMYT	Holetta	1984
Dashen	CIMMYT	Holetta	1984
Gara	CIMMYT	Holetta	1984
HAR-407	CIMMYT	Holetta	1987
HAR-416	CIMMYT	Holetta	1987
1990s			
Mitikie (HAR-1709)	CIMMYT	Kulumsa	1993
Kubsa (HAR-1685)	CIMMYT	Kulumsa	1994
Wabe (HAR-710)	CIMMYT	Kulumsa	1994
Galama (HAR-604)	CIMMYT	Kulumsa	1995
Magal (HAR-1595)	CIMMYT	Kulumsa	1997
Abola (HAR-1522)	CIMMYT	Kulumsa	1997
Tusie (HAR-1407)	CIMMYT	Kulumsa	1997
Katar (HAR-1899)	CIMMYT	Kulumsa	1999
Tura (HAR-1775)	CIMMYT	Kulumsa	1999
Shinna (HAR-1868)	CIMMYT	Adet	1999

Annex 2

Durum Wheat Varieties Tested and Released in Ethiopia Since 1967

Variety	Origin	Year released	Areas of adaptation
Marou	DZARC	1967	Akaki, Gimbichu, and similar areas
Arendato	DZARC	1967	Akaki, Gimbichu, and similar areas
Cocorit-71	CIMMYT	1976	Ada, Akaki, and Gimbichu areas
Gerardo	CIMMYT	1976	Akaki, Gimbichu, and Ada areas
Ld-357	USA	1979	Gimbichu and similar areas
Boohai	CIMMYT	1982	Ada, Lume, and well-drained areas
Foka	CIMMYT	1993	Ada, Akaki, Ambo, and Arsi Robe
Kilinto	DZARC	1994	Ada, Akaki, Ambo, and drought-prone areas
Bichena	DZARC	1995	Bichena and similar areas
Arsi Robe	DZARC	1996	Arsi Robe and similar areas
Sinana	DZARC	1996	Sinana and similar areas
Quami	DZARC	1994	Koka, Alem Tena, and similar areas
Asassa	DZARC	1997	For Asassa and similar areas
Ginchi	DZARC	1999	For Ginchi and similar areas

Note: DZARC = Debre Zeit Agricultural Research Center, Ethiopia.

Annex 3

Bread Wheat Varieties Presently in Use in Ethiopia

Variety	Location where selected	Year released	Maturity (days)	Altitude (m)
Dereselign	Debre Zeit	1974	144	1,650-2,200
K6290 Bulk	Kulumsa	1977	128-131	1,800-2,200
K6295-4A	Kulumsa	1980	128-131	1,900-2,400
ET-13.A2	Holetta	1981	107-149	2,200-2,700
Pavon-76	Werer	1982	120-135	750-2,200
Mitikie (HAR-1709)	Kulumsa	1993	125-135	2,000-2,600
Wabe (HAR-710)	Kulumsa	1994	120-140	<2,200
Kubsa (HAR-1685)	Kulumsa	1994	120-140	2,000-2,600
Galama (HAR-604)	Kulumsa	1995	120-155	2,200-2,800
Abola (HAR-1522)	Kulumsa	1997	128-131	2,200-2,700
Magal (HAR-1595)	Kulumsa	1997	113-124	<2,200
Tusie (HAR-1407)	Kulumsa	1997	125-130	2,200-2,500
Tura (HAR-1775)	Kulumsa	1999	120-149	2,200-2,700
Katar (HAR-1899)	Kulumsa	1999	110-134	2,000-2,400
Shinna (HAR-1868)	Adet	1999	100-120	1,800-2,500