CHAPTER 4

APPROACH AND METHODS OF THE STUDY

4.1 Introduction

As indicated in the previous chapter, this study used two approaches to analyse smallholders' decisions to adopt improved crop production technologies in Ethiopia. First, a model was developed to determine the importance of learning and other factors in the adoption process. Second, a framework for analysing intensity of adoption was developed to use panel data to capture the inter-temporal aspects of farmers' adoption decision over time through a learning process in terms of gains in profits. The technology adoption analysis undertaken in this study also examined the role of risk in adoption decisions.

The next section presents the technology adoption analytical framework. The empirical specification and estimation procedures for implementing the approach are presented in section 4.3. Data sources and methods of collection are discussed in section 4.4.

4.2 Analytical approaches to technology adoption

The importance of information gathering and learning-by-doing in the adoption of new technology has been emphasized by a number of analysts (Carletto et al, 1996; Dong and Saha, 1998). The said studies argue that producers' choices are significantly influenced by their exposure to information about new technologies. Consequently, these studies modelled adoption as a dynamic process in which the adopters update information about the new technology through a learning process. Thus, the decisions whether or not to use and intensity of adoption in conjunction with the adoption choice were modelled separately.

In the adoption process of a new technology, a learning period precedes any adoption decision. In this phase of the adoption process the level of farmers' acquired information (learning) determines whether or not to use a new technology. The level and quality of awareness and knowledge acquired are functions of information costs as well as individual characteristics of the farmer such as age and education. At the end of the learning process, the farmer decides whether or not to use, which is subject to the farmers' assessment of the benefits obtained and risks faced from using the new technology. Adoption is chosen only if the benefits from the improved technology outweigh costs. Then, the farmer decides what proportion of resources (i.e. land) to allocate to the new technology (e.g. intensity of use) based on actual benefits obtained and risk faced in the previous years.

4.2.1 Modelling learning and adoption decisions

Farmers face the choice of switching from using their old production methods, which they have worked with and known for some time to using newly introduced methods claimed to be better. Guided by their objectives of profit maximization they need to evaluate the claimed advantages of the new technology. But farmers are uncertain about the benefits of the new technology given their limited knowledge about its performance and require some learning about how best to use it to maximize its profits. The learning process phase of adoption involves forming expectations by farmers about gains (in terms of profit) from using the new technology.

The variable, Y_{ijt}, is defined to reflect farmer's adoption decision at time t, which equals 1 if the new technology is used and zero otherwise. One can write

$$
\begin{aligned}
Y_{ijt} &= 1 \qquad \text{if } E(\pi_{ijt} - \pi_{ilt}) > 0 \\
&= 0 \qquad \text{if } E(\pi_{ijt} - \pi_{ilt}) < 0
\end{aligned} \tag{1}
$$

Where Y_{ijt} represents the decision of farmer i to adopt technology j at time t; $E(\pi_{ijt} - \pi_{ilt})$ is the expected gains in profit from using the new technology in place of the old method by farmer i at period t; and π_{ijt} and π_{ilt} are, respectively, profits from the new and the old technology by farmer i at time t;

As explained earlier a learning period precedes any adoption decision and in the adoption process the level of farmers' acquired information (learning) determines whether or not to use a new technology. Following Cameron (1999), the expectation of the profitability of the new technology relative to the old technology can thus be represented as:

$$E(\pi_{ijt} - \pi_{ilt}) = f(x_{it}, K_{ijt}) \tag{2}$$

Where x_{it} is a vector of explanatory variables of farmer i at time t and K_{ijt} is the state of knowledge of farmer i about the new technology at time t. It is assumed that the stock of knowledge does not decrease over time (Cameron, 1999).

In this study, it is assumed that a farmer can better learn about the new technology by using it (learning by doing) and improves his information. When the farmer uses the new technology there is learning. If the new technology is not used then no learning has occurred in that year and the farmers' stock of knowledge remains the same.

Farmers accumulate experiences (knowledge) as they continue to learn from using the new technology. Thus, knowledge gained from previous experience in using the new technology may increase over time (Cameron, 1999). Hence, the average of all profits differentials that the farmer has experienced in previous years (i.e., the difference between the profitability of the newly introduced technology and the old technology averaged over all previous periods) in which the new technology was used indicate whether the farmer has gained knowledge or not and can be specified as:

$$K'_{ijt} = \sum_{n=1}^{t-1} L_{ijt-n}(\pi_{ijt-1} - \pi_{ilt-1}) / N_{it} \tag{3}$$

Where K'_{ijt} is the knowledge gained about the new technology from previous experiences of farmer i at time t (i.e., the weighted sum of average gain in profit from the new technology in previous years). L_{ijt-n} is control for whether there is learning or not about the new technology in previous years by farmer i at t. If the farmer used the new technology in previous years, L_{ijt-n} equals 1 and 0 otherwise. π_{ijt-1} and π_{ilt-1}, are profits from the new and the old technology by farmer i in previous years and N_{it} is the number of years farmer i had used the new technology previously. The above formulation suggests that the farmer is updating his knowledge based on new observations but still gives some weight to his observations in previous periods.

One can therefore postulates that a vector of explanatory variables including farm and household characteristics, farmer's stock of knowledge about the new technology and riskines of the new technology determine farmers' decision to adopt a new technology at any time, which can be modelled as:

$$Y_{ijt} = f(x_{it}, K_{ijt}, R_{ijt}) \tag{4}$$

Where R_{ijt} measures riskiness of technology j to farmer i at time t and other variables as defined earlier.

The above adoption model is useful for a binary outcome variable and the appropriate models are either probit or logit. When adoption decisions are monitored over time, the appropriate model needs to account for the whole period (T) since introduction of the new technology such that the variable, Y_{ijt}, reflects farmer's decision to adopt at any period and equals 1 if the new technology was used during time horizon T (whether later abandoned or not) and zero otherwise. To capture the change in adoption decision over time this study used panel data to support the Xtprobit regression modes specified as:

$$Y_{ijt} = f(x_{it}, K_{ijt}, R_{ijt} + Cr_{ijt}) \tag{5}$$

where Y_{ijt} is adoption decision of farmer i about technology j at time t, K_{ijt} and R_{ijt} are knowledge gained and risk faced by farmer i at time t; and Cr_{ijt} is availability of credit for farmer i to purchase technology j at time t.

4.2.2 Modelling intensity of adoption

A farmer who continues using the new technology this year may discontinue next year due to unavailability of complementary inputs (e.g. fertilizer in case of improved seed) but could continue again a year or two later after solving the problem. Such farmers could be wrongly defined as non-adopters if cross-sectional data were used. Thus, there is a need for monitoring the adoption process over time. In such case, the appropriate model needs to account for the whole period (T) since introduction of the new technology such that the variable, Y_{ijt}, reflects farmer's decision to adopt at any period and equals 1 if the new technology was used during time horizon T (whether later abandoned or not) and zero otherwise.

When decisions to adopt and intensity of use are made sequentially, stepwise decisions models are used. The experiences gained in previous years from using the new technology influence the intensity of use of the new technology in the following year (Ghadim and Pannell, 1999; Dong and Saha, 1998; Leathers and Smale, 1991). The intensity of use can change depending on farmers' gained experiences in the previous years. To capture the change in intensity of use of the new technology over time this study employed panel data to support the Xttobit regression model, which defines intensity of use as:

$$A_{ijt} = a(X_{it}, K'_{ijt}, R_{ijt-1}, Cr_{ijt}) \qquad (6)$$

Where A_{ijt} measures intensity of use of new technology j (amount of fertilizer or herbicide, proportion of area under the technology, etc.) at time t by farmer i; Cr_{ijt} is availability of credit for farmer i to purchase technology j at time t; and other variables as explained earlier. A farmer also learns about the rates applied in the past from his previous experience in using the new technology. The knowledge gained from previous farmer's experience in using the new technology combined with household and farm characteristics and riskiness of the new technology in previous years determine intensity of use of improved technologies over time.

4.3 Specification of the empirical models

Following the analytical representations described earlier, the empirical models employed in this study split the explanation of the observed decision to adopt and intensity of use into two components. First, experience is gained only when farmer uses the new technology over time. Second, this gained experience guided the farmer in his decisions to intensify adoption (how much land and other inputs to allocate to the new technology) in the future. This implies that the factors influencing adoption and intensity of use over time may be different and application of Xtprobit and Xttobit models, respectively, are more appropriate than the Probit and Tobit models in analysing panel data (Stata, 2001).

Although improved seed is the major component of the new technology package promoted in the study area, models of adoption of the improved variety as well as fertilizer and herbicide on the two main crops grown (*tef* and wheat) were estimated based on separate Xtprobit models, specified as:

$$Y_{ijt} = \partial_0 + \partial_1 X_{i1t} + \partial_2 X_{i2t} + \ldots + \partial_9 X_{i9t} + \partial_{10} R_{ijt-1} + \partial_{11} K'_{ijt-1}, + \mu_{ijt} ;(t=1\ldots5) \qquad (7)$$

Where Y_{ijt} is farmers' decision to adopt improved *tef* or wheat technologies at time t (equals 1 if the farmer adopted the improved *tef* or wheat technologies at least once during 1997-2001 and 0 otherwise). The j refers to the three technologies improved seed, fertilizer and herbicide. All explanatory variables as explained earlier and defined in Table 4.1.The vector of model parameters to be estimated is specified as ∂ (∂_0 to ∂_{11}) and μ_{ijt} is the error term.

For the intensity of adoption of improved *tef* and wheat technologies, separate Xttobit models were specified for each technology:

$$A_{ijt} = \beta_0 + \beta_2 X_{i1t} + \beta_2 X_{i2t} + \ldots \beta_9 X_9 + \beta_{10} K'_{ijt} + \beta_{11} R_{ijt-1} + \mu_{ijt} \qquad (8)$$

Where A_{ijt} measures intensity of adoption of technology j (share of land area planted to improved *tef* or wheat variety, amount of fertilizer and herbicide inputs used per hectare by farmer i at time t. β is the vector of model parameters to be estimated and ε_{ijt} is the error terms. All other explanatory variables as defined earlier and listed in Table 4.1.

4.3.1 Variables included in the empirical models

In order to analyze farmers' adoption decisions over time in Ethiopia, farmers' learning from own experience about the new technology was included with farm and household characteristics into the regression models.

Tef and wheat are grown in different farming systems by different farmers and hence farmers' choices for the two crops are assumed independent. Thus, separate empirical models were estimated for each crop in their major production areas. Besides, *tef* is an indigenous crop to Ethiopia while wheat is relatively new. In the major growing areas the most important questions are to grow improved or local variety, and how much resources (land, labour and purchased inputs such as improved seed, fertilizer and herbicide) to allocate to *tef* or wheat.

The knowledge gained (K'_{ijt}) was included to capture the dynamics of farmers' learning about the promoted technologies. The improved *tef* and wheat technologies were introduced as packages during the 1995-1996 in limited areas where farmers were able to have some information about these packages. These technologies were widely demonstrated to farmers in 1997 and 1998 crop seasons. Thus, sample farmers learned more about improved *tef* and wheat technologies from their own experience from 1997 onwards. Unfortunately data were not available on the stock of knowledge of farmers before 1997. However, it is possible to compute learning from own experience in using the improved *tef* or wheat packages after 1997 as specified in equation (3). This study used the lagged profit differential between the new and the old technology specified in equation (3) to measure knowledge gained (K'_{ijt}) from learning as a function of actual gains in profit from using the improved *tef* or wheat technologies for the period the farmer used these technologies in previous years. Equation (3) is repeated below to define the learning horizon (T):

$$K'_{ijt} = L_{ijt-1}(\pi_{ijt-1} - \pi_{ilt-1}) / N_{it} \qquad (3')$$

Where j refers to technologies: 1 for improved seed (V), 2 for fertilizer (F), and 3 for herbicide (H). The learning time horizon was defined over a period of 5 years (t = 1-5) denoting the beginning of promoting the new technologies in 1997 to survey time in 2001. L controls for whether there was learning (L=1 if farmer used technology) or not (L= 0 otherwise), which means that if there is no learning in previous years from the improved *tef* or wheat technologies, farmers experience will be zero for that period.

Farmers' profit for any technology j at a given time can be derived as:

$$\pi_{ijt} = P_{Q_{ijt}} Q_{ijt} - P_{I_{ijt}} I_{ijt} \qquad (9)$$

Where π_{ijt} is profit of farmer i from technology j at time t; P_{Qijt} and P_{Iijt} are prices of output (Q_{ijt}) and input (I_{ijt}), respectively, for farmer i at time t. Total profit is derived from two joint products (i.e., grain and straw). Omitting the value of straw in evaluating the new crop technology underestimates the total profit obtained from the adoption of the new crop technology (Traxler and Byerlee, 1993). Furthermore, learning from own experience (K'_{ijt}) also improves by considering the value of straw in farmers' adoption decisions. Thus, the knowledge gained in previous years in equation (3) was specified to vary with the measure of the total profit derived from the two products (grain and straw).

This is the best available proxy for learning although it has a number of limitations most important of which is the fact that it fails to take into account learning from others such as neighbours. The study collected panel data over the five years of learning (1997-2001) based on farmers' recall of the use of the improved *tef* or wheat technologies in their respective production areas.

This study measured riskines of the new and the old technologies (R_{ijt}) as the variance of farmers' yield. As it is expected that yield variations will be different in medium and high potential areas and among PAs within the same potential area and therefore, yield variances were estimated for farmers in each peasant association.

$$R_{ijt-1} = \sum (Q_{ijgt-1} - \overline{Q}_{ijgt-1})^2 / n_{gt-1} \qquad (10)$$

Where: R_{ijt-1} is the measure of riskiness of technology j for farmer i in previous year. Q_{ijgt-1} is yield of farmer i for technology j in peasant association (PA) g in previous years; $\overline{Q}_{ijgt-1}$ is mean yield for technology j in PA g in previous years; and n_{gt-1} is number of sample farmers in each PA in previous years. It is assumed that the new technology is more risky than the old technology since the farmer has no experience in using the new technology (Carleto et al., 1996).

Family members helping the farmer are male and female members above the age of 15 who help the farmer in different farm operations (land preparation, weeding, harvesting, threshing, etc.) in the production of the two crops.

Variables X_1 to X_9 measure selected farmer characteristics such as age, education, etc. and key farming attributes (farm size, credit, distance to market, roads, etc.) as described in Table 4.1.

Table 4.1 Description of variables used in the empirical adoption models

Variable	Name of variable	Unit/type	Variable description
Y_{ijt}	Adoption decision	Dummy	D = 1 if adopted; 0 otherwise
A_{ijt}	Intensity of input use	Percent kg/l	Proportion of land under improved seed, or amount of fertilizer (kg) and herbicide (l) per hectare
X_1	Farm size	ha	Farm size owned
X_2	Age	Years	Age of household head
X_3	Family labour	Number	Family members above 15 years old helping farmer
X_4	Education	Dummy	Level of education of household head:
X_5	Livestock owned	TLU[a]	Number owned by farmer
X_6	Frequency of DA[b] visit	Hours	Access to information (inputs)
X_7	Distance to Addis Ababa	Hours	From *Woreda* capital to Addis Ababa
X_8	Road condition	Dummy	1 if asphalt from *Woreda* to Addis; 0 otherwise
X_9	Credit	Kg	Amount of fertilizer obtained on credit
K'_{ijt}	Knowledge gained	Birr1/ha	Gains in knowledge about improved over traditional technology
R_{ijt-1}	Risk	index	Yield variance in PA[c]

a. TLU is tropical livestock unit
b. DA is development agent
c. PA is peasant association

4.4 Survey design and data collection

Given that the main objective of this study is to analyse the adoption of *tef* and wheat technologies by smallholders in their respective major growing areas, it was necessary to collect information on several aspects of relevance in the two production systems. Particularly it was necessary to measure the variables included in the empirical models listed and described in the preceding sections.

1 1 US $ = 8.5 Ethiopian Birr at the time of the study

The availability of farm records by smallholders could have been an ideal source of information from which the required input and output data could be obtained. Unfortunately, neither farm records nor adequate disaggregated time series data on input and output use in the systems under study exist in Ethiopia particularly those relating to smallholders. Several alternatives for obtaining information are available. The most common among those is the method of undertaking field surveys. Surveys are useful means particularly if the object to be studied includes variables that are measurable and can be aggregated (Assefa, 1995). Directly measured and quantified variables include resource use, production, costs and returns. Hence, basic information on these and other factors can be obtained through field surveys.

There are several ways of organizing field surveys depending on frequency of visits to the respondents whereby sets of questions are usually administered by an interviewer using a detailed structured questionnaire. Survey methods range from single visit to multi-visits. A single visit survey is where information is colleted in a single meeting between the enumerator and the respondent (farmer) whereas in multi-visits survey the interviewer makes more than one visit (e.g., weekly or fortnightly) to respondents. The periodic visit survey is in between the single visit and multi-visits surveys where an enumerator meets the respondents on well defined and timed rounds organized around the completion of crucial phases. The decision on which survey method to choose depends on tradeoffs between quality of data required and the cost of the information obtained. Due to limitations on the time and financial resources available for this, the single visit field survey method has been employed to generate the necessary information for the intended analyses.

Primary data collected from the farm surveys included area, both grain and straw yield of *tef* and wheat varieties, input use, prices of inputs and outputs, farmers' perception of improved technology, and distance to markets and input distribution centers. Times of initiation (year) of adoption of improved *tef* and wheat technologies, source of seed and credit, criteria for selecting the improved varieties were also recorded. The collected data also included farm and household characteristics such as farm size, family size, age, education, and experience in growing improved varieties measured in years.

In addition, secondary data were gathered to supplement the primary sources. The secondary data were collected from institutions involved in technology generation, multiplication, and transfer and promoting formal rural credit. Using short guidelines to collect secondary data, information on fertilizer procurement, supply, and marketing was collected from the Agriculture and Input Supply Enterprise (AISE), the Ministry of Agriculture (MOA), and the Ethiopian Fertilizer Agency. Information on the status of improved variety generation, production and distribution was obtained from the Ethiopian Agricultural Research Organization (EARO), the Ethiopian Seed Enterprise (ESE) and the Ethiopian Seed Industry Agency (ESIA). Data on crop area, production, yield and prices were extracted from different bulletins of the Central Statistical Authority (CSA). Information regarding prices and quantities of inputs (improved seed, fertilizer, herbicide) used and credit supplied were obtained from the Northern and Western *Shewa* Zones of the *Oromiya* Regional State of Ethiopia.

Based on the scope of the study defined above, the following sub-sections describe the study area, sampling procedures and sample size determination methods employed for collection of the required data, and types of collected data needed for the study.

4.4.1 Study area

The study was conducted in the Northern and Western *Shewa* Zones of the Oromiya Regional State of Ethiopia during the 2001 crop season. Northern and Western Shewa Zones are among the major *tef* and wheat producing areas in the country where improved t*ef* and wheat technologies have been demonstrated to farmers. The Northern *Shewa* Zone represents the medium potential producing areas while Western *Shewa* Zone represents the high potential areas based on area, production, and yield of t*ef* and wheat crops (CSA, 2001). The major crops in Northern and Western Shewa Zones include cereals, pulses and oil seeds. Cereals account for 78% and 87% of total crop production in Northern and Western Shewa Zones, respectively. *Tef* accounts for about 35% and 40% of crop area in Northern and Western Shewa Zones, respectively. Wheat, the second most important crop covers about 18% and 17% of the area in Northern and Western Shewa zones, respectively. In terms of production, *tef* contributes more than 20% and 30% where as wheat accounts for 23% and 20%, respectively, in Northern and Western Shewa Zones. Furthermore, t*ef* and wheat account for about 25% and 16% of crop area, and about 15% and 18% of crop production in Oromiya. *Tef* yields are low in the study areas. It is at most about 1000 kg/ha. However, yields in Western Shewa Zzone are higher than Northern Shewa Zone. On the other hand, wheat yields are better than *tef* yields in the study areas, and Western Shewa Zone is better than Northern Shewa zone in production. Generally, yields are low but better in Western Shewa Zone than in Northern Shewa Zone due to better utilization of inputs such as improved seed, fertilizer and herbicide (CSA, 2001). Farmers who grow both crops are not included in this study.

Fichae, the capital of Northern *Shewa* Zone is located along the *Addis Ababa- Debre Markos* road 115 km north of *Addis Ababa*. The capital of Western *Shewa* Zone, *Ambo* is situated 125 km west of *Addis Ababa* along the *Addis Ababa-Lekemit* road. There are 12 and 23 *woredas* (districts) in Northern and Western *Shewa* Zones, respectively**.**

4.4.2 Sampling procedure and sample size determination

Due to scarcity of resources (human and physical) and time required a sample was needed following the laws of the statistical theory of sampling in order to draw valid inferences from the sample and to ascertain the degree of accuracy of the results. A sample is desirable over census not only for less costs incurred but also for allowing frequent empirical investigation, possibility to minimize systematic errors through training, improved measurement and supervision, and allowing for wider scope and more specific studies. The appropriateness of a sampling method depends on how it will successfully meet the objectives of the study and follows the statistical theory of sampling. This study used multi-stage stratified sampling design in selecting farmers to be surveyed.

The first stage involved a purposeful selection of Northern and Western Shewa zones from central Ethiopian highlands based on availability of strong research and extension programs for smallholders' food grain production and presence of distinct zones (medium and high potential). The two zones are representative of most smallholders' farming conditions in central Ethiopia. The second stage involved selection of *weredas* in the two zones based on their adequate representation of distinct potential *tef* or wheat production areas across agro-climatic zones and on active operation of the National Extension

Program (NEP) in these *weredas*. The third stage involved selection of peasant associations (PAs) from each selected *weredas* while in the final stage farm households from selected PAs were chosen for the survey.

In the study area, farmers are organized into peasants associations (PAs)[2]. In this study, in order to capture the impact of *tef* or wheat technologies on food grain production in different agro-climatic conditions relatively homogenous PAs were needed to minimize heterogeneity (in terms of agroclimate). Therefore, five relatively homogenous PAs were selected from each district and 10 farm household heads in each PA were selected for each crop. Whereas selection of PAs aimed at more homogeneity within strata, the sample was designed to also represent wide heterogeneity of climates and farming conditions between PAs.

The head of the farm household who actually makes the day-to-day decisions on farm activities, technology adoption and inputs' use was used as the basic sampling unit for this study. A sampling frame was available at the PAs in each district listing members of the PA, which were used for selection of the target sample units to be surveyed for this study. The PAs include all family heads who live within the boundary of the PA and make their living from farming.

In any research work, sample size determination is necessary but it is usually a difficult exercise. Theoretically, the sample size is determined by the pre-assigned level of accuracy of the estimates of the mean of the parameters. However, this requires knowledge about the variability of a large number of parameters because all have different degrees of variability. Unfortunately, this knowledge seldom exists prior to the study. Therefore, in practice sample size is mostly determined by considering financial constraints, and availability and adequacy of other resources such as trained manpower and time (Assefa, 1995). Nevertheless, it is possible to improve this situation by stratifying the population into as many sub-population as possible based on one or more classification variables.

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[3]Following the 1975 Rural Land Reform (Nationalization), PAs were organized in the rural areas with the aim of implementing the land reform. The PAs are responsible for the management of the distribution of land. They were established on an average of 800 ha of land with 80 to 350 family heads residing in villages adjacent to one another. The PAs also serve as the lowest administrative unit of local government (Stork et al, 1991).

Taking these issues into considerations, a total of 300 farm household heads were selected from the two zones.

Either reducing the spread measure (standard deviation) or increasing sample size can increase sampling precision (Hassan, 2000). Thus, there is a trade-off between spread measure or precision level (F) measuring the gain in efficiency and the cost of increasing the sample size. An optimal sample size is determined at the point where no significant efficiency gains will be attained by using extra resources to include additional sampling units. For this study a 5% precision level was decided desirable. Using the number of oxen owned in 2000, the mean ($\ddot{X}$) and standard deviation (S) were estimated and used to determine the total sample size[3]. The numbers of *weredas* in Western *Shewa* zone are twice the numbers in Northern *Shewa* zone. Accordingly, variable sampling fractions have been applied such that the number of selected PAs and sample farmers are distributed proportionally to *woredas* between the two zones for each crop.

The multistage random sampling procedures were used to draw a sample of farmers for the study. First, *tef* or wheat producing *woredas* (districts) in each zone were identified and divided into relatively homogenous agro-ecological zones (high and medium potential) based on total area and average production. Because of limited time and resources, not all the *weredas* in each zone were covered by the survey. Instead potential *weredas* to be sampled were selected based on percent of farmers using t*ef* or wheat technologies, and accessibility (reachable by four-wheel drive vehicle). Particularly, *weredas* where t*ef* or wheat was produced as a major crop and where technologies of these crops have been demonstrated were identified in consultation with zonal extension specialists. *Weredas* that were inaccessible and where t*ef* or wheat are not grown as major crops were excluded from the lists. Using proportional sampling procedure, 6 *woredas* (2 from North and 4 from West *Shewa* Zones), each for t*ef* and wheat were selected randomly. The selected *woredas* were *Degem* and *Wore Jarso* for wheat, *Girar Jarso* and *Wore Jarso* for *tef* in Northern Shewa zone. In Western *Shewa* zone *Ada Berga, Dendi, Lemon a*nd *Wolis*o were selected as major t*ef* producing districts where as *Ambo* was substituted for *Dendi* as major wheat producer.

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3 $n = \frac{(100 * S)^2}{F * \ddot{X}}$ Where $\ddot{X}$ is sample mean and S is standard deviation (Hassan, 2000)

In the second stage, relatively accessible and representative PAs from the selected *weredas* were identified using available records from *wereda* agricultural offices and in consultation with *wereda* extension team leaders and supervisors who have good knowledge of the PAs. After the complete lists of accessible PAs were assembled, five PAs were randomly selected from each *wereda.* In total 30 PAs were selected each for *tef* and wheat technology adoption.

In the third stage, farm household heads who participated in the *tef* or wheat technology packages demonstrations in each of the selected PAs were identified from the lists of farmers held at the extension center and *wereda* bureau of agricultural offices. Since we are interested in farmers' learning from their own experience only farmers who participated in 1995 and 1996 demonstration programs were included in the sampling frame. Therefore, farm households who participated in the improved *tef* or wheat technology demonstrations in the selected PAs were selected proportional to the number of woredas. Thus, 165 and 234 farmers were sampled for wheat and *tef*, respectively from Northern and West *Shewa* Zones.

Table 4.2. Structure of the selected sample of farmers

	Area under Crop (ha)[b]	Number of Selected *woredas*	Number of Selected *PAs*	No. of selected farms
North Shewa	**257.48**	**4**	**12**	**102**
Wheat system	69.35	2	7	45
Proportion (%)[a]	9	17	23	11
Tef system	93.27	2	5	57
Proportion (%)[a]	12	17	17	14
West Shewa	**487.52**	**8**	**18**	**297**
Wheat system	102.2	4	8	120
Proportion (%)[a]	14	33	27	30
Tef system	237.47	4	10	177
Proportion (%)[a]	32	33	33	44
TOTAL	**745**	**12**	**30**	**399**

a. Percent of total **b**. CSA, 2001

4.4.3 Survey instruments and procedures of data collected

An important step in data collection was development of a structured and detailed questionnaire. The questionnaire was designed for a single visit survey. A structured questionnaire was used to collect primary data. The researcher using his experience and the experiences of similar interviews in Ethiopia and other developing countries prepared the questionnaire. The questionnaire focused on the use of improved agricultural technology on *tef* and wheat separately. The structured questionnaire was pre-tested for appropriateness (clarity, adequacy and sequence of questions), revised according to the feedback from pre-testing and finalized. Selection of appropriate enumerators who had experiences in field surveys and provision of intensive training on the objectives, contents and method of the study preceded the actual data collection. Data collection took place during the 2001 crop season through a single visit to the selected sample of farm households.

As elsewhere in Ethiopia, in the study areas, farmers are used to local units to measure area, weight and volume and rarely use standard metric units. It is, therefore, expected that the measurement methods and conversion factors used may introduce some measurement errors in the data. In spite of this problem, data for this study were collected using local measurement units. This alternative was chosen because most farmers were more comfortable giving responses in the local units than standard metric units. In addition, information regarding units of measurement and their conversion factors were gathered from extension agents and rural input and grain traders. Rural grain traders (grain assemblers) use local units when they purchase grain from farmers and metric units when they are selling to consumers or wholesalers, so they are knowledgeable about the local measurement units and their conversion factors. In the case of land area, the common conversion factor (4 *timad*/kirt = 1 ha) used by the agricultural department in reporting cultivated area was used. Moreover, in this study neither areas of land under improved varieties, fertilizer and herbicide nor yield were measured (i.e. study did not use crop-cut methods). The data were obtained from farmers' memory recall method. As farmers typically report very low yield due to fear of high income tax and other contributions. Thus, reported yields were adjusted upward by 50% for *tef* and 45% for wheat based on yield difference from crop-cut and what farmers had reported for the two crops in the selected PAs (personal observation during pre-testing). Yield adjustment is necessary when farmers' reported yields are found not representing the real situation (CIMMYT, 1988).

Another limitation of the study was on estimation of the straw yield. Farmers could not be blamed on this because they have never attempted to measure it. Besides, the local unit they are used to is so confusing and also vary not from one area to another area but from farmer to farmer within the same area. Therefore, it was very difficult to standardize the local unit for each location with the time available for the survey. The best alternative was to use available research data, grain and straw yield multiplying factor (Alemu et al, 1991; Amsal et al, 1994). Thus, straw yield was estimated by multiplying *tef* and wheat grain yield with their respective multipliers (0.8 for wheat and 1.0 for *tef*).