

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
REGIONAL AND LOCAL DEVELOPMENT STUDIES

**THE IMPACT OF IMPROVED TECHNOLOGY ON
CROP PRODUCTIVITY: A CASE STUDY IN BASONA
WORANA WEREDA, NORTH SHEWA, AMHARA REGION**

BY
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CROP PRODUCTIVITY: A CASE STUDY IN BASONA
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A Thesis Presented to the School of Graduate Studies, Addis Ababa University
In Partial Fulfillment For the Degree of Master of Arts in Regional and Local
Development Studies

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ABBREVIATIONS

ACSI-	Amhara Credit and Saving Institute
ADDP	Adaa District Development Project
ADLI	Agricultural Development Led-Industrialization
AGVA	Agricultural Value Added
AIDB	Agricultural and Industrial Development Bank
AISCO	Agricultural Input Supply Corporation
AISE	Agricultural Input Supply Enterprise
AMC	Agricultural Marketing Corporation
BoA	Bureau of Agriculture for Amhara Region
CADU	Chilalo Agricultural Development Unit
CBE	Commercial Bank of Ethiopia
CBR	Crude Birth Rate
CSA	Central Statistical Authority
DA	Development Agent
DBE	Development Bank of Ethiopia
DoA	Department of Agriculture for North Shewa
DoPED	Department of Planning and Economic Development for North Shewa
EAL	Ethiopian Amalgamated Pvt Ltd Company
EPRDF	Ethiopian Peoples Revolutionary Democratic Front
GDP	Gross Domestic Product

GFR	General Fertility Rate
IAR	Institute of Agricultural Research
IR	Inverse Relationship
MEDaC	Ministry of Economic Development and Cupertino
MoA	Ministry of Agriculture
MoPED	Ministry of Planning and Economic Development
MPP I & II	First and Second Minimum Package Programs
MRP	Marginal Revenue of Product
NEP	New Extension Program
NFP	National Fertilizer Policy
NGO	Non-Governmental Organizations
ONCCP	Office of the National Committee for Central Planning
OPHCC	Office of Population and Housing Census Commission
PAs	Peasant Associations
PADEP	Peasant Agriculture Development Program
PADETES	Participatory Development Training and Extension System
PIE	Partial Income Elasticity
RELC	National and Zonal Research and Extension Laisaon Committee
R & D	Research and Development
S.D	Standard Deviation
SIDA	Swedish International Development Assistance
TFR	Total Fertility Rate
TGE	Transitional Government of Ethiopia
T & V	Training and Visit
USAID	United States International Development Assistance
WADU	Wolaita Agricultural Development Unit

ABSTRACT

This paper tries to examine the impact of improved technology on farm productivity and income of farm households. Further, yield and income difference between adopters and non-adopters resulting from the level of technology adoption. Theoretical and empirical findings suggested that crop yields particularly that of wheat whose proven technology (improved seed varieties) are available showed marked productivity. Technology adoption by far increased the income of farmers that use commercial fertilizer both with local and improved seed.

The reason for technology adoption is that yield could not be increased to satisfy the present food requirements of the population, given the decline in soil fertility and poor agronomic practices.

Agricultural productivity in the Ethiopian context suffered from low input application, deterioration in the soil nutrients, inappropriate agricultural policies, recurrent drought, etc. All these factors adversely affect food production and productivity and thus have made the country to heavily depend on food imports and food aid. Although the past package programs prove the possibility of increasing yield, its coverage and the purpose to which it served had never changed the life of the rural poor in particular and the overall the sector's performance, at large. That is to say, those package programs prior to the early 1990's served only the small portion of the rich farmers. In understanding of the problem, the present government put into effect the

new extension program known as the PADETES with the objective of increasing farm productivity of the mass of the small farmers through widespread application of improved technologies and farmers' participation in the process of planning and implementing in the choice and adoption of available technologies. Since its implementation reports showed that it was possible to increase farmers' yield by more than two-fold.

Having examining the hitherto theoretical and empirical findings, this paper tried to link its results with these facts. The results of this study from the sample of 175 households in Basona Worana woreda of Amhara North Shewa showed that farmers with better land, farm oxen, educational status, etc are adopters of improved technology. All adopters were found better both in yield and income levels than non-adopters. Wheat and barely yields showed significant productivity improvement. Further, it is tried to show farm income differential between adopters and non-adopters through employing financial analysis method.

It is important to note that problems related to the input and credit market, poor extension and research links, and institutional problems, among others arrested the level of technology adoption and hence the increase in farm productivity. Therefore, it is essential to mitigate albeit solve these problems so as to attain the objective of food self-sufficiency and food security at the national or household levels.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Ethiopia is one of the highly populated countries of Africa. Growth of cereal production falls behind the rate of growth of population nearly for about more than three decades. A close look at the per capita food production of the country exhibited that it is the least among most sub-Sahara African countries.

In Ethiopia, a continuous cultivation of the land without any improvements in land management and farming practices has led to severe soil erosion. Continuous cultivation together with rapid population growth, climatic and topographic factors as well as inappropriate agricultural policies (Beyene, 1996, Debebe, 1997) have resulted in a considerable decline of agricultural productivity. To alleviate the decline in crop productivity and attain the objective of food self-sufficiency, certain measures have been attempted. Among the measures are the application of modern agricultural technologies, expanding research activities and the dissemination of extension messages to farmers. These efforts have been effected through the comprehensive package projects (such as CADU, WADU, etc), the minimum package programs (MPP I and MPP II), and the peasant agricultural development

program-PADEP (Goshu, 1995; Dejene, 1996; Befekadu and Berhanu, N., 1999/2000). Although these programs have spatial biases and limited coverage, they ensured the increase in major cereal crop productivity through improved technology adoption and extension communication in that impact area. However, most of the programs failed to realize their initial objectives which emphasized to increase the real incomes of the rural farm households, generate additional employment opportunities, and produce surplus output as a means of capital formation (Tesfai, 1975; Dejene, 1996; Habtemariam, 1996).

All package programs exercised since the 1960's have not brought promising productivity as a whole due to various reasons. The causes may be found in government policies and environmental distress. Thus, inappropriate input and output policies, poor design of research-extension systems, lack of access to credit by the poor, weather changes, crop pests and diseases, etc accounted for low productivity.

It is important to note that the agricultural sector has substantial diversity of farming systems of which the 'plough-cereal' farming is the one (Dercon and Krishnan, 1994). Improved technologies mostly practiced on teff and wheat and sometimes on barely. Further, cereal crops are the dominant in the country that accounted for about 88.3 and 83.2 percent of the total production and cultivated land, respectively (Befekadu and Berhanu, n., 1999/2000). Available data showed that the area

cultivated under cereals increased from 4.7 million hectares in 1980 to 8.8 million hectares in 1996, while that of total production increased from 56.1 to 110.6 million quintals. Likewise, the lowest and highest cereal yield between the period in question was 8.8qt/ha and 14.4qt/ha, the average being 12.2 qt/ha (table 1.1). It was stated that recent increase in the total production attributed mainly to the increase in area expansion that was in turn the result of cultivating hill sides, degraded areas, and grazing lands and reducing the fallow land (Befekadu and Berhanu, N., 1999/2000). From table 1.1 it can be observed that annual percentage change in yield showed greater variability between 1980 and 1996. Cereal yield in Ethiopia is the lowest as compared to the yield in other developing countries. For instance, in the close of the 1970's average wheat yield in China, India, North Korea, South Korea, and Japan was 15, 17.92, 23.33, 21.18, and 30.56qt per hectare, respectively (Hsu Robert, 1982) while recent average wheat yield in Ethiopia was 12.2qt per hectare.

Table 1.1 Total Cereal Production, Area cultivated and Average Yield

Year	Production (000qt)	Cultivated area (000 ha)	Yield Qt/ha	% change in yield
1980	56118.61	4711.85	11.91	-
1981	54057.7	4625.77	11.69	-1.85
1982	67182.80	5029.22	13.36	14.29
1983	55268.19	4715.59	11.72	-12.28
1984	42398.47	4715.59	8.81	-24.83
1985	48199.87	4814.68	9.66	9.65
1986	65040.00	5304.00	12.26	26.92
1987	61950.00	5237.00	11.83	-3.51
1988	63840.00	5300.00	12.05	1.86
1989	63550.00	5180.00	12.27	1.83
1990	64370.00	5060.00	12.76	4.00
1991	63050.00	5120.00	12.31	-3.53
1992	70700.00	5265.00	13.43	9.09
1993	69060.00	5217.00	13.24	-1.41
1994	72760.00	5023	14.49	9.44
1995	91670.00	6737.00	13.61	-6.07
1996	110600.00	8771.00	12.61	-7.35
Average	65883.27	5399.48	12.23	

Source: Annual Report on the Ethiopian Economy, 1999/2000, Addis Ababa.

Of all the cereal crops, wheat and teff are considered to be the highest user of improved technologies. For instance in the fertilized areas of wheat and teff, fertilizer application rate was 128 and 99 kg/ha, respectively (Befekadu and Berhanu, N., 1999/2000). Nevertheless this higher rate of application on these crops has not brought desirable impact on productivity. However, there is a yield gap between well-managed extension demonstration plots and farmers' field where in the former case the highest yield recorded for wheat and teff was 45qt and 31qt per hectare, respectively (Takele, 1996; Befekadu and Berhanu, N., 1999/2000). Nonetheless, their respective average yield between 1991/92 and 1995/96 was 13qt and 8.5qt per hectare, respectively (Dejene, 1999).

The application of improved agricultural technologies greatly differs between regions. Table 1.2 indicates the total cereal crop area and applied improved seed, pesticides and fertilizer on the cropped area in some selected regions.

Table 1.2 Agricultural Inputs Applied on Cereal Cropped Area in some Selected Regions for Private Peasant Holdings, 1997/98

('000)

Regions	Total area under cereal (000 ha)	Improved seed Applied		Pesticides Applied		Fertilizer Applied	
		Area(ha)	%	Area (ha)	%	Area (ha)	%
Tigray	468.23	1.02	0.22	10.22	2.18	148.88	31.80
Amhara	1907.31	37.50	1.97	23.01	1.21	575.19	30.16
Oromia	2549.04	65.95	2.59	542.57	21.29	1210.95	47.51
SNNPR	478.40	13.55	2.83	92.16	19.26	246.45	51.52
National	5599.94	134.90	2.4	671.88	11.99	2199.90	39.28

Source: CSA (1998), Statistical Bulletin 193, Addis Ababa.

Note: the percent indicates the Ratio of area applied with the respective inputs to the total cereal cropped area.

The above table expedites what has been stated, as fertilized cereal area is by far better than that of the total cropped area. Further, there is a variation in the level of technology adoption between regions. Oromia and the SNNP regions seem to be higher adopters on cereals, i.e.; their respective fertilizer adoption in 1997/98 was 47.51 and 51.52 percent, respectively. On the other hand, the level of all input application on cereal crops both in Amhara and Tigray regions was below the national average (39.28%). It is important to note that, in all regions, wheat, teff, and maize have the largest share of all cereal fertilized area (CSA, 1998).

The total quantity of fertilizer applied may give provident examples of variations in the level of fertilizer application between regions. Table 1.3 provides the total quantity of fertilizer applied by type in the previously selected regions. Except for the SNNPR, fertilizer applied on cereal crops was more than 93 percent of the total application in all regions as well as at the national level in 1997/98. Oromia and Amhara regions constitute about 55.8 and 22.4 percent of the total fertilizer applied by the private peasant sector in the country, respectively. The rest of the regions applied only 21.8% that is quite less than the total fertilizer applied in Amhara region. Furthermore, of the total fertilizer applied at the national level teff and wheat accounted for 38.6 and 26.4 percent, respectively. It holds true in most regions too. For instance, in Oromia and Amhara regions teff and wheat constituted about 36 and 32, and 52 and 17 percent, respectively.

Table 1.3 Estimates of Fertilizer Applied on Crops in some selected regions for Private peasant holdings (Meher Season), 1997/98.

(000qt)

Region	Total fertilizer Applied	Quantity of Fertilizer Applied by Crop Type							
		Cereals		Pulses		Oil Seeds		Others	
		Quantity	%	Quantity	%	Quantity	%	Quantity	%
Tigray	141.56	140.99	99.60	0.45	0.32	0	0	0.12	0.08
Amhara	514.07	490.94	95.51	7.36	1.43	11.02	2.14	4.72	0.92
Oromia	1284.10	1205.72	93.90	52.87	4.12	10.66	0.80	14.85	1.15
SNNPR	337.56	288.51	85.47	23.44	6.95	0.03	0	25.58	7.58
National	2300.06	2147.31	93.36	85.09	3.70	21.86	0.95	45.80	1.99

Source: CSA (1998), Statistical Bulletin 193, Addis Ababa.

Note: It excludes fertilizer applied on permanent crops.

In Amhara region, teff received greater fertilizer application rate than in other regions because it is a stable food crop and is also a source of cash income for most farmers. Like that of the difference in technology adoption, it could be alleged that there would be variations in the level of productivity between regions.

The Transitional Government of Ethiopia (TGE), amiable to that of EPRDF, formulated an Agricultural Development-Led Industrialization (ADLI) strategy with the aim of accelerating agricultural development the implications of which are to produce sufficient food, exportable products and raw materials and supply surplus labor to foster agro-industrialization (MoPED, 1993). In achieving the objectives nested in the ADLI strategy, the government designed the new extension system known as “Participatory Development Training and Extension System” (PADETES) in 1994/95 which can be considered as a ‘hybrid’ form of the training and visit (T & V) and the SG-2000 extension approaches (Takele, 1996; Mulat, 1999; Howard, *et al* 1999; Beyene, 2000). Initially, the new extension program (NEP), like that of SG-2000 mainly focused on increasing the productivity of major cereals (Teff, Wheat, Maize, and Sorghum).

The PADETES has been chosen for that it can provide an equal opportunity and access to modern agricultural technology for both the rich and poor farmers (Beyene, 2000). The NEP lends it self to the widespread application of improved inputs on the farmers’ plots that are to be communicated through extension messages. Moreover,

the program advocated for making available credit facilities in order to enhance the input purchasing capacity of the farm households.

Improved technologies transferred by the new extension program as discussed earlier may increase crop yield on properly managed plots. In analogous to this, Takele (1996) and official reports pointed out that the application of improved technologies helped increasing cereal yield by more than two-fold and the highest yield recorded for wheat, teff, sorghum, and maize was 45, 31, 82.5, and 68 quintals per hectare, respectively.

In addition, the application of improved technologies on demonstration plots found to be profitable under different price scenarios (Takele, 1996; Howard *et al*, 1999). However, the continuity of technology adoption by the former participant on a broader scale to maintain the productivity obtained from the demonstration plots seems to be precarious. Studies made by different professionals focused on the impact of improved technologies to areas of research outreach sites that have higher potential productivity. Thus, this study will thoroughly examine the impact of improved technologies on the productivity of major cereal crops in the area where the MoA provides the extension service. Further, it will make assertions on the level of profitability of adopting the inputs and partial productivity of each factor input by examining the following questions. Do the adoption of the improved inputs have shown improvements in crop productivity and on farmers' income? Who are the most benefited from the adoption of improved inputs? What constraints do farmers face in

technology adoption? Does the implementation of the PDETES help increasing the number of adopters/ participants? To what extent research and extension mutually support?

1.2 STATEMENT OF THE PROBLEM

In most of the developing countries particularly in Africa agricultural production has showed dramatic decline and reached the level that it failed to satisfy the food requirements of the population. The demand for and the supply of food crops in the continent have shown a wide gap over the years. The critical problems that hampered raising agricultural production and productivity are diverse and interrelated. These problems include, among others, ineffective agricultural policies, rapid population growth, inadequate research and extension services, environmental degradation, limited technical capabilities, political instability, persistent drought, and deficient institutional management (Abalu, 1997; Tekolla, 1997).

All these factors combined together has brought menacing effect on food grain production and consequently led Africa to heavily relied on commercial food imports and food aid. The food import dependency ratio and the percentage of population that live in abject poverty has dramatically increased in sub-Saharan Africa (Mulat *et al*, 1995). Furthermore, among the total 39 poorest countries of the world 24 are in Africa, and from 1133 millions of poverty-stricken population of all developing countries sub-Saharan Africa alone constitute 216 million (Tekolla, 1997:3). In an attempt to tackle rural poverty and food insecurity the African states undertook

measures such as land reform and the application of the 'Green Revolution inputs'. However, none of them have brought promising results and rather domestic food production has seriously declined.

In many African countries as well as in Ethiopia, the application of agricultural technologies failed to meet the needs of small holder farmers. Such undesirable effects of the Green Revolution inputs was explained as that the application of technical innovation, although greatly helped raise agricultural productivity, was resulted in wide income differentials among the rural community in which most farmers were remained in absolute poverty (Griffin, 1973; Tesfai, 1975; Mellor, 1985; Tekolla, 1997; and others).

In Africa, the sector's capacity to feed the population dropped from 98% in 1960 to 84% in 1984; where as the population growth rate was as high as 3 percent per annum (Habtemariam, 1996). He continued on saying that the agricultural sector grew at a rate of 1.2% per annum while that of the population by 2.7 % between 1965 and 1980. The gap between agricultural production and population growth has further widened since the 1980's that resulted in the increase of commercial food imports and food aid. To this end, net commercial cereal imports and food aid increased from 140000 in 1979/80 to 1091000 metric tones in 1991/92(MEDaC, 1997).

It is palatable to state that low productivity of agriculture caused serious food shortages. Analogous to this, Befekadu and Berhanu, N. (1999/2000) pointed out that despite its contribution to the national economy, agriculture was and still is the least productive sector that in turn failed to meet the food requirement of the population. In the early 1950's Ethiopia was considered as a 'bread-basket' of Africa and by far "had been self-sufficient in food production and classified as a net exporter of food grains until the late 1950,s"(Sisay and Debebe, 1994:207). It is a myth for such a country to become renown recently as the land of hanger when one thought of its position before four decades.

Continuous cultivation without improving the land and other factors such as rainfall variability, water logging, crop diseases and pests, etc caused severe productivity decline. Unless the land has to be fertilized the loss in some biological productivity and physical properties of the soil needed for plant growth will be exacerbated in the future (Befekadu and Berhanu, N., 1999/2000). The present situation in the country manifested itself by little or no manure application because dung and crop residue have been used for firewood and the latter usually for animal feed (TGE, 1992). Moreover, inorganic fertilizer application in the country is by far low in the country.

Despite the attempt to increase agricultural productivity through improved technology adoption, the average cereal production could not have exceeded the level of 1.2 ton per hectare until recently. Low productivity of cereals accounted for, among others, low application of improved technologies, inappropriate research and

extension design, lack of credit, improper input and output market, tenure insecurity, decreasing holding size, poor institutional and management coordination (Habtemariam, 1996; Mulat, 1996; Yigremew, 1997; Johannes, 1999; Befekadu and Berhanu, N., 1999/2000).

Samia and Wubshet (1996) pointed out that 32.69, 9.45, and 0.71 percent of the cultivated land covered with fertilizer, pesticides, and improved seeds, respectively. Despite the increasing coverage of demonstration plots under the new extension practice, fertilizer application was not exceeded 29kg/ha in 1995/96 as compared to the recommended amount of 150-200kg/ha. Although wheat and teff were considered as having the highest fertilizer application rate, the productivity of these crops has not shown substantial increase. Poor quality of improved seeds, frequent attack by or lower resistance to crop diseases, pests, and weeds accounted for low productivity of improved technologies (Anderson, no date; Griffin, 1973; Befekadu and Berhanu, N., 1999/2000). Further, politically inspired land reform, lack of credit, unfavorable terms of trade, blanket recommendation of input application, shortage of improved seeds, lack of verification on disseminated inputs, shortage of extension agents and so on, among others, accounted for the decline in productivity (Habtemariam, 1996; Mulat, 1996; Mulat and Techane, 1999); Howard *et al*, 1999). Unless such situations are reversed and alternative solutions are sought for, the problem of increasing productivity would not be achievable. Moreover, inappropriate loan disbursement and repayment arrangement and risk associated to technology

adoption brought pervasive situation on input use that in turn affected the growth of food crops production and productivity.

1.3 LITERATURE REVIEW

1.3.1 Technological Change and Agricultural Development

Despite various attempts to transform agriculture by the developing countries, the sector has still remained in its traditional state. The reason behind the low level of agricultural development is introverted policies followed by the governments of these countries over the years. Development strategies of the 1950s and early 1960s gave priority to promote the industrial sector for which agriculture was neglected. The rapid population growth, on the one hand, and the widening gap between the demand for and the supply of food production, on the other, has brought an impetus for agriculture to receive increased attention in the late 1960s. Mellor (1976) noted that agriculture is not only the source of food, raw materials and surplus output but also provides the physical goods to support increased employment and wage earnings.

Therefore in order to reap the benefits that agriculture can provide to the mass of the rural poor in particular and to the national development at large, it is necessary to transform the traditional agriculture into a productive sector (Shultze, 1964) or what Mosher (1966) termed as “getting agriculture moving.” Agricultural transformation, therefore, requires appropriate public policy intervention (Yotopoulos, 1967; Halcrow, 1984) so as to generate the surplus produce. Further the formulation of

agricultural policy in turn requires a consideration of various interacting factors that include, among others, organization of agriculture, natural factors, institutional arrangements, product characteristics, factor and product markets (Halcrow, 1984; Dejene, 1995).

One of the basic factors in the transformation of agriculture is 'technological change.' Seclar (1993; cited in Dejene, 1995) described that adoption of new technologies, on a regular basis, among others, induce a dynamic growth process that enable the agricultural sector to produce food cheaply, and releasing labor to the non-agricultural sector. Agricultural technology, hence, refers to innovations of new ideas, methods, practices or techniques of production that provide the means of achieving sustained increase in farm productivity (Abate, 1989:19). Anderson (no date: 30) pointed out that adoption of a new technology not previously used in the production process implies technological change, adoption being defined as the act of incorporating something into the production process. It is important to note that the generation of new technology is not suffice by itself but the degree of its diffusion does so. In this regard, Anderson (31) stated that the adoption of technology must be preceded by technology diffusion where the latter term implies the act of making technology available to potential adopters and is then a link between R&D and adoption. In his thesis Mosher (1966) emphasized that new technology adoption and diffusion alone is not enough to get agriculture moving and thus changes in the institutional, infrastructural, and cultural factors must occur in

the process of transformation. Similarly, Nerlove (1993; cited in Dejene, 1995:9) noted the following:

Technology apparently plays a crucial in agricultural modernization, but the process cannot be understood solely in terms of technology. The interactions of technology with a number of social and economic factors have to be taken into account.

The need for technology adoption in agriculture, besides increasing factors' efficiency, is to cope with natural hazards faced by the sector. Experiences of many countries showed that sizable proportion of agricultural technology is commodity specific (improved seeds and animal breeds) that are suited only for limited and usually most favorable ecological environments (Anderson, no date). Therefore, areas with poor environments may not have a chance of adopting due to their poor response to the technologies in question.

Agricultural technology includes not only biological and chemical types but also mechanical and management technology. It is within this given framework that agricultural technology should have to be perceived. These technologies can help increasing efficiency in a number of ways. Anderson (no date) described that agricultural technology increase efficiency through increasing production for a given country of one or more resources, or a reduction in the use of resources with constant production, and efficient utilization of other agricultural resources used in the production process. It can be deduced that technological change in agriculture, its diffusion and adoption can substantially induce growth to agricultural production.

Agricultural research and extension are the basis for such a process to advance further.

In summary, policy opted for the transformation of traditional agriculture have to give due concern for technology, research and extension so as to enhance the productivity of production factors, among others. However, the question of sustainability has to be addressed. Yotopoulos (1984) pointed out that increasing agricultural productivity through the use of chemical and mechanical devices with more intensive use of natural resources tend to have adverse environmental effects. Hence, technological change in agriculture must lend itself towards reducing such environmental hazards to bring about sustainable agricultural development.

1.3.2 Agricultural Technology, Research and Extension: The Interrelationships And Impacts on Productivity and Income Distribution

Agricultural research, as defined by Habtemariam (1996:165), is a purposeful, controlled, often formal, systematic, critical and intensive activity whose prime objective is to generate or adapt technically and financially feasible, economically viable and socio-culturally acceptable technologies to promote or transform traditional agriculture. Therefore, research is the basis for the generation and adoption of technologies, and in which these technologies can be diffused through extension messages. In recent development approaches environmental issues have

come on the front line and the term 'environmentally sound' technologies is incorporated into research's definition.

Agricultural research is aimed at solving definite problems in the process of agricultural production. In order to effectively solve agricultural problems, research activities have to be undertaken in a continuous manner. Anderson (no date) stated that effective agricultural research should be based on the objective of solving a defined or agricultural problem orientation that requires a research program of a cumulative nature, i.e., new research must be based on the outcome of the previous research. This would eventually lead to better results and provides the basis for new technology to be generated. The development of the new technology could lead to further enhance the research in light of developing better technologies. It is here that the link between agricultural technology and research offer an understanding of their interrelationships.

Although agricultural research and technology are central to the development of any nation, their development and extensive application in the developing countries is quite limited. Hence, their potential to increase food production and to improve the efficiency of factors of production is largely restricted. The reasons for limited contribution to economic growth by agricultural technology and research, among others, are lack of financial and skilled human resources, poor priority given to these activities, and institutional problems (Anderson, no date; Mellor, 1976;

Habtemariam, 1996). Agricultural technology, as Anderson claimed, may reduce or increase production risks.

For instance, the use of irrigation and the development of drought and disease tolerance crop varieties may reduce the risk of rainfall variability and crop damage with drought and diseases, respectively. On the other hand, the adoption of new high-yielding varieties with little or no resistance to the slightest change in weather changes; crop pests and diseases could bear risks to adopters and hence may largely hinder adoption by the end users (Anderson, no date).

Agricultural technology developed/improved by the research centers could be communicated through the extension system. The latter term can be defined as a process through which new ideas, techniques or materials are communicated or introduced in a number of ways to the agricultural community (Habtemariam, 1996:168). The shortcomings, experiences and requirements of extension system that are acquired through the adoption of the new technologies are also communicated back to the concerned research institutions. It can be argued that agricultural technology, research and extension are mutually interrelated and the weakness in one could be reflected in the others. Therefore, development policies opted for promoting agricultural technology; research and extension with the aim of accelerating agricultural growth should give attention to the intrinsic interrelationships.

The main emphasis to agricultural technology, research and extension is to increase the productivity of agriculture through increasing factor efficiency. Experiences

since the 1960s showed that the application of the Green Revolution inputs (improved seeds, fertilizer and mechanical devices) have brought substantial increase in crop productivity per unit area of farm land (Anderson; Hsu Robert, 1982; Cohen, 1985; Gsanger, 1994; Habtemariam, 1996; Heltberg, 1998; and others).

The prominent role played by agricultural technology, research and extension, apart from increasing productivity, is their impact on poverty alleviation and/or income distribution. In this respect, they have brought considerable increase in agricultural productivity and hence raising the income of the adopters who were mainly classified as landowners or the richer ones. Therefore, the effect of income distribution on the basis of equity has been still remained questionable. To this end the adoption of improved seeds and fertilizers has brought wide income differentials among the farming community where ever applied and the contention that new technology could benefit the poor by reducing the cost of production and real prices of food crops has remained uncommon (Tesfai, 1975; Hsu Robert, 1982; Cohen, 1985; Mellor, 1976; Goshu, 1995; and others). Gsanger also explained the following analogous to the above argument:" although the Green Revolution strategies, where they had an impact, as they did in the South and South-East Asia, tended to make the richer rich...."(Gsanger, 1994:43). The fact that agricultural resources are concentrated in the hands of few individuals could best reflect the income differential among the farm households. Anderson (no date: 48) noted that the introduction of the new technology affects functional as well as personal income

distribution where the former implies the distribution of income among owners of resources and the latter refers to income distribution in the society as a whole.

Lastly, it is important to note that literatures of the 1980s and after emphasized on the need for sustainable development of the economy, in general and agricultural development, in particular. Sustainable agriculture includes, among others, the following:

high, efficient and stable production, low and inexpensive input in particular making full use of technologies of organic farming and indigenous traditional knowledge, preservation of traditional values and small family farm, a high level of participation in development decision by the farmers themselves (Conway and Barbier, 1990:10).

The writers further argued that the need for sustainable agriculture is that the Green Revolution, despite its impressive yield results, suffered from the problem of equity and failures to achieve stability and sustainability of production (11). Compounded by the prevailing development approaches (sustainable development, participatory development, bottom-up approach to planning, etc), technology selection and adoption, research and extension systems have been put into the realm of participation. These important agricultural resources must be realized through the participation of the farm households for their sustainable use and stable increase in food production (Conway and Barbier, 1990; Burkey, 1993; Gsanger, 1994; Chambers, 1983, 1997; Rice, Smale and Blanco, 1998). Hence, the current philosophy in development as well as in research and extension system calls for stakeholders' participation. However, the impact of participatory approach to technology adoption and choice, research and extension on sustainable increase in

productivity has not been assessed at a broader scale. Nonetheless, it can be said right away, regardless of the approaches, that the widespread application of agricultural technologies (seeds, fertilizers, and chemicals) could bring substantial increase in productivity.

1.3.3 RESEARCH-EXTENSION SYSTEM AND AGRICULTURAL PRODUCTIVITY IN ETHIOPIA

The evolution of agricultural research and extension in Ethiopia dated back in the 1950's and 1960's, respectively. Research activities were undertaken by different institutions albeit the Institute of Agricultural Research (IAR) was the main responsible institution. It was established in 1966 and it tried to generate improved technologies that are mainly adaptable to specific agroecological conditions. These high-yielding varieties were experimented on IAR's research outreach stations that were eventually demonstrated to farmers by the extension department of the Ministry of Agriculture-MoA (Goshu, 1995; Habtemariam, 1996). Moreover, research and extension activities fell under different institutions that seriously lacked coordination. Habtemariam (1996) stated that IAR and MoA formed National and Zonal Research and Extension Liaison Committee (RELC) in 1986 with the aim of coordinating and devising research priorities, make periodic review of research-extension mechanisms, etc. Nonetheless, RELC could not bring substantial improvements in the coordination of research and extension as its activity was left to different institutions (MoA, 1989).

Extension service was introduced in the country along with the introduction of the comprehensive package projects and the beginning of modern farms (Dejene, 1996; Habtemariam, 1996; Beyene, 2000). It has been further enhanced in the successive package programs such as the minimum package programs and the peasant agricultural development program (PADEP). The implementation of these programs and the impacts they brought on agricultural productivity and on the income of rural farm households are briefly discussed below.

The Chilalo Agricultural Development Unit (CADU), Wolaita Agricultural Development Unit (WADU), and Adaa District Development Project (ADDP) were some of the comprehensive package approaches that were enforced in the late 1960s and early 1970s. These comprehensive package programs were funded by SIDA, the World Bank, and USAID with the aim of bringing about “economic and social development, to give the population increased awareness of and responsibility for the development process, and to verify methods of agricultural development” (Cohen, no date: 6).

The comprehensive approach was replaced by the minimum package projects (MPP I) and initiated in the early 1970s in high potential areas. The comprehensive and minimum package programs were facilitated in high potential areas on the premises that concentrating resources on most promising regions yield better results than spreading them thinly over broader areas (Cohen, 1986; Dejene, 1996; Befekadu and Berhanu, N., 1999/2000).

Although package projects that consisted of improved seeds, fertilizers and chemicals, and infrastructure development together with dissemination of extension messages (Tesfai, 1975; Habtemariam, 1996; Dejene, 1996) failed to meet the objective of accelerating rural development at large and food self-sufficiency in particular. Tesfai (1975) and Dejene (1996) noted out that these largely ‘aid-financed’ projects whose primary objectives were to increase the real income of the small holders, to enhance their participation in rural development, to generate additional employment opportunities and narrow the prevailing income gap of farm households benefited the landlords rather than the poor. Furthermore, Shenin described the resultant effect of such covert policies of most developing countries as:

--- policies aimed primarily at accelerating economic growth, in most developing countries, have benefited the upper 40 percent of the population and allocation of services and investment funds has tended to strengthen rather than to offset the trend (Shenin, 1988:425).

The major factors pervading the achievement of the packages’ objectives, among others, are area-focused nature of the program, lack of access to resources to the poor, tenure insecurity, weak inter-institutional research collaboration and functional and purposeful linkages between technology generation and adoption (Dessalegne, 1984; Brune, 1990; Befekadu and Berhanu, N., 1999/2000). Lack of access to resources (mainly credits, farm oxen and implements) and the tenure system limited the application of modern technologies and investment in land improvements on a sustainable basis.

Agricultural development of the post-1974 has been characterized by land nationalization, the establishment of peasant associations and producers' cooperatives, villagization, resettlement program, etc., intended mainly to transform the peasant agriculture (Dessalegne, 1984; Brune, 1990; Pausewang, 1990; Hansson, 1995; Dejene, 1996) or simply "to get agriculture moving"(Mosher, 1966). The 1975 land reform of the country was considered by many to bring marked change in the development of the peasant agriculture through generating sufficient food for the population and surplus for the growth of the sector itself and other sectors of the economy. However, it could neither bring

Neither equity nor growth as it was envisaged. Rather it resulted in the shift of land ownership from individual landlords to the state keeping the status quo of the farmers being subservient to the land owning classes of different status (the landlord and the state).

In the beginning of the 1980's the second minimum package program (MPP II) was enforced thinly spread on a broader area and remained unfruitful. Further, the PADEP approach to extension services was enforced in grain surplus producing awrajas in the 1980s that was funded by the World Bank. The PADEP was mainly gave prior attention to the producers' cooperatives that accounted for 2% of the total cultivated land while neglecting the peasant sector that accounted for 94% of the cultivated land (Brune, 1990; Mesfin, M., 1994; Hansson, 1995). Hence the 1980s agricultural extension system shifted from the model farmer approach to the producers, cooperative approach (Habtemariam, 1996) implying that the bulk of the

public agricultural expenditure was channeled to the producers' cooperatives as well as the state farms. Producers' cooperatives and state farms received better agricultural technologies and farm implements, access to credits, extension services, and better quality lands (Mesfin, M., 1994; Hansson, 1995). Land redistribution within the peasant farm households has frequently undertaken reduced the holding size. This situation in turn resulted in an abject use of improved technologies *raison d'être* for low agricultural productivity. However, it is important to note that there was productivity or income differential between the peasant sector the other two. For instance, a study made by Mesfin Mirtochie (1994) indicated that the marginal revenue product (MRP) and the partial income elasticity (PIE) of fertilizer for the peasant sector was Birr 9.29/ha and 0.09, respectively, while the partial income elasticity of the state farms for all modern yield increasing inputs was -0.02 . The MRP and PIE reflect the marginal yield increase per hectare as a result of an increase in the unit of those inputs applied. Therefore, in the above case the PIE of the peasant sector 0.09 shows with a one percent increase in the use of fertilizer the gross farm income growth per hectare will increase by 0.09 percent whereas it will decrease by 0.02 percent in the case of the state farms (Mesfin, M., 1994). Although the result of the study showed productivity differences between the small holder farmers and the state farms, it may not be possible to draw a fully-fledged conclusion on this difference. This is because such difference may be resulted from either measurement/quantification errors or the notion of scale economies. That is to say the continuous application of inputs in the state farms may in the end tend to have no more impact on productivity due to constant or decreasing returns to scale and that

state farms may use more capita-intensive technologies than small holder farmers which often use traditional labor and other farm resources.

By and large, the PADEP extension approach, as its predecessors, heavily relied on improved technologies developed by researchers to be applied in grain surplus producing awrajas involve a class and spatial biases (Dejene, 1996; Habtemariam, 1996). The approach was basically to increase the agricultural productivity through introducing new crop varieties, widespread application of inorganic fertilizers and training and visit (T&V) extension system to be communicated through the subject matter specialist (SMS) by developing the “ideal’ production practices so as to maximize yield (Low, 1984; Woodhouse, 1994; Goshu, 1995).

The peasant agricultural sector was also suffered from the marketing and distribution of outputs and inputs. Marketing of agricultural out put was monopolized by the state-owned institution-the Agricultural Marketing Corporation (AMC). AMC purchased agricultural products at fixed prices through compulsory quota deliveries. Hansson (1995:31) stated that state farms and producers’ cooperatives received higher prices of 10-20 percent than the private peasants on grain sold to AMC. This statement apparently indicates that the peasant sector suffered from not only from the bias in agricultural technology access but also from the price differentials.

Due to the inefficiency of the public sector involving in the marketing and distribution of inputs, the price of those inputs increased and consequently pervades

poor farmers to apply the improved technologies, given the unavailability of credit facilities. Despite the attempt to promote agricultural development through increasing productivity, the average cereal yield never exceeded 1.2 ton per hectare between 1980 and 1997(Mulat and Techane, 1997). Although this is the case, the application of improved agricultural inputs by the package programs verified the possibility of increasing agricultural productivity per hectare of farmland. Nevertheless, its coverage was so limited that the effect on the overall sector's productivity has become unnoticed.

The application of improved inputs requires the expansion of irrigation facilities. Irrigated farmlands would positively respond for improved technologies to agricultural productivity(Hsu, Robert, 1982). Despite having untapped water resources in Ethiopia, irrigated farmlands in the country was quite low, i.e. below one percent (0.71%) of the total cultivated land (Samia and Wubshet, 1996) implying that the sector is largely dependent on rainfall. This in turn makes agricultural production more susceptible to the slightest rainfall variability. It was often argued that “ improved farm inputs such as chemical nutrients, irrigation facilities, improved seeds, pesticides and better agronomic practices are of a paramount importance in raising productivity of land and labor and thereby increasing total farm output” (Samia and Wubshet, 1996: 153-54). Therefore, the low level of agricultural productivity in the country mainly accounted for the inadequate application of improved inputs, and lack of available farm resources such as farm oxen, capital, irrigation facilities, better agronomic practices, etc, among others. The low

agricultural output that mainly emanated from a number of interrelated and complex problems has led the country to critical food shortages. In this regard, Sisay and Debebe explained the following:

total domestic production on the average declined by 11% while the level of per capita production dropped by 4.3 percent ... the latter case was observed during the years 1994/85(114kg/head/year), 1985/86 and 1991/92 (122kg/head/year each) (Sisay and Debebe, 1994: 207).

In addition, when 'nature generously' provided the country with considerable increase in total agricultural production and that the state boasted of being food self-sufficient in production in 1995/96, per capita food production and per capita food demand were 177.3 and 1269kg/head/year, respectively, showing a gap of 21.2 percent(Eshetu, Dejene, and Daniel, 1999).

The current strategy in Ethiopia gives emphasis to increase agricultural production with the main aim of making the country self-sufficient in food production(MoPED, 1993) through effecting the new extension program(PADETES), among others. The new extension program, as the case may be in the past, focused on the widespread application of improved seeds, fertilizers, pesticides and other chemicals, and improving agronomic practices, etc. to enhance the productivity of major cereal crops (Habtemariam, 1996; Takele, 1996). In its early period of implementation, the NEP gave priority to potential areas and latter its coverage was expanded to moisture-stress environments(Amhara Region Bureau of Agriculture, 1999).

Although there was no much evidence on yield levels from the moisture-stress areas, crop productivity on farmer-managed demonstration plots in the potential areas has

shown considerable rise over the traditional practices (Takele, 1996). He further argued that the application of the available technologies could produce better results if they are applied on most favorable environments and managed properly. Hence, conducive environment is essential for improved technologies to give desirable response for the rise in productivity. Such environment, among others, include suitable farmland, adequate moisture, proper application of the inputs, good farm management, and adequate extension messages. However, the present practice of broadening the extension coverage has become quite demanding on the existing inadequate farm resources that makes the success of increasing productivity to be questioned (Howard *et al*, 1999). Furthermore, the past as well as the present extension practice in Ethiopia signifies 'blanket recommendation' in the application of available technologies without considering the great diversity of agroecologies and nutrient requirements of crops (Habtemariam, 1996; Mulat, 1996). It was observed that demonstration plots became less productive due to this reason in some areas, particularly in mid-lowlands where land is relatively suitable for crops. In addition, both research and extension hardly gave emphasis on farmers' knowledge that in turn resulted in the gap between technology generation, dissemination, and adoption. This situation was described as that such gaps will persist as far as farmers and their centuries-aged indigenous knowledge about their physical and biological environments are taken into account by the existing agricultural research-extension institutions (Amare, 1977; Seleshi, 1980; Langlais *et al*, 1984 as cited in Habtemariam, 1996). Howard *et al* described the following on the rapid expansion of extension plots:

... [this] program expansion implies not only a challenge for the extension agents who will progressively encounter farmers with less capacity to adopt the technologies but also researchers who must work to [generate] and adapt improved varieties and other technologies to more difficult production environments(Howard *et al*, 1999: 53).

Therefore, technology adoption on demonstration plots at a broader scale that lack to realize the resources at hand may produce unsatisfactory results. It seemed that extension has moved ahead of research activities in the country without reinforcing each other. Further, the link that would have been existed between research and extension and farmers' participation has kept the *status quo*. Hence, it can intuitively conclude that the contribution of research and extension to agricultural development, in general, and to raise productivity, in particular, may not be attainable as envisaged by the present extension practice.

The major challenges for the Ethiopian agriculture to increase land productivity are diverse and complex. These problems include, among others, declining farm size, weather changes, tenure insecurity, soil degradation, poor (often not well developed) link between research and extension systems, lack of credits, imperfect agricultural markets, and poor infrastructure (Ghiorgis, 1989; Goshu, 1995; Habtemariam, 1996; Mulat, 1996; Befekadu and Berhanu, N., 1999/2000). It is essential to look into each of these problems how they have affected agricultural productivity.

1.3.4 Conceptual Framework

The principal inputs in agriculture are land, labor and capital, among others; and by far agricultural production largely depend on land resource as compared to other activities (Dejene, 1995; Cook and Maurier-Fazio, 1999 and others). Therefore, agricultural productivity is explained in terms of these factors of production. Hayami

and Ruttan (1984) noted that productivity growth in agriculture could be seen through changes in output per unit of area cultivated and output per labor employed to produce that product. Agricultural productivity can also be measured in terms of annual value of production per unit of cultivated land or farm labor and the marginal increase over these factors of production. In this regard, it is argued that:

Technological change shifts the production function up ... extends it substantially to the right, this provide a larger output per worker at any given labor input and maintaining positive marginal productivity for much level of labor input (Mellor, 1985:31).

Land has become the scarce agricultural input resulting from population growth and increasing agricultural production through extensive farming could not be attainable. Therefore, this calls for the intensification of agriculture (Boserup, 1965), i.e., use of agricultural technologies to produce more of the product from a given area of cultivated land.

Further, Timmer (1993; cited in Dejene, 1995) argued also in land-scarce environment facing rapid population growth to limited absorption of labor by industry ... raising output per hectare might be the only way to raise labor productivity. Similarly, Mellor (1985:31) stated that agricultural labor productivity could be raised by only increasing land productivity through adopting high yield-increasing technology if land is fully utilized. In contrast to this some defined agricultural productivity as crop yield per unit area of farm land-land productivity. Dorward stated the following:

... most studies have, for practical reasons, defined productivity as the gross value of production per unit area of holding. This simple measure is usually considered to be a satisfactory yardstick of relative economic efficiency in the

context of developing countries where land is a scarce resource and capital plays a negligible role in production
(Dorward, 1999:143).

In the context of increasing yield per unit of farmland through intensification, many argued about the inverse relationship (IR) between farm size and productivity to support the hypothesis that small farmers produce more per unit of farmland than large farmers (Heltberg, 1998; Dorward, 1999). The concept of inverse relationship between farm size and productivity took much of the agenda for land reform in rural development. The rationale behind land reform is to solve the problem of the small farmers' access to farmland thereby alleviating rural poverty through increasing productivity. Dorward (1998), Heltberg (1999), and others argued that this inverse relationship constitute a core argument for redistribution of farmland in the belief that it would lead to a more equal size of land ownership that help promoting rural development. However, recent experiences showed that the inverse relationship hypothesis has to be questioned on two grounds. First, that the failure to control for unobserved land quality and other farm heterogeneity could lead to erroneous conclusion when measured in terms regression models; and second, the new technologies may have diminished or reversed the relationships (Heltberg, 1999:1808). Befekadu and Berhanu, N. (1999/2000) noted that redistributive land reform may not at all reflect the inverse relationships between farm size and productivity as experienced by periodical land redistribution process in Ethiopia. Rather this periodical land redistribution has impaired the problem of technological adoption and thus limits agricultural productivity.

In Ethiopia, agricultural productivity is considered, particularly by policy makers, as yield per hectare that ignores the relative efficiency of other factor of production. Befekadu and Berhanu, N. (1999/2000:197) pointed out that the current agricultural policy largely rests on, among others, on the issues of the strategy's concentration on improving land productivity instead of labor productivity.

It is important to note that technology, research, extension and land reform are not the only determinants of agricultural productivity but also other factors that have diverse nature. Such factors include, among others, suitable farmland (land quality), tenure security, weather conditions, factor and output prices, access to credits and other farm resources, institutional changes and management capacity (Mellor, 1985; Dsanger, 1994; Heltberg, 1998; Dorward, 1999, Befekadu and Berhanu, N., 1999/2000).

1.4 OBJECTIVE OF THE STUDY

Since the 1970's improved technologies have been adopted in Ethiopia by means of different extension approaches. Furthermore, the application of improved technology has been increased in coverage after 1994/95 under the new extension program. It was advocated that the program benefited small holder farmers from increased productivity of cereals per unit area of farmland by way of applying improved technology. Such generalization may obscure the overall effect of improved technology on farm income and productivity in all agroecological areas. Therefore, it is necessary to examine such generalization through undertaking profound study on

the subject under reference. In this regard, a case study is carried out to evaluate the impact of improved technology on the productivity of major cereal crops.

The main objective of the study is to assess the effect of improved technology on the productivity of cereal crops and as a result, to indicate whether the income of the adopters is improved or not. The specific objective include:

- 1) To assess the major yield determinants and measure the productivity of major production factors;
- 2) To measure the financial profitability of adopting improved technologies;
- 3) To identify the major policy-related constraints of technology adoption that limit the rise in productivity;
- 4) To describe the prevailing shortcomings and success of technology adoption in raising productivity.

1.5 SIGNIFICANCE OF THE STUDY

This study could provide decision-makers, institutions and farmers with the necessary insight to strengthen or redress the current instruments used in technology adoption.

Therefore, the result of this study may have the following significance:

- a) Help decision makers to strengthen the positive aspects of technology adoption, on the one hand, and look for the best alternative policy instruments that would mitigate the existing problems;
- b) Make institutions (Agricultural Offices and others) be aware of the operational level problems and help them device appropriate measures;

- c) Finally, as a result of the measures taken to improve the situations, constraints of technology adoption could be solved thereby creating enabling environment for farmers to increase their productivity as well as their income.

1.6 SCOPE AND LIMITATION

Given the time and financial constraints, this research paper may subject to certain limitations. Moreover, factors that determine the yield of crops are numerous and complex. However, all factors that determine yield are not grossly explained here in their generic form. This is because of the fact that the study is confined to the examination of a particular objective. The objective of the study is to assess the impact of improved technology on particular types of food crops. Therefore, the major yield determinants taken into account in this study are technological, environmental and management factors. Furthermore, the study is confined to limited geographical area. That is to say, it is focused in one woreda and only in four PAs within the woreda in North Shewa of the Amhara Region.

All the PAs in which this study has been carried out represent the *Dega* agroecological zone that comprised of areas larger than 2700 meters above sea level. In addition, it is believed that sample households may not provide actual data on some of the variables such as the amount of yield they obtained. On the other hand, secondary data obtained from official sources may conceal some of the farmers' real situation for one or other reason. Although this may be the case, this study may provide an insight on the overall situation of cereal productivity and initiates further

research in the future on the same subject. Moreover, the result of the study may serve as a proxy to the productivity of the same crop types in other parts of the region or the nation that have the same agroecology and level of technology adoption. Finally, it would help to comprehend which type of technology contributes to the growth of productivity, given similar agroecological conditions in the region, in particular, and in the country, in general.

1.7 Organization of the Paper

Literature review, the objective and significance of the study, background, etc are discussed in the preceding section (section I). Section two explains the research design and the methodology including the hypothesis to be tested. The description of the study area is presented in part three. Section four provides the econometric results of this study and related issues. Factors that influence farm profitability and the level of profit from adoption of improved technology is discussed in section five. Section six tries to examine the factors that impede or necessitate technology adoption. Finally, section seven provides concluding remarks and policy implication of the findings of the study.

CHAPTER TWO

RESEARCH DESIGN AND METHODOLOGY

2.1 Data Source

The purpose to which this study is designed and the method of analysis employed demands the use of both secondary and primary data sources. The primary source mainly used to analyze the level of productivity. Furthermore, secondary data and information obtained from key informants (qualitative data in nature) are also used to describe the problem and prospects of technology adoption.

2.1.2 Secondary Data

The data from the secondary source mainly covered the period between 1995/96 and 1998/99. The data include the amount and type of improved inputs applied, the unit price of these inputs, the amount of credit made available, collected and uncollected, and problems related to the inputs and credit market, etc.

The above data were collected from official records of different institutions that include zonal and woreda agricultural offices, planning and economic development department (DoPED), Peasant Service Cooperatives' Promotion Office, Ambasel Trading House Private Limited Company and Amhara Credit and Saving Institute branch offices, and North Shewa Administration Zone Office. Furthermore, data on the Producers' and retail prices of major cereal crops was obtained from CSA's sample survey and North Shewa Trade and Industry Department.

2.1.2 Primary Data

The primary information data was taken from the Department of Economics of the fifth round rural household sample survey from November to December 1999 in Basona Worana woreda in North Shewa of the Amhara region.

The questionnaire used to undertake the survey comprised of broad category of data on the demographic and socioeconomic conditions of the woreda and all variables were collected through sample survey. The survey was conducted on 4 sample peasant associations (PAs) and enumerators managed the questionnaire. The enumerators were oriented on how to complete the questionnaire before undertaking the first round rural household sample survey. Therefore, it was believed that the enumerators could complete the required data on the questionnaire. Field supervisors assisted the enumerators.

The PAs in which this survey was carried out are Faji, Koremargefia, Karafino, and Melki. A total of 175 households from these peasant associations were covered by the survey. Among the total of sample households 127 were adopters while 48 were non-adopters. About 11 percent of the total adopters were participants in the new extension program in 1997/98-crop season.

Furthermore, unstructured questionnaire was designed to collect information from key informants, with the intention that such information would complement other sources. In this regard, about 30 key informants were selected from different

institutions. The key informants include executive members from zonal and woreda council and kebele administration, department heads of different offices, experts from both zonal and woreda councils, experts from extension department of zonal and woreda agricultural offices, extension agents/DAs, technology adopters and non-adopters farmers. The questionnaire was distributed for the upper level informants while for informants like kebele executive members and farmers, extension workers and other selected personnel administered the questionnaire.

Of the administered questionnaire 27 were returned with the required information while 3 of them were not returned. The status of questionnaire distributed with the respondent category is provided in table 2.1.2 below.

The data collected through this method were mainly qualitative in nature. Such information include the overall view on the significance of technology and level of technology adoption, the legitimacy of the recommended rates of application, agricultural input marketing and distribution, the main source of inputs, the amount of input credit made available by type of source, the selection procedure and criteria of credit receiving farmers and so on. Such data is believed to expedite the study's analysis in a more palatable manner.

Table 2.1.2 Status of Key Informants, Questionnaire Distributed and Returned

S. N	Respondent Category	Number of questionnaire			Remark
		Distributed	Returned	Returned as a% of distributed	
1	Zonal and Woreda council officials	2	2	100	Distributed
2	Department/Office Heads	6	4	66.7	''
3	Experts	6	5	83.3	''
4	Development Agents	3	3	100	''
5	Kebele Officials	3	3	100	Managed by field assistants
6	Farmers	10	10	100	''
	Total	30	27	90	

Source: Compiled from the results of Key Informants' questionnaire, February 2000.

2.2 Sampling Procedure

The survey has been carried in the area for five rounds to collect panel data on the socioeconomic aspects of the rural households. The PA's are the focus area of A.A.U/Economics Department to undertake the stated survey

The survey was carried out in 4 PA's that fall under 1 Kebele under the present rural administration setups. If we consider as a representative of sample of PA's out of a total of 102 PA's in Basona Worana, it would represent about 3.92 percent of the total PAs.

The total population in the survey area as of July 1, 1999 was 4480 with a total household number and average household size of 850 and 5.3, respectively. In addition, the sample population as of December 1999 was 848 or 18.9 percent of the total. The number of the

sample households was 175 or 20.6 percent of the total and the average household size was 4.8. The details of these indicators were given in Table 2.2.1

Table 2.2.1 Total Population size, Number of Households and Average household size in the survey area

Peasant Association	Total Population ¹			Sample Population ²			Sample population as a % of the total	
	Population size	No. of HHs	Average HH size	Population size	No. of HHs	Average HH size	Population	HHs
Fajji & Bokafia	1074	195	5.5	182	37	4.9	16.9	19.0
Koremargefia	1277	255	5.0	276	58	4.7	21.6	23.7
Melki	1239	229	5.4	277	56	4.9	22.4	24.5
Karafino	890	171	5.1	113	24	4.7	12.7	14
Total	4480	850	5.3	848	175	4.8	18.9	20.6

Source: 1) Estimated based on the 1994 population and Housing census, results for Amhara Region, OPHCC, 1995.

2) Results of the sample survey, December 1999.

2.3 Hypothesis

In the study area, where cultivation has long been practiced with centuries-aged techniques of production brought an appalling degradation of the soil. In addition, the opportunity to expand cultivation is closed due to shortage of arable land. Therefore, the alternative means of increasing the yield of food crops is possible through the application of improved technologies (Mulat, 1995; Mulat and Techane, 1999;), among others. In this regard, the widespread application of improved technologies, since recent years, has been practiced on demonstration plots as a way out for further dissemination. As a result, the yield obtained from demonstration plots showed dramatic yield increase in which wheat, teff and maize yield increased to 53.4, 25.8 and 58 quintals per hectare, respectively (Takele, 1996; and official reports). One study (Howard et al, 1999) showed that the application of improved technology on demonstration plots helped increasing the yield of maize and teff for adopters nearly more than double than traditional way of production. Further, a study made by Dejene and Yilma (2000) confirmed that adopters of improved inputs produce

more cereal output per unit of area than non-adopters; but the former less profitable than the latter.

Given these set of arguments, it is hypothesized that cereal yield/productivity is higher for adopters than for non-adopters. Nevertheless, the yield of adopters would not be as high as argued above and adopters are more profitable. To summarize, **the hypothesis of this study is that improved technology adopters could attain both higher yield and profit than non-adopters.**

2.4 Method of Analysis

The secondary data and information obtained from key informants were organized in accordance to the purpose in which this analysis was made. The primary data were entered, cleaned, and relevant variables were selected for analysis purpose. After completing such procedures, the data were analyzed using ratios, descriptive statistics, regression and cost-benefit analysis. Such methods of analysis were made depending on the scope and degree of sophistication that the analyzed subject demands.

The most prominent method employed to examine/analyze the impact of improved technologies on productivity is the regression analysis, among others. To work on the econometric analysis on yield determinants of cereal crops such as barely, wheat, and teff, a regression model was developed and the variables so far used in the model were specified.

2.4.1 The Regression Model

Selection of a functional form that can show the relationships between the dependent and independent variables has a considerable importance in econometric analysis. In many studies, different functional form was used that measures the relationships between the explained and the explanatory variables. Such models may measure the elasticity of substitution and the marginal

product. The type of models employed under such circumstances are usually non-linear that can be transformed into linear models to measure the second order effects. Such models that imply the elasticity of substitution or the marginal product with or without restrictive forms is the Translog and the Cobb-Douglas production function, respectively (Greene, 1997; Cook, S., 1998; Dorward, 1999; Felipe, J., 1999). However, in this study the linear regression model is used to measure farm productivity in relation to technology adoption and other major yield determinants. To arrive at this model, it is essential to define the generic form of the production function for the sample households' firm and this can be written as:

$$Y=f(X_1, \dots, X_i, \dots, X_n)+\epsilon \quad (1)$$

where Y is the mean cereal yield (the dependent or explained variable), X_1, \dots, X_n are different set of inputs (the independent or explanatory variables), and ϵ is the random disturbance term.

The above functional form indicates the rate of increase or decreases of the mean cereal yield per unit of a set of inputs. In this regard, the multivariate linear regression model is chosen because of its convenience and manageability to estimating the proportion of the regressand to a particular type of input (regressor), other inputs being constant. Yotopoulos (1967) argued that the choice of specific algebraic form for a production function can be made on the basis of the theoretical implications of the functions. The multivariate regression model, therefore, would take the form:

$$Y=\alpha+\beta_1X_1+\dots+\beta_iX_i+\dots+\beta_nX_n+\epsilon \quad (2)$$

where Y is the mean cereal yield, X_i are inputs, α is the constant, β 's are the coefficients of the unknowns, and ϵ is the disturbance term.

The Least Squares Estimates are used to estimate the unknown parameters (β 's).

2.4.2 Assumptions of the Model and Selection of Variables

The marginal productivity of each factor input is one of the crucial concepts in the production theory (Yotopoulos, 1967). Thus the partial derivatives of the mean yield with respect to a single input, other inputs being held constant, can manifest the marginal productivity. The marginal value of the parameter with respect to one input, X_i , can be written:

$$dY/dX = \beta_i A X_1^{\beta_1} \dots X_i^{\beta_i - 1} \dots X_n^{\beta_n} = \beta_i Y/X \quad (3)$$

then the marginal value under this multiple regression model will take the form:

$$dY/dX_1 = \beta_1; \quad dY/dX_i = \beta_i; \quad \text{and} \quad dY/dX_n = \beta_n$$

The marginal value (or in this study, the marginal productivity), therefore, implies a decrease or an increase in mean cereal yield per unit of a factor input, other inputs held constant. Hence, this is a property of the linear regression model employed in this study for estimating productivity.

Furthermore, the model involves a certain assumptions and these assumptions are discussed as follows.

- 1) the variance of the disturbance term (ϵ_i) is the same for all observations, i.e.

$$\text{var}(\epsilon_i) = E(\epsilon_i^2) = \sigma^2$$

- 2) there is serial independence of the disturbance term (ϵ_i). In other words, the covariance between the disturbance associated with the value of the regressand and that associated with other values of the regressand, given the corresponding j th observations, is zero, i.e.

$$\text{cov}(\epsilon_i, \epsilon_j) = E(\epsilon_i \epsilon_j) = 0 \quad \text{for all } i \neq j \text{ and for } i, j = 1, 2, \dots, n$$

3) the covariance between the disturbance term and the explanatory variables (regressors) is zero indicating the independence of ϵ_i and X_i , i.e.,

$$\text{cov}(\epsilon_i, X_i) = (\epsilon_i, X_i) = 0 \quad \text{for all } i, j = 1, 2, \dots, n$$

4) there is no serious multicollinearity between the explanatory variables. In other words, there is no exact linear relationship among the independent variables.

In addition, it is implicitly assumed that each of the error term (ϵ_i) is normally distributed. These assumptions of the least squares method may not exactly be satisfied due to the problem of estimation and interpretation in the process of data collection. However, applying statistical techniques, the variables that cannot satisfy the assumptions of the model will be rejected.

The analysis of econometric model requires a complete and correct specification of the variables so as to avoid omission of prominent variables from the function. Therefore, great care has been made in the selection and specification of the variables in question. However, all variables that determine agricultural production are not fully covered and specified in this model due to the peculiar nature of the objective set so far in this study. Thus, according to the objective, which this study tries to materialize, only the major yield determinants are chosen and specified. The following variables are, therefore selected and specified to fit our model and to test the hypothesis that is set in the study.

Yield: it is defined as the quantity of cereal output per hectare of farmland and is measured in terms of kg. This dependent variable is denoted by Y .

Fertilizer: chemical fertilizers such as DAP and UREA that are applied by farmers separately or in combination are taken as one variable. It is also measured in terms quantity applied on a hectare of farmland and its unit of account is kg. It is an independent variable and denoted as X_1 . Therefore, it is assumed that application of commercial fertilizer would increase the yield of adopters.

Improved seed: being an independent variable, improved seed applied on a hectare of land by adopters is taken into account to determine yield level. Its unit of account is kg. This variable is denoted by X_2 in the model. Hence application of improved seed with fertilizer can significantly increase yield.

Chemicals: insecticides, herbicides, fungicides, etc are categorized under this variable. Hence, the quantity of chemicals applied on a hectare of land is taken as a variable and it is implied by X_3 in the model. The Assumption here is that the application chemicals on pests/crop diseases and weeds reduce yield losses and then have a positive effect on the total crop yields.

Labor: it refers to the total man-days used to produce a certain crop on a hectare of land. Mesfin Mirotschie(1994) pointed out that the labor variable in the peasant farm sector is limited to adult labor(both male and female) aged between 15 to 59 years. However, in most developing countries child labor plays an important role in farm activities such as weeding, harvesting, threshing and transporting to the threshing site, among others. Given this holistic assumption, child labor used in farm activities of the above kind can be converted to adult male labor equivalents. However, the additions to yield as a result of a one additional labor in the farm activity is zero, i.e., the marginal productivity of

labor is zero (Lewis, 1954). Therefore with the assumption that the marginal productivity of labor is zero, the labor variable is excluded from the model.

Land quality: the land variable is measured in terms of land quality. The quality of land in the country as well as in the study area is heterogeneous. Further, agricultural land is not well classified in Ethiopia according to its quality and hence, it becomes more difficult to differentiate the land quality. However, the response of sample households based on the rough classification such as fertile (lem), semi-fertile (lem-Teuf) and infertile (Teuf) is taken as a proxy measure to the quality of land in the study area. Given this classification, land quality is categorized into Lem, Lem-Teuf, and Teuf. The land variable is taken as a dummy variable and symbolized as D_1 . Variable D_1 , thus, takes the value 1 if the land is Lem (fertile) and semi-fertile (Lem-Teuf) and 0, otherwise. Therefore, farm households with holding of Lem/Lem-Teuf (fertile/semi-fertile) can increase their yield significantly than those with Teuf or infertile farm plots.

Land Area: area covered with barely and wheat crops is taken as yield determinant and represented by X_4 . It is assumed that an increase in the cultivated area would have a positive effect on yield.

Education: the level of education that a farm household has could determine technology adoption and hence influences productivity. In this regard, it is taken as dummy variable and a household who has at least elementary education level (1-6) is taken as a threshold to education variable. It is denoted by D_2 in the model and taken as dummy variable. Therefore, it takes the value 1 if the household at least has a level of education of grades

1-6 and above, and 0, otherwise. Thus, farmers that attended formal education may possibly be adopters and hence yield would increase consequently.

Rainfall Distribution: the rainfall variable is measured in terms of its distribution rather than its quantity unit. Therefore, excellent and good distribution of rainfall is taken as one category while poor distribution as another. This variable is denoted by D_3 and entered the production function as dummy variable. 1 if the rainfall distribution is excellent/good and 0 if its distribution is poor or no rain at all. Thus, it is assumed Good/Excellent rainfall distribution over crop fields can increase yield.

Frost: frost is a serious problem in the study area and its occurrence may cause crop output loss to a larger extent. The farm households provide the occurrence of frost with a "yes" or "no" response. This variable, therefore, is taken as dummy and implied by D_4 in the model. Hence, 1, if households responded that there is crop damage by frost and 0, otherwise. The assumption here is the occurrence of frost would reduce yield and therefore negatively related to yield.

Crop Pests: crop pests would negatively affect yield if its intensity is high. The intensity of crop damage due to the occurrence of pests is grouped into heavy, medium, and low. Heavy and medium intensity may cause great damage to crops while that of low intensity cause little damage. Given this distinction, it is denoted by D_5 and considered as dummy variable. This variable would take the value 1 if the intensity is heavy/medium and 0, otherwise. Hence, heavy/medium intensity of crop damage by these factors can significantly affect yield in a negative direction.

Access to Extension Service: this variable is supposed to influence technology adoption and therefore help increasing productivity. Further, it improves traditional farming practices. The number of visits of the extension worker/DAs to farm households during critical farm operations would help them to acquire better knowledge of applying improved inputs and improves farming

practices. In the current extension system, the number of visit depends on the prevalence of copy farmers in the farmers' extension group. If the number of copy farmers, as membership, in the farmers' group, the number of visits of the DAs would be low on the premises that the copy farmers can introduce modern farming practices(Bureau of Agriculture for Amhara Region, 1999). Hence, this situation makes problem deciding how many visits can an extension worker makes to help the farm community. Nevertheless, the study assumes that it could be suffice for the extension worker to give technical advice for the farm community at least once during the critical farming operations such as planting/sowing or land preparation of the main season. Given this assumption, the variable is taken to be dummy and denoted as D_6 . Its value takes 1, if the farm household was visited at least once in the critical farming operations during the main season and 0, otherwise.

Although about nine major independent variables or yield determinants were considered in the model, few variables that have inconsiderate significance may be rejected.

CHAPTER THREE

DESCRIPTION OF THE STUDY AREA

3.1 Physical Features

3.1.1 Location and Size

The study area, Basona Worana woreda, is found in North Shewa Administration zone of the Amhara Region. It is located North East of Addis Ababa at about a distance of 130 km on the Addis-Dessie main road.

Basona Worana is bordered in the North by Tarmaber, in the South by Angollela Asagirt, in the East by Ankober woredas and in the west by Oromia Region. Moreover, it is one of the eighteenth woredas of Amhara North Shewa. The total area of the woreda is about 1394.56 sq. km that covers about 7.9 percent of the total zonal area(BoPED, 1999).

The survey area covered 1 Kebele Administration-Fajji- out of the total 17 in the woreda. In other words, it covers 4 former Peasant Associations(PAs) namely Fajji & Bokafia, Kormargefia, Melki, and Karafino, all of which are located within 4-10 km radius from the zone capital-Debre Birhan. Therefore, the total PAs covered in the study area about 66.7 percent of the PAs in the Kebele or about 4 percent of the total woreda.

3.1.2 Topography

The study area is characterized mainly by highland plateau, undulating terrain, and plain land which accounted for 50, 23, and 27 percent of the total area, respectively. Its altitude ranges between 1700 and 3000 meters above sea level.

3.1.3 Soils and Vegetation

The soil texture of the area is predominantly red clay soils, brown loam soils and heavy clay soil(vertisols) that accounted for 30, 9, and 52 percent of the total area, respectively(DoPED, 1999). The sample area/PAs are also characterized by such soil property. The highland plateaus of the study area are, therefore, characterized mainly by vertisols texture with poor drainage. Given such properties, the soils of the area have low organic content and it is susceptible to water lodging problem.

The area is generally devoid of vegetation cover and mainly characterized by scattered bushes, privately backyard woodlot, community forests, and state owned woodlot. The dominant tree in most woodlots is exotic type called Eucalyptus Globules. Poor vegetation cover coupled with susceptible nature of topographic features in the area caused severe soil erosion. In addition, steep slopes have already been under cultivation for centuries which in consequence have lost surface soil with exposed bedrocks. Thus, high degree of soil erosion contributed to severe decline of the fertility of the soil.

3.1.4 Climate

The woreda is divided into three main agroecological zones, namely the *Dega*, *Woina Dega*, and *Kolla* that accounted for about 55.1, 21.5, and 23.5 percent, respectively, of the total area. The survey area is found within the *Dega* agro-climatic zone. The Debre Birhan Meteorological Station is taken as a proxy measure of the rainfall and temperature for the area. Based on the recent records of this station(1993-1997), the mean annual rainfall is about 990mm. The rain is bimodal, i.e., short rainy season(February-April) and the main rainy season(July-September). In recent periods, rainfall distribution has become erratic and unreliable, particularly in the *Belg* (short rainy)season. Furthermore, the area can be characterized by very cool temperature with slight humid atmosphere. Given five years rainfall data, the lowest(0.2mm) and the highest(405mm) rainfall was recorded in December and July, respectively.

The mean annual temperature of the study area is 12.4⁰c, the lowest and highest average temperature being 14.8⁰c and 9.9⁰c, respectively. Under some circumstances the daily temperature would be below 0⁰c. the highest temperature was recorded between March and July while the lowest between October and December.

3.2 Demographic and Socio-Economic Characteristics

3.2.1 Demographic Characteristics

Under this sub-heading, the population characteristics both in the woreda and survey area will briefly be discussed. Note that the population estimates of various indicators are based on the 1994 Population and Housing Census of the country. The total population of the woreda, as of July 1, 1999, was estimated at 134828 of which male and female constitutes about 50.1 and 49.9 percent of the total, respectively(BoPED, 1999). The average growth rate of the population is 3.1 percent per annum. Population aged below 5 years accounted for about 18 percent of the total and male and female under this age category constitutes 18.3 and 17.6 percent, respectively. In addition, children aged under 1 accounted for 4.1% and 22.9% of the total population and children aged below 5 years, respectively.

The size of population aged between 0-14, 15-59, and 60 and over was 57422, 68267, and 9137, respectively. Population under the age cohort 0-14 and 60 and above are considered to depend on the economically active population, i.e., aged between 15-59(CSA, 1989). Therefore, the dependency ratio in the area is estimated to be 97.5 and the young dependency ratio being 84.1 which is the highest.

Table 3.2.1.1 provides essential population characteristics such as age and sex, male-female ratio. Moreover, the population density of the woreda is 96.68 per sq. km which is lower than the zonal average(100.49/sq. km).

Table 3.2.1.1 Population size by sex and age structure and sex ratio for Basona

Worana, 1999.

Age category	Population size by sex				Male-female ratio
	Total	Male	Female	%of the total	
0-4	23656	11824	11832	17.55	99.9
5-9	17760	8911	8850	13.17	100.6
10-14	16006	8124	7882	11.87	103.0
15-19	14017	7142	6875	10.40	103.8
20-24	11853	5983	5870	8.79	101.9
25-29	9623	4782	4841	7.14	98.7
30-34	7997	3900	4097	5.93	95.1
35-39	6572	3142	3430	4.87	91.6
40-44	5638	2703	2935	4.18	92.0
45-49	4870	2384	2486	3.62	95.8
50-54	4186	2090	2096	3.10	99.7
55-59	3511	1784	1727	2.60	103.3
60-64	2881	1485	1396	2.14	106.3
65 ⁺	6257	3356	2901	4.64	115.6
Total	134828	67610	67218	100	100.5

Source: Bureau of Planning and Economic Development-BoPED(1999), Bahir Dar.
 Note: ratios are computed on basis of the figures provided.

It is also important to note that the total population of the woreda is typically rural residents. The average household size is 4.6 and the total number of households, during the reference period, was 29247 which form about 8.6 percent of the total households of the zone. No available data is found on the fertility rate and infant and child mortality rates for the woreda. However, the rates of the zone for rural population are taken as a proxy for such variables in the woreda. To this end, the crude birth rate(CBR) and the general fertility rate(GFR) is 28.7 and 132 per 1000 mid-year population and 1000 women in the reproductive age, respectively. This implies that the total fertility rate (number of children a mother is likely to reproduce at the end of her reproductive period) is 4.7(OPHCC, 1996). Moreover, the infant and child

mortality rates are estimated at 101 and 145 per 1000 life births, respectively. The life expectancy is also estimated to be 53.7 years.

It is tried to indicate below the population characteristics for the survey area, i.e., for the four Peasant Associations-PAs. The total population of the survey area as of July1, 1999 estimated at 4480 of which male and female accounted for 50.4 and 49.6 percent of the total, respectively. The economically active population(aged between 15-59) was 2268 or 50.63 percent of the total while that of population under 15 and 60 and above years of age accounted for 42.59 and 6.78 percent. Based on this figure, the dependency ratio, therefore, is about 97.53 which is the same for the woreda. Table 3.2.1.2 provides the total population by sex, average household size and number of households by PAs. In terms of population size Fajji and Bokafia, Kormargefia, Melki, and Karafino constitute about 24, 28.5, 27.6, and 19.9 percent of the total population in the survey area, respectively. The average household size is 5.3 which is higher than the woreda average(4.6) and the total household number was 850 in 1999.

Table 3.2.1.2 Estimated population size by sex, sex ratio, and number of households by PAs, 1999.

Peasant Association	Population size by sex				Male-female Ratio	Average household size	No. of households
	Total	Male	Female	% of the total			

Fajji &Bokaf ia	10 74	531	543	24.0	97.7	5.5	195
Korema rgefia	12 77	655	622	28.7	105.3	5.0	255
Melki	12 39	642	597	27.6	107.5	5.4	229
Karafin o	89 0	431	459	19.9	93.9	5.2	171
Total	44 80	2259	2221	100	101.7	5.3	850

Source: Estimated and computed on the basis of 1994 Population and Housing Census, results for Amhara Region, OPHCC, 1995.

3.2.2 Socio-cultural Aspects

The dominant ethnic group settled in the woreda is Amhara. 97.4 percent of the population are Amharic language speakers while Oromigna and other languages constituted 1.25 and 0.85 percent.

With regard to religion, Orthodox Christian, Catholic, Protestant, and Muslim, comprised of 98, 0.06, 0.94, and 1.0 percent, respectively. From these figures one can understand that most of the population are Amharas, orthodox religion believers, and speak Amharic language(CSA, 1996).

3.3 Socio-Economic Conditions

3.3.1 Economic Resource Base

The woreda is endowed with water and land resources. To this end, the water resource endowments include unprotected/untapped springs, potential underground water and unexploited perennial rivers with a good potential for small-scale irrigation. There are about eight perennial rivers most of which drain to the Abbay river basin. The irrigation potential of these rivers is estimated at about 1771ha(DoPED, 1999).

The land use pattern in the study area is presented below. About 49995 ha of the woreda is cultivated or under temporary and permanent crops that has been intensively cultivated for centuries. Grazing land pattern of land use comprised of the third largest area in the woreda. The forest cover of the woreda is about 3.13 percent or 4365 hectare that largely composed of backyard woodlots, community forests and the Debre Birhan fuel wood forest. The latter alone constitutes for about 68.2 percent or 2979ha of the total forest cover. Marginal land the includes undulating terrain, plateaus, gorges and heavily degraded areas form the largest share in the land use pattern, i.e., about 42 percent. This indicates that the potential to expand cultivation is largely difficult. Moreover, the land, which is currently under cultivation, is also severely eroded and some of it may be converted into marginal areas in the near future unless alternative measures are taken.

Table 3.3.1.1 Land Use pattern of the Area

S.N.	Land use category	Coverage	
		Hectare	%
1	Area under cultivation	49995	35.85
2	Grazing land	20737	14.87
3	Forest/woodland	4365	3.13
4	Bushes/shrubs	5522	3.96
5	Settlement	740	0.53
6	Marginal land	56097	41.66
Total		139456	100.00

Source: computed on the basis of land use percentiles given by Department of Planning & Economic Development-DoPED, 1999.

The centuries plough-culture, rapid growth of population, and topographic factors have been the major causes of soil erosion. Due to severe decline of soil fertility, farmers have shifted their cropping mechanisms to grow *Sinar/Gerima* (which was a weed plant commonly found in wheat and barely) as food crop. Furthermore, rapid population growth and absence of job opportunities outside agriculture have caused land holding to decline over time. In this regard, the average farmland holding per household in the area is about 1.7ha. due to grazing land shortage, crop residues have long been used as cattle feed which otherwise would have been used as organic fertilizer.

3.3.2 Tenure and farming Systems

The tenure system in the woreda is land allocated to farm households by Kebele administration/PAs since 1975. As it is elsewhere in the country, land resource is under the public control and is subjected to redistribution as the will of the government.

In this regard, in 1996, land was redistributed in the woreda in accordance to land redistribution strategy of the region(Yigremew, 1997). During the redistribution process,

farmers that were categorized as 'bureaucrats' and 'feudal remnants' were made to have as low as 4 '*timads*', that is an equivalent of 1 hectare.

In addition, sharecropped, and rented-in land are other forms of tenure systems in the area. Therefore, it can generally be deduced from the nature of tenure that long-term security is absent. Furthermore, the survey results showed that the tenure types prevailed in the area, as respondent farmers feel, are kebele owned, sharecropped and private rented that accounted for 77.2, 19.4 and 1.8 percent, respectively.

The farming system in the area can be characterized by subsistence mixed small holder rain-fed agriculture. Crop production and livestock raising is common to the area. The 'plough-culture' dominates and it long lasts for centuries with unchanged techniques of production. Draft animals are the main sources of traction power and traditional tools such as plough, '*mofar*', '*kenber*', sickle, and hoe play an important role in the production of food crops (DoPED, 1995). Soil burning (locally known as the '*Gay*') is a common practice in the area in the belief that it improves the organic matter of the soil.

Farmers largely rely on the cultivation of cereal crops accompanied by pulses. Therefore, cereal crops have the largest share in terms of area and production. Table 3.3.2.1 provides the proportion of area coverage and average yield by major crop types.

Table 3.3.2.1 Area coverage and yield of major crops

Crop type	Area coverage %	Yield(qt/ha)	
		Without fertilizer	With fertilizer
Barely	20.9	10.6	16
Wheat	17.5	11	18
Teff	4.2	8	14
Sorghum	11.3	13	-
Horse bean	14.3	7	-
Chickpeas	8.3	9	-
Field peas	6.9	8	-
Lentils	4.9	4	-
Cow peas	3.4	8	-
Line seed	4.6	5	-

Source: Basona Worana woreda Agricultural Development Office, 1999.

From the table it can be observed that barely, wheat, horse bean, and sorghum are the dominant food crops in the area, according to their importance. Agricultural production and productivity is severely affected by declining soil fertility, drought and erratic nature of rainfall.

Livestock raising both as a source of traction power, food and cash income is a common practice. The livestock potential in the area is high and this is provided in table 3.3.2.2 below.

It can be observed from Table 3.3.2.2 that cattle and sheep alone constitute about 65 percent of the livestock population. Shoats are mainly used as a source of food and cash income; and equines for transporting goods. Despite high livestock potential, the prevalence of livestock diseases, shortage of grazing land/animal feed, lack of improved breed and poor management practices has made the sub-sector less productive (Department of Agriculture,1995).

Table 3.3.2.2 Livestock population by type, 1997.

Type of livestock	Number	% of the total	Average holding size/household
Cattle	78584	30.9	2.69
Sheep	86907	34.2	2.97
Goats	17526	6.9	0.60
Equines	14351	5.6	0.49
Poultry	56985	22.4	1.95
Total	254353	100.00	8.69

Source: Department of Planning and Economic Development, 1999.

3.3.3 Access to Social Infrastructure

Most of the population of the area has little access to education and they are dominantly illiterate. There are about 24 elementary and 2 junior secondary (grades 7-8) schools in the woreda of which only one junior secondary school is found in the survey area. Furthermore, the elementary school gross enrollment ratio was 43.64 percent in 1998/99.

Access to health institutions is another problem in the area. There is no any health institution in the survey area and people walk about 7-10 km distance to Debre Birhan to get health services. Given the number of clinics, (i.e., 4) the overall health coverage is about 29.7 percent, which is by far below the zonal average, i.e., 46.5 percent.

In 1997, about 3.2 percent of the population had access to latrine services. In addition, during the same period access to safe drinking water was 7.68 percent. It is important to note that there is no road infrastructure that connects distant kebeles to service centers.

CHAPTER FOUR

ECONOMETRIC RESULTS

4.1 Characteristics of Sample Farm Households

4.1.1 Land Holding Size and Socioeconomic Characteristics

Farmland holding of the sample households ranges between 0.5 and 7.0 hectares. In this regard, table 4.1.1 provides a brief summary of the land holding size of the sample households by peasant association.

Table 4.1.1 Number of Households with farmland size, total number of households and total farmland size

Peasant Association	Total sample HHs	Farmland size by number of HHs						Total holding size (ha)	Average holding size (ha)
		<0.5 ha	0.50-1.00 ha	1.01-1.50ha	1.501-2.00ha	2.01-2.50ha	>2.5 ha		
Fajji&Bokafia	58	5 (8.6)	12 (20.7)	8 (13.8)	9 (15.5)	14 (24.1)	10 (17.8)	103.28	1.78
Koremargefia	56	2 (3.6)	5 (8.9)	14 (25.0)	11 (19.6)	14 (25.5)	10 (17.9)	112.273	2.00
Melki	37	4 (10.8)	5 (13.5)	9 (24.4)	7 (18.6)	2 (5.4)	10 (27.0)	68.119	1.84
Karafino	24	3 (12.5)	5 (20.8)	4 (16.7)	5 (20.8)	4 (16.7)	3 (12.5)	37.688	1.57
Total	175	14 (8.0)	27 (15.4)	35 (20.0)	32 (18.3)	34 (19.4)	33 (18.9)	321.359	1.84

Source: Computed from the Sample Survey Data, December 1999.

Note: Figures in parenthesis are percents.

Table 4.1.1 indicates that the average farmland size is 1.84 hectare with the highest and lowest mean holding size of 2.0 and 1.57 hectare in Koremargefia and Karafino kebeles,

respectively. Nevertheless, when rented/ sharecropped out land is deducted, the mean size of own cultivated area is reduced to 1.54 ha for all crop grower sample households. In other words, the cultivators that grow cereal crops enhance their holding through sharecropped- and rented-in farmland. Furthermore, only small proportion of farm households (8%) owned less than 0.5 ha and households that owned 1.01-1.50 ha per head accounted for 20 percent while 19 percent owned holding size of larger than 2.5 ha per head. The above figures showed greater holding size as compared to the national average that explain considerable portion of farm households owned less than one hectare. This difference may be explained by the difference in the level of soil fertility deterioration in the study area. Due to poor condition of soil nutrients in the study area, farmers have already changed their crop cultivation mechanism, i.e., they have shifted from growing barely to *Sinar/Gerima*. The survey data showed that 68 percent of the sample households grew this crop on 17.4 percent of their farmland in 1998/99.

It is often argued that resource poor and female headed household's rented/sharecropped out their land. The survey data supports this argument. It depicted that about 1.5 and 19.1 percent of male- and female-headed households rented or sharecropped out their farmland. In other words, female-headed households accounted for about 81.8 % of the total households that rented or sharecropped out their

farmland. It should be noted that, of the total sample households about 73.1 and 26.9 percent were male- and female-headed households.

4.1.2 Characteristics of Adopters and Non-adopters

As it has been discussed in section 3 of the paper, most farmers grow cereals and pulses. The dominant cereal crop grown in the area is barely. Among the total sample households, about 93.7 percent or 164 of the total households cultivate the land while 6.3 percent never cultivated during the reference period. Barely and wheat growers accounted for 96.3 and 81.2 percent of the total crop grower households, respectively. Further, improved technology adopters on wheat and barely crops comprised of 69.9 and 75.3 percent, respectively. Table 4.1.2 provides the details of technology adopter and non-adopter households. It can be observed from the table that about 79.6 and 98.3 percent of the adopters used fertilizer only on wheat and barely fields. Improved seed with fertilizer is adopted only on wheat fields.

Table 4.1.2 Number of adopters by type of technology adopted on wheat and barely and non-adopters

S.N	Technology type	Adopters by crop type						Non-adopters		Total wheat and barely growers
		Wheat		Barley		Total		Wheat	barley	
		No.	%	No.	%	No.	%			
1	Fertilizer only	74	79.6	117	98.3	107	84.5	40	39	164
2	Fertilizer with improved seed	16	17.2	0	0	16	12.7			
3	Fertilizer with chemicals	3	3.2	2*	1.7	3	2.4			
	Total	93	100	119	100	126	100	40	39	164

Source: computed from sample survey data, Dec.1999

*chemicals applied on barely field is applied with local seed

The chemical inputs (herbicides and pesticides) used on wheat and barely accounted only for about 3.2 and 1.7 percent, respectively. In general, about 85, 12.6, and 2.4 percent of

the adopters used fertilizer only, fertilizer with improved seed, and chemicals, respectively.

The survey data exhibited that improved wheat seed adopters were low. The low proportion of improved seed applied can be attributed mainly to its critical shortage. The application of fertilizer without improved seed, therefore, may not have significant yield response. Further, barely growers do not use improved seed because of the unavailability of supply (DoA, 2000). Moreover, about 30 and 24.7 percent of wheat and barely growers are non-adopters, respectively.

Table 4.1.3 and table 4.1.4 provide with farm resource and education level and descriptive statistics of socioeconomic characteristics of adopters and non-adopters.. It is important to note that sample households could at the same time grow both crops. However, they are grouped into adopters of wheat and barely growers for the purpose of our analysis. The average land holding size for wheat and barely growers is 2.14 and 1.99 ha with a respective standard deviations (S.D) of 1.07 and 1.01. Both barely and wheat

growers have relatively larger size of land holding. Farmland size could determine technology adoption (Beyene, 2000; Dejene and Yilma). Table 4.1.3 can support this argument. For instance, adopters that own less than 1 ha accounted only for 6.3 % while that own land between 1 and 2 ha accounted for about 44.1 percent of which most of their holding size is larger than 1.5 ha. Households that own farmland size between 2 and 3,

and greater than 3 hectares accounted for 31 and 12.6 percent, respectively. Therefore, the level of adoption tend to increase with the increase in holding size, among others.

Table 4.1.3 Farm resources and education level of sample households

Farmers group	Farmland size (ha)				Number of oxen owned				Education level			
	<1	1-2	2.01-3.00	>3.00	No oxen	1 ox	2 oxen	>2 oxen	Never any formal schooling	Grade 1-6	Grade 7-8	Grade 9-12
Adopters (N=127)	8 (6.3)	56 (44.1)	47 (31)	16 (12.6)	2 (1.6)	11 (8.7)	93 (73.2)	21 (16.5)	59 (46.5)	47 (37)	8 (6.3)	13 (10.2)
Non-adopters (N=31)	6 (19.4)	20 (64.5)	4 (12.9)	1 (3.2)	6 (19.3)	8 (25.8)	15 (48.4)	2 (6.4)	18 (58.1)	11 (35.6)	1 (3.2)	1 (3.2)
Others* (N=17)	12 (70.6)	3 (17.6)	2 (11.8)	0	12 (70.6)	1 (5.9)	4 (23.5)	0	10 (58.8)	7 (41.2)	0	0
Total (N=175)	26 (14.9)	79 (45.1)	53 (30.3)	17 (9.7)	20 (11.4)	20 (11.4)	112 (68)	23 (13.2)	87 (49.7)	65 (37.1)	9 (5.1)	13 (8)

Source: Computed from Sample Survey data, Dec. 1999.

Note: Figures in parenthesis are percents calculated as a percentage of the respective group

* include households that grow other types of crops and those who do not cultivate(grow other type of crops =6; do not cultivate=11).

More than 50 percent of the sample households received formal education of which about 69.1, 11.8, and 19.1 percent attended elementary, junior and senior school education (Table 4.1.3). Non-adopters that received formal education accounted for 41.9 of the sample group. 46.5 and 58.1 percent of the adopters and non-adopters are illiterates/never attended any formal education. This figure depicts that adopters are better of than non-adopters in the level of education. It seemed that the level of household education is relatively high as compared to other areas because of the area's proximity to Debre Birhan town.

More than 11 percent of the total households has no oxen while households that owned 2 oxen and over accounted for about 68 and 13.2 percent respectively. moreover, adopters that owned no oxen, 1, 2, an more than 2 oxen accounted for about 1.6, 8.7, 73.2, and 16.5 percent, respectively. Similarly, more than 19 percent of the non-adopters has no oxen whereas that owned 1 ox and 2 oxen accounted for 25.8 and 48.4 percent.

It can be observed from Table 4.1.4 that the mean area covered with wheat crop is 0.46 ha with a S.D of 0.279 while for that of barely it is 0.76 and 0.459 ha, respectively. The mean area for wheat and barely crops for adopters is less than one hectare implying that

Table 4.1.4 descriptive statistics of socioeconomic variable for wheat and barely grower sample households.

Description	Wheat Growers(N=133)				Barely Growers(N=158)			
	Mean	S.D	Min.	Max.	Mean	S.D	Min.	Max.
Total farmland size(ha)	2.14	1.07	0.50	7.00	1.99	1.01	0.50	7.00
Age of household	53.8	15.92	21	95	55.4	16.3	21	95
Cropped area/ha*	0.464	0.279	0.063	1.50	0.762	0.459	0.125	3.00
Fertilizer applied kg/ha	121.44	54.8	0	250	119.29	56.2	0	260
Improved seed applied(kg/ha)	16.51	40.6	0	150	0	0	0	0

Source: computed from the sample survey data, Dec. 1999.

*Refers to wheat and barely area.

farmers could not use improved inputs on larger area. The mean fertilizer applied on all wheat and barely fields is 121.44 and 119.29 kg/ha with a S.D of 54.8 and 56.3. It is reported that the maximum amount of fertilizer used on wheat and barely fields is 250 and 260 kg/ha. According to the survey data, the total area under wheat and barely crops is 181.7 hectare while the total applied amount of fertilizer was 25489 kg. Taking into account these figures, the mean fertilizer applied on all barely and wheat fields would be 140 kg/ha. The average fertilizer applied on barely is relatively higher than the national average, i.e., 112.78 kg/ha(CSA,1999). It is also by far greater as compared from the Amhara region's average fertilizer applied on barely(i.e., 56.3/ha). Mean fertilizer application rate of adopters is below the recommended rate 150kg/ha for the area(BOA, 1999). All adopters used insignificant amount of chemicals. Considering the area under wheat, the average improved seed applied is 16.5 kg/ha (Table 4.1.4). Of the total 16 households that used improved seed, about 88 percent (or 14 households) are participants in the new extension program.

Table 4.1.5 Comparative Description of Adopters and Non-adopters of Wheat and Barely for Selected Variables.

Variable	Wheat Crop			Barely Crop		
	Mean		t-Test for paired samples	Mean		t-Test for paired samples
	Adopters	Non-adopters		Adopters	Non-adopters	
Household age	51.48 (19.)	54.9 (14.6)	-0.94	51.1 (18.3)	57.6 (16.4)	-1.49*
Household education	2.0 (2.63)	1.2 (2.15)	1.63*	1.82 (2.32)	1.13 (2.19)	1.32
Area under crop(ha)	0.478 (0.29)	0.42 (0.93)	1.26**	0.76 (0.46)	0.589 (0.41)	1.50*
Total farm size(ha)	1.9 (0.93)	2.01 (1.29)	-0.49**	1.82 (0.94)	1.56 (0.91)	1.22*
No. of oxen owned	2.13 (0.4)	1.9 (1.01)	1.33	2.13 (.38)	1.54 (0.94)	3.54***
Number of DA's visit (Access to extension)	0.15 (0.80)	0	1.18	0.23 (0.93)	0	1.548*

Source: Compute from Sample survey data, Dec. 1999.

*, **, *** are significant at 10, 5 and 1 percent and figures in parenthesis are standard deviations.

Table 4.1.5 provides a summary of descriptive comparison of wheat and barely adopters and non-adopters. Given the level of adoption, it is tried to describe the characteristics of households that used improved technology on wheat and barely crop using paired sample statistics. It is important to note that Tables 4.1.4 and 4.1.5 are quite different. The former provides the description on all households of wheat and barely growers while the latter refers to adopters from the total wheat and barely growers.

The mean education level(in grade level) for adopters on wheat and barely crop is 2.0 and 1.83 while it is 1.2 and 1.13 for non-adopters, respectively. The average total farmland size for adopters on wheat and barely crop is 1.9 and 1.8 hectare, respectively, with a standard deviation of 0.93 and 0.94. Similarly, the respective total farmland for non-adopters is 2.01 and 1.56 hectare. The average area under wheat and barely for adopters is 0.48 and 0.76 ha with a standard deviation of 0.29 and 0.46.

The above discussion could lead to the conclusion that technology adopters are better of than non-adopters in terms of land holding(only for barely growers), level of education and farm oxen possession. Although it seemed that the proportion of adopters from the sample is high, the quantity of improved inputs applied per hectare of farmland is below the recommended rate. For instance, about 26.8 and 32.8 percent of the total adopters applied fertilizer below 90 kg/ha on wheat and barely fields, respectively. Therefore, less of fertilizer application on cropped area would result in low yield response. Hence, along the expansion of fertilizer application, it is necessary to expand the extension service for agricultural households so as to generate rewarding crop yield.

4.2 Crop Yield Results

In this section, yield results from the sample data is presented. As it has been discussed in section 4.1.2, the dominant type of technology applied by the sample farm households is commercial fertilizer followed by improved wheat variety. Thus the yield variation comparison between adopters and non-adopters is presented from

the perspective of the difference in the level of technology adoption. Furthermore, the variation in wheat yield is treated through examining the effect of different types of input level application, i.e., yield across all adopters in aggregate input application, fertilizer with local seed and fertilizer with improved seed. In the case of barely, yield variation is explained by the application of only fertilizer with local seed. The yield results of wheat and barely are presented in tables 4.2.1 and 4.2.2.

4.2.1 Wheat Yield Results

The yield of wheat for adopters and non-adopters showed significant variation. The average wheat yield for adopters is by far greater than the yield obtained by non-adopters.

Technology application, therefore, can clearly explain yield variation. Although the limited type of technology adopted by wheat growers restricted the analysis of yield variation across different level of technology adoption, an attempt is made to explain the variation with the presentation of the available adoption level.

The average yield for adopters in the 1998/99 cropping season was 15.75 qt/ha that exceeded the national average (12.2 qt/ha) by 3.55 qt or by 29.1 percent. From the point of individual adopters the maximum wheat yield observed was as high as 40 qt/ha. This maximum yield level is almost nearly approaching the yield level (45qt/ha) obtained from the demonstration plots of the new extension program. On the other extreme, the average yield for non-adopters was 8.61 qt/ha that was by far lower than the yield for adopters. The average yield of adopters, therefore, was higher by 83 percent or by 7.1 qt than non-adopters' average yield. This yield variation clearly

demonstrates that the application of fertilizer both with local and improved seed can considerably increase yield. The yield obtained through the application of this mix of technology exceeded the average yield for North Shewa zone (i.e., 10.8qt/ha) by 44.6 percent or 4.9 qt.

It has been discussed in section 4.1.2 that 16 households applied improved wheat variety with fertilizer. Such level of technology adoption by far increased wheat yield. To this end, the application of fertilize with improved seed provide an average yield of 21.29 qt/ha far exceeded by 34.9 percent (or by 5.5 qt) than the average yield of all adopters.

Table 4.2.1 Wheat Yield results for adopters and non-adopters by level of technology Application.

Technology type	Adopters			Non-adopters		
	Yield (qt/ha)	Minimum	Maximum	Yield (qt/ha)	Minimum	Maximum
Fertilizer with local and improved seed	15.75*	5.33	40.0	-	-	-
Fertilizer with local seed	14.60**	4.0	40.0	-	-	-
Fertilizer with improved seed	21.29**	16.0	28.6	-	-	-
Local seed with no fertilizer	-	-	-	8.61*	4.0	16.0

Source: computed from Sample Survey data, Dec. 1999.

*Yield difference between adopters of fertilizer with local and improved seed and non-adopters is significant at 1%.

** Yield difference between fertilizer with local seed and fertilizer with improved seed adopters is significant at 5 %.

As it can be observed from Table 4.2.1 application of fertilizer with local seed provide promising yield results. The mean yield obtained through such level of technology application was 14.6 qt/ha slightly lower by 1.2 qt than the average for all adopters. Further, the yield for adopters of fertilizer with improved seed by far exceeded the yield for user of fertilizer with local seed, i.e., by 6.69qt or by 45.8 percent.

This greater yield variation explained the superiority of improved seed over the local ones when applied with fertilizer. Nevertheless, the highest yield was obtained from the application of local seed with fertilizer, i.e., 40 qt/ha; while that of improved seed with fertilizer provide a maximum yield of 28.6 qt/ ha. It is difficult to examine which factor contributes to this yield variation. However, the variation may be explained by the interaction of technological and environmental factors.

4.2.2 Barely Yield Results

Barely is the dominant crop in the study area and the least user of fertilizer with local seed. Barely growers has no access to improved barely variety and it was for this reason that the adopters never applied improved seed during the reference year.

Nevertheless, the application of fertilizer with local seed variety improved the yield of barely to greater extent. To this end, the average yield for adopters was 13.35 qt/ha. This average yield level exceeded the national average (,i.e., 11.9qt/ha) by 1.5 qt or 12.2 percent. Furthermore, the mean barely yield for adopters was higher by 4.77 qt than the zonal average (8.58qt) or by 55.6 percent.

The mean barely yield for non-adopters was 8.96 qt/ha. Fertilizer application on barely field with local seed increased yield by more than 50 percent or by 4.4 qt than the yield of non-adopters.

Table 4.2.2 Barely yield Results for Adopters and Non-adopters.

Technology Type	Adopters			Non-adopters		
	Yield (qt/ha)	Minimum	Maximum	Yield (qt/ha)	Minimum	Maximum
Fertilizer with local seed	13.35*	6.0	32.0	-	-	-
Local seed without fertilizer	-	-	-	8.69*	2.4	24.0
Total mean yield**	12.26	6.12	19.52			

Source: Computed from sample survey data, Dec. 1999.

*Mean yield variation between adopters and non-adopters is significant at 1%.

** indicates the overall mean barely yield for both adopters and non-adopters.

It is possible, therefore, to explain that application of fertilizer resulted in greater yield variation among adopters and non-adopters. Had improved seed been applied on barely fields the yield would have been increased much higher than its present level.

The maximum yield for adopters and non-adopters was 32 and 24 qt/ha, respectively. This yield results showed that the yield variation between adopters and non-adopters was relatively narrower than the variation between these group of farmers in the case of wheat

yield. It is hardly possible to explain this narrow yield variation between the two groups of farmers. Moreover, the minimum yield for adopters was too low (i.e., 2.4 qt/ha). This considerable yield decline may be attributed to environmental factors such as shortage of rainfall, frost occurrence and poor land quality, among others.

Given the present level of farmland shortage and soil fertility decline, the best alternative means of increasing yield is wider application of improved agricultural inputs (fertilizer and improved seed), at least in the short run. Therefore, farm households have to be encouraged to adopt improved technology so as to attain food security objective.

4.3 Econometric Analysis of Yield Determinants

Restating the linear regression model established in section 2.1 of equation 2, we obtain the following form:

$$Y = \alpha + \beta_1 X_1 + \dots + \beta_i X_i + \dots + \beta_n X_n$$

Where Y = the mean barely or wheat yield/ha, $X_1 \dots X_i$ = factor inputs and α and β 's are the constant and the coefficient of the parameters for the sample observation.

About 10 yield determinants (explanatory variables) were selected to fit into the model. Substituting these variables into the above model, we obtain the following form;

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 D_1 + \beta_6 D_2 + \beta_7 D_3 + \beta_8 D_4 + \beta_9 D_5 + \beta_{10} D_6 \quad (4)$$

where; Y = the mean yield (kg/ha)

X_1 = fertilized applied (kg/ha)

X_2 = improved seed applied (kg/ha)

X_3 = chemical applied (kg/ha)

X_4 = area under crop(ha)

D_1 = dummy for land quality, 1 if the farmland is lem and lem-teuf(fertile and semi-fertile), 0 otherwise.

D_2 = dummy for household education level, 1 if a household has attended grades 1-12, 0 otherwise.

D_3 = dummy for rainfall distribution, 1 if the distribution is good/excellent, 0 if poor

D_4 = dummy for frost occurrence to cause crop damage, 1 if yes, 0 otherwise.

D_5 = intensity of pests/plant disease occurrence to any crop damage, 1 if medium/heavy, 0 if light/none.

D_6 = dummy for access to extension service, 1 if households were visited by the DA at least once in the main season, 0 otherwise

α , β = the constant and parameter coefficients, respectively.

Applying the OLS method, the coefficients of the yield determinant variables were estimated. The estimation of the parameter coefficients is corrected for autocorrelation and heteroskedasticity. In addition, the estimation of the parameters was performed by the SPSS 9.0 for Windows and Limped 7.0 software. Although both software programs provide almost similar results, the Limped 7.0 software result was taken in most instances. This is not to mean that results obtained from SPSS 9.0 window software is rejected, however. Hence the best of the results that fit the model and the hypothesized results were taken into account.

4.3.1 Econometric Analysis of Wheat Yield Determinants

Examination of factors affecting wheat yield is crucial in analyzing the relative contribution of yield affecting variables (explanatory), i.e., to understand to which direction the variables influence wheat yield. In general, yield is affected by a number of interrelated causes that include factor inputs, management and environmental factors, among others.

It was hypothesized that all the selected variables could either positively or negatively affect wheat yield. Primarily, the variables were entered the model to check the existence of high association (multicollinearity problems) between the explanatory variables. The 'backward' parameter estimation procedure of the OLS method was used and the outcomes showed that some variables have high multicollinearity problems and thus rejected from the model. These collinearity problems appeared significant in the case of environmental factors with other explanatory variables. To this end, rainfall distribution (Dummy variable 3) have high association with land quality, fertilizer and access to extension. In addition, pest/ plant disease crop damage intensity (Dummy variable 5) tend to have collinearity problem with area. After correcting for multicollinearity problems, variables that significantly determine yield were made to fit our model. Moreover yield determinant results were also corrected for autocorrelation and heteroskedasticity. Consequently, the coefficients of the accepted variables (parameters) were estimated. Fitting the estimated coefficients of the independent variables that are significant at 1%, 5% and 10% into equation 5, we obtain the form:

$$Y = 812.32 + 4.07X_1 + 4.66X_2 + (-235.62)X_4 + 322.59D_1 + 208.74D_6$$

The coefficients indicate the increase(decrease) in wheat yield as the result of one unit increase(decrease) in the independent variables. Table 4.3.1 provides the results of regression analysis of wheat yield determinants. It can be observed from the table that most yield determinant variables are significant at 1%. The contribution of each yield determinant is discussed below.

Technology Factors: wheat yield has positive direction across all technology types adopted by the farm households explaining that adopters obtain higher yield than non-adopters. Note that the coefficients of the technology variables explain the direction of yield by type of technology adopted.

That is to say a unit of increase or decrease in any of the technology types would result in an increase or decrease in wheat yield. The results of regression analysis depict that application of 1 kg of fertilizer increased yield by 4.07 kg or an application of the recommended rate of 150 kg(100 kg DAP + 50 kg UREA) could increase yield by 6.1qt , other variables being constant. Similarly 1kg application of improved seed increased wheat yield by 4.66 kg or an application of the recommended seed rate of 125 kg would increase wheat yield by 5.82 quintal. Therefore, it can be inferred that the application of technology increased yield for adopters as expected in the hypothesis.

Table 4.3.1 Results of the Regression Analysis Affecting Wheat Yield.

Explanatory Variables	Coefficients	S.E Coefficients	T- Ratios	Sig. T
Constant	812.82	108.55	7.49	0.000
Fertilizer applied (X ₁)	4.07	0.58	7.09	0.000* **
Improved seed applied (X ₂)	4.66	1.14	4.09	0.000* **
Area under wheat(X ₄)	-235.62	135.67	-1.74	0.085*
Land quality(Dummy 1) 1= if the land is <i>Lem/Lem-Teuf</i>	322.60	92.97	3.47	0.001* **
Education level(Dummy 2) 1= if attended grades 1-12	-57.96	77.49	-0.75	0.456
Frost occurrence (Dummy4) 1= if yes	48,28	105.09	0.46	0.647
Access to extension(Dummy 6) 1= if visited at lest once by DAs	208.74	106.02	1.97	0.051* *
R ² = 0.54 F[7 125] =20.82 N= 133 Adjusted R ² = 0.51 Durbin-Watson Test = 1.86 Dependent Variable(Y) = Wheat Yield				

Source: Estimated from Sample Survey Data, Dec. 1999.

*, **, ***. Significant at 10, 5, and 1 percent, respectively.

Farmland: it is unfortunate to obtain result that shows negative relationship between area and yield. It was hypothesized that yield would linearly increase with the increase in farm area. For instance, Befekadu and Berhanu, N.(1999/2000) pointed out that the increase in cereal yield in the past half a decade is due to area expansion. However, the finding of this study showed a decline in yield with an increase in the area. To this

end, the result showed that a hectare of farmland increase would cause yield to decline by 235.62 kg(2.36 qt/ha). This result signifies the inverse relationship (IR) between farm size and productivity.

Therefore, it is most likely to obtain such inverse relation ship between farm size and productivity in a subsistence agriculture and the findings of this study also confirms this situation.

Environmental Factors: environmental factors such as rainfall distribution and pest/plant disease intensity were excluded from the model due to high collinearity problem. Further, the yield determinant such as land quality was only accepted in the model. Therefore, the only factor that accepted as significant in explaining yield was land quality(D1). Farmland categorized as *Lem/Lem-Teuf* (fertile/semi-fertile) increase wheat yield by 322.60 kg or 3.2 qt. In other words, the quality land owned by the farm households being *Lem/Lem-Teuf* can have substantial effect on yield.

Education: households that attended formal education between grades 1-12 were considered to influence productivity. Nonetheless, it was found less significance in explaining yield variation. And yet it is negatively related to the dependent variable- wheat yield.

Access to Extension: agricultural extension service can successfully enhance yield through improving farm management practices and further influences technology adoption. Households that have access to extension service can maximize yield than

adopters who have no access. As expected access to extension service showed a positive relationship with wheat yield. Hence, this variable could increase wheat yield by 2.09 qt for adopters and it is significant at 5 percent.

4.3.2 Econometric Analysis of Barely Yield Determinants

Factors that affect barely yield are closely examined through the use of regression analysis. It was hypothesized that all factors affecting wheat yield would also affect barely yield. However, technology adopters that grow barely had never applied improved seed variety and the quantity of chemicals applied was insignificant. Thus, both variables were automatically rejected from the model. The rest of the variables that entered in the model to explain wheat yield determinants were also used for barely. The regression analysis results of barely yield determinants indicate only 3 out of 8 variables are significant in explaining barely yield variation. Explanatory variables whose significance vary between 20 and 40 percent were household education level(D2), rainfall distribution, pest/crop disease damage intensity, frost occurrence and access to extension service. It is true to happen multicollinearity problem in cross-sectional data (Greene, 1997) and this problem appeared to be the major factor for more variables to show poor impact on barely yield.

All accepted variables but area under barely showed a positive relationship with barely yield. This relationship is consistent to the expectation of the hypothesis. Hence, the estimated coefficients of the parameters entered the original regression model to give the form:

$$Y = 693.36 + 2.87X_1 + (-147.86)X_4 + 481.37D_1$$

All variables are significant at 1 % in explaining yield variation. All the visible output of the regression analysis are presented in Table 4.3.3.

As expected fertilizer application increased barely yield. In this regard, barley yield increased by 2.87qt per 1qt application of fertilizer. Area under barely showed also negative relationship with barely yield. An increase in farmland by one hectare could reduce yield by 1.5 qt/ha, on the average(see in section 4.3.2 for the explanation). The effect of land quality on barely yield perfectly explained our hypothesis that it has positive association with yield. Consequently good land quality increased barely yield to 3.4 qt per hectare.

It can be argued that technology adopters can increase yield by the amount that the technology generates over non-adopters. More importantly, fertilizer, and land quality significantly determine barely yield in positive directions. Further, area expansion across barely crop has a negative consequence on barely yield.

From the above econometric results of yield determinants for adopters and non-adopters, we can conclude the following. First, yield results for technology adoption is consistent with the theories and past practices that stated technology adoption can increase yield and thus our result confirms this argument. Second, under condition of fertilizer application with local seed wheat and barely yields tend to increase considerably.

Table 4.3.2 Regression Analysis Results of Barely Yield Determinants

Variables	Coefficients	S.E Coef.	T-ratios	Sig T
Constant	693.36	97.96	7.08	0.000
Fertilizer applied(X_1)	2.87	0.50	5.74	0.008*
Area under barely(X_4)	-147.86	54.26	-2.73	0.007*
Land quality(Dummy1) 1= Lem /Lem Teuf.	343.91	60.51	5.68	0.000*
Household education(Dummy2) 1= if education level is grades 1-12	74.69	58.64	1.27	0.205
Rainfall distribution(Dummy3) 1=if Good/Excellent	104.60	86.51	1.21	0.229
Frost occurrence(Dummy4) 1=if yes	65.14	88.95	0.72	0.465
Pest/crop disease intensity(Dummy5) 1= if Medium/Heavy	-115.77	83.91	-1.38	0.169
Access to extension (Dummy6) 1=if visited at least once	67.07	75.64	0.89	0.377
Log-Likely hood Ratio= -1152.18		Adjusted R^2 = 0.40		
Restricted Log-Likely hood= -1197.80		Durbin-Watson statistic= 1.98		
R^2 = 0.44		Dependent Variable(Y) = Barely Yield		
Chi-square(8)= 19.40 with 8 DF.				

Source: Estimated from Sample Survey Data, Dec. 1999.

*. Significant at 1%.

Third, there is an inverse relationship between farm size and productivity that explain where area under crop increases yield tend to decline. Finally, yield determinants considered commonly entered in the model for both adopters and non-adopters showed greater significance in determining yield for adopters. This may explain the difference between adopters and non-adopters in the possession of land quality, access to extension and education level.

CHAPTER FIVE

FINANCIAL ANALYSIS

In section 4, yield results were presented and factors that determine yield in a positive or negative direction were well presented. The yield analysis results expound that improved agricultural technology adoption significantly increase yields. Therefore, it is essential to assess whether yield increase resulting from technology adoption is financially profitable or not. In addition, the financial profitability status of adopters and non-adopters is also thoroughly analyzed and presented. This comparison of financial returns for adopters and non-adopters would prove the hypothesis that states: although technology adoption require additional costs such as labor, cost of fertilizer, improved seed, chemicals, etc over the traditional practices, the yield that these factors of production generate could offset the additional costs.

5.1 Methods and Assumptions Used in Computing Financial Profitability

In computing the financial profitability of barely and wheat yields, different data source and price scenarios were used. In this instance, primary and secondary data were used for computational purposes. The cost of producing a specific crop yield and the period in which that crop is sold determine its profitability. The cost components that should have entered in the computation of financial profitability are, costs of improved inputs, local seeds, hired labor, oxen, depreciated value of farm implements and farm animals, interest paid for input credit, and the cost of sacks used to transport the products to market. In this regard, the depreciated value of farm implements and

animals and the cost of sacks were not included in the computing financial profitability due to data limitation. Nonetheless, it is assumed that both adopters and non-adopters use the same type of farm implements and farm animals and the difference in the cost of maintenance is not significant.

The costs of other inputs were obtained from the survey data and the price of inputs from CSA (1999) sample survey on retail prices of goods and services and producers' prices in rural areas. Furthermore, cereal retail prices at Debre Birhan town were also taken from North Shewa Trade and Industry Department. Due to the proximity of the study area to Debre Birhan town the retail price of wheat and barely was taken as a proxy measure of farmgate price. It may not be a mistake to use this retail price as a proxy measure of farmgate price of wheat and barely for the area in the absence of any alternative unit of measurement. Thus, multiplying this price by the total volume of wheat and barely output would give the gross value of production (gross income).

The price of improved inputs (fertilizer, improved seed, chemicals) was take from Ambasel Trading House Pvt. Ltd. Co. and woreda agricultural office. These prices were multiplied by the respective total quantity of inputs used to produce the commodity in question to obtain the cost of production. In addition, the quantity of local seed applied was also multiplied by the retail prices. Interest payment was estimated from the survey data. That is the amount of loan that farmers received in the reference period were multiplied by the reported amount of interest rate, i.e., 12.5%. Purchased animal feed, medicine and other treatment outlays were taken from the

survey data as reported by sample farm households. Further, animal feed from own source (crop residue) was considered as costs but it was excluded from the computation because of data limitation on the price of crop residue. Under these circumstances, it is heroically assumed that farmers that feed their animals from their own source do not have significant cost difference. Moreover, the value of crop residue can be considered as an imputed benefit to farmers but we failed to estimate its value due to the reason stated above.

Family labor used in the production of wheat and barely crops was converted into adult equivalent labor days. In this regard, the average conversion factors for male, female and child labor used in the calculation were 0.72, 0.55 and 0.2, respectively. It is important to note that these conversion factors were adopted from Yotopoulos (1967) and Abebe, H.(No date). Family/ mutual labor in adult equivalents was, therefore, used to calculate the net income per Labor Day. The method used to arrive at net income per family/mutual adult equivalent days was by dividing the net income per hectare by the number of family/mutual labor adult equivalent labor days(Howard *et al*, 1999). This net income per hectare could show income differentiation between technology adopters and non-adopters.

It is worth mentioning to calculate the net returns per hectare from the point of different price scenarios so as to reflect the opportunity cost of selling the crops at different period of time (Howard *et al*, 1999). To this end, January, April and July 1999 prices were taken to compute the net returns of farmers from producing wheat

and barely. In the calculation of net returns from selling at different periods, the cost of storage in terms of the cost of protecting from insect damage was not included. The assumption here is that output loss would occur from pest damage in the store due to cold temperature. Hence, the cost of chemical to protect pest would be insignificant. In addition, net income per hectare is also computed by taking into account the hypothetical drop in output prices 25 % and 50 % from the January 1999 levels. Moreover, the annual average output prices were used to calculate the level of profitability and benefit-cost ratio.

Wheat and barely cereals are traded commodities. It could have been useful to look into the economic feasibility of producing of these crops. But due to the scope and the objective set in this study, we exclude the economic analysis of producing wheat and barely from the discussion.

5.2 Profitability Analysis of Wheat

The result of financial analysis for wheat demonstrates that both adopters and non-adopters earn profit from producing wheat. Table 5.2.1 provides a summary of financial analysis for wheat crop. Net income per hectare for adopters is higher than for non-adopters, however. Gross income per hectare for adopters at January, April and July 1999 prices was Birr 2520, 2866, and 3307, respectively, while that of the respective gross income for non-adopters was Birr 1378, 1567 and 1807. The total cost of production (expense) for adopters and non-adopters was Birr 598 and 271 per hectare, respectively.

Net return(income) for adopters at January price for adopters and non-adopters was Birr 1922 and 1107 per hectare. In this instance, the net income per hectare for adopters at January, April and July 1999 prices exceeded that of the net income per hectare of non-adopters by 73.6, 77.7, and 76,1 percent, respectively. Further, it is possible to increase the income of farmers by selling when output prices are improved. In this instance the net income per hectare at April and July 1999 prices increased by 11 and 31 percent over the January level for adopters. In general, application of improved technology could generate net income per hectare by more than 73 percent over the traditional practices.

Net returns per family labor day for adopters and non-adopters at January 1999 price was Birr 8.1 and 9.0, respectively. The net income per labor day for non-adopters is relatively higher than that of adopters. This income differential may arise from the fact that technology adopters may use more labor than non-adopters and hence the net income per labor day for adopters would decline. The net income per labor day is higher by about 50% than the average daily wage rate(i.e., Birr 4.5/day) in the area. Therefore, it can be concluded that technology adoption is more profitable than traditional practices.

Table 5.2.1 Financial Analysis of Wheat Yield under Different Price Scenarios.

S.n	Description	Adopters(N=93)	Non-adopters(N=40)
1	Yield (qt/ha)	15.75	8.61
2	Family/Mutual Labor (adult equivalent labor days/ha)	236	123
3	Gross income (Birr /ha)		
3.1	At January 1999 price	2520	1378
3.2	At April 1999 price	2866	1567
3.3	At July 1999 price	3307	1809
4	Total Expenses(Cost of production) –Birr/ha	598	271
4.1	Cost of Fertilizer(DAP +UREA)- Birr/ha	292	0
4.2	Seed costs(Local+Improved)-Birr/ha	274	250
4.3	Cost of Hired Labor(Birr/ha)	11	9
4.4	Other costs(Interest payment, Purchased animal feed and Medicine/ Vet. Service(Birr/ ha)	20	12
5	Net income (Birr/ha)		
5.1	At January 1999 price	1922	1106
5.2	At April 1999 price	2268	1276
5.3	At July 1999 price	2709	1538
6	Net income per Family/Mutual labor days(Birr/ha)		
6.1	At January price	8.14	9.0
6.2	At April price	9.61	10.37
6.3	At July 1999 price	11.48	12.5

Source: 1) Computed from sample survey data, Dec. 1999.

2) Secondary Data on the prices of inputs and output.

Note: Grain retail prices recorded by Zonal Trade and Industry Department was used as a proxy to farmgate price.

5.2.2 Profitability Analysis of Barely

Like that of wheat crop, barely adopters earn more income than non-adopters do. The result of financial analysis for barely crop is presented in Table 5.2. The total family/mutual labor day used to produce barely was 170 and 110 per hectare for adopters and non-adopters, respectively. The gross income for adopters and non-adopters at January price was Birr 1668 and 1120, respectively while the respective total expenditure was Birr 497 and 188 per hectare. The cost of production incurred by adopters is far higher by 164 percent than non-adopters' costs.

Net income at January, April and July 1999 price was Birr 1261, 1572 and 1905 per hectare, respectively for adopters, while to that of non-adopters it was Birr 948, 1201, and 1425 per hectare. The net income difference between adopters and non-adopters was more than 30 percent, i.e., the net income of the former exceeded the latter by 30 percent. The income difference between adopters and non-adopters under the case of barely is relatively low as compared to wheat crop. The reason for this low difference may arise from low difference in yield. Non-adopters in the study area used the traditional practice known as '*Gay*' (burning of the soil) so that yield could increase for the year that this practice was carried out.

The net income per family/mutual labor day for adopters and non-adopters at January 1999 price was Birr 7.29 and 10.18/ha. In this case the net income of adopters was larger by 46.8 percent than the net income of adopters per family/mutual labor day.

However, the net income per family/mutual labor day for adopters is still higher by 62 percent than the average daily wage rate in the area.

Table 5.2.2 Financial Analysis of Barely Yield under Different Scenarios.

Sr. N.	Description	Adopters(N=119)	Non-adopters (N= 39)
1	Yield (qt/ha)	13.35	8.69
2	Family/Mutual labor (adult labor equivalent day/ha)	173	110
3	Gross Income (Birr/ha)		
3.1	At January 1999 price	1668	1120
3.2	At April 1999 price	2069	1389
3.3	At July 1999 price	2402	1613
4	Total cost of Production (Birr/ha)	497	188
4.1	Cost of fertilizer	309	0
4.2	Cost of seed (Local seed only)	170	172
4.3	Hired labor cost	24	7
5	Net return(Income) Birr/ha		
5.1	At January 1999 price	1261	948
5.2	At April 1999 price	1572	1201
5.3	At July 1999 price	1905	1425
6	Net Returns(Income) per Family/Mutual labor day (Birr/ha)		
6.1	At January 1999 price	7.29	10.18
6.2	At April 1999 price	9.99	12.60
6.3	At July 1999 price	11.01	12.95

Source: 1) Computed from Sample Survey Data, Dec. 1999.

2) Secondary Data From CSA, Trade and Industry Department and the like were also used.

5.2.3 Sensitivity Analysis, Benefit-Cost Ratio and Level of Profitability

This section presents financial returns of a hypothetical fall in output prices by 25% and 50 % below the January 1999 levels, and benefit-cost ratio and the level of profitability. In computing returns from selling output when prices declined by 25 % and 50 % below the January levels storage cost were not included for reasons explained before. Table 5.2.3 presents the level of returns under price drop scenario.

Although output price declined by 25% and 50%, net returns for both adopters and non-adopters showed a positive direction. Net income for adopters on wheat and barely crops was Birr 1292 and 755 per hectare, respectively, under a hypothetical output price decline of 25% below its January level. In addition, at a 50% decline in output prices the net income for adopters was Birr 662 and 337 per hectare, respectively. The net return from wheat at a 50% and 25% price decline showed a 65.6 and 32.8 percent decrease as compared from the January 1999 price levels. Similarly, net income from barely(for adopters) declined by 73.3 and 40.1 percent.

With a 25% drop in out prices, net income per labor day for wheat and barely growers that used fertilizer was Birr 5.47 and 4.36/ha, while for those of non-adopters it was Birr 6.2 and 5.7/ha, respectively. Under this scenario net income per labor day for wheat and barely crops(adopters) declined by 25 and 40 percent.

It is interesting to mention that under price decline in output prices by 25%, net income for adopters and non-adopters on wheat was still higher than the average daily wage rate(Birr 4.5) for the area. Further, it is also interesting to note that the net income per labor day was higher for non-adopters than adopters. This situation demonstrates that technology adopters incurred higher labor costs with regard to land preparation, fertilizer application weeding and threshing activities and thus may not be profitable or earn attractive return per labor day as prices of output severely declined.

The benefit-cost and profitability ratios are also used to assess whether technology adoption is financially feasible or not. The income was calculated based on the annual average farmgate prices. In addition, the family/mutual labor in adult equivalent labor day per hectare, at this stage, was taken as cost of production rather than the earlier assumption of opportunity cost concept. In this regard, the cost of labor was calculated multiplying the labor days by the average daily wage rate reported by sample households(i.e., Birr 4.5/day/labor).

Table 5.2.3 Returns with a hypothetical decline in output prices by 25% and 50% below January 1999levels.

Sr.n	Indicators	Wheat		Barely	
		Adopters (N=93)	Non- adopters (N=40)	Adopter s (N=119)	Non- adopters (N=39)
1	Yield(qt/ha)	15.75	8.61	13.35	8.69
2	Family/Mutual labor(adult equivalent labor days/ha)	236	123	173	110
3	Total expense(Birr/ha)	598	271	497	188
4	Net Income(Birr/ha)				
4.1	At January 1999 price-25% decline	1292	762	755	627
4.2	At January 1999 Price-50% fall	662	513	337	355
5	Net income per labor day(Birr/ha)				
5.1	At January 1999 price-25% fall	5.47	6.20	4.36	5.70
5.2	At January 1999 price-50% fall	2.81	4.17	1.95	3.22

Source: 1) Calculated from Sample Survey data, Dec. 1999.

2) Prices of inputs and Output for estimating income and expenses is obtained from secondary sources.

Given the assumption and methods used, the gross income for wheat and barely (adopters) was Birr 2833.98 and 1997.16 per hectare, respectively. In addition, the total expense for adopters and non-adopters on barely and wheat crops was Birr 1660, 824.50, 1275.50, and 683.0 per hectare, respectively. The total expense demonstrates that the cost of producing a quintal of wheat and barely under fertilizer application was Birr 105.4 and 95.54/qt implying that the cost of producing one quintal of wheat exceeded the cost of producing a quintal of barely by 10.3 percent.

Table 5.2.4 Summary of Costs, Income and Benefit-Cost Ratio for Adopters and Non-adopters.

Sr .n	Indicators	Wheat		Barely	
		Adopters (N=93)	Non- adopters (N=40)	Adopters (N=119)	Non-adopters (N=39)
1	Yield (qt/ha)	15.75	8.61	13.35	8.59
2	Gross Income(Birr/ha) ¹	2823.98	1543.77	1997.16	1300.02

income. Such condition could lead to the conclusion that fertilizer application can generate sufficient income for adopters. Net income for fertilizer users on wheat and barely was Birr 1663 and 721.66 per hectare, respectively. Fertilizer application on wheat was more profitable or generates net income that exceeded fertilizer application on barely by 130 percent. It can also be observed from the table that net income obtained from wheat without fertilizer application was nearly equal to the income of adopters on barely crop. In both situation producing wheat crop provide sufficient income and it may be for this reason that its production cost was high. The reason for the relatively higher costs of wheat production is that it heavily requires more labor than that of barely production.

The benefit-cost ratios also showed that both adopters and non-adopters largely benefited from producing these crops. To this effect, the ratios demonstrate that the benefits of adopters on wheat and barely crops far exceeded the total costs of production by 70 and 57 percent, respectively. Moreover, farmers that do not use fertilizer on both crops also obtain benefit(income) that exceeded the respective costs by 87 percent. Therefore, the benefit-cost ratio also demonstrated that wheat was attractive in income than barely and technology adoption require additional costs over the traditional practices.

Lastly, financial profitability was also examined using the concept of value-cost ratio (VCR). Value cost ratio explains the level of profitability of additional yield resulting from fertilizer application. In this respect, the regression analysis results for wheat and barely (see section 4.3.1 and 4.3.2) showed that an application of 100kg fertilizer per hectare on wheat and barely could generate additional yield of 407 and 278 kg/ha, respectively. Therefore, these yield levels are taken as the main focus of value cost ratio. Table 5.2.5 provide the result of value-cost ratio analysis on barely and wheat crops.

The value-cost ratio concept depicts that a ratio of 2:1 or a profit level of 100 % and above is taken as a yardstick to measure the level of profitability. Based on this premises and the results indicated in the table 5.2.5, application of 1 quintal of fertilizer on wheat and barely crop provides us value-cost ratio of 2.80 and 1.60, respectively. This result demonstrates that fertilizer application on wheat is more profit responsive than applying it on barely, i.e., the level of profitability from wheat is 180 percent and it is promising. On the contrary,

Table 5.2.5 Value-Cost Ratio (VCR) Analysis of wheat and barely crops for fertilizer Users.

Sr.n	Indicators	Crop Types	
		Wheat	Barely
1	Fertilizer Applied (qt/ha)	1.00	1.00
2	Yield attained from fertilizer application(qt/ha)	4.07	2.78
3	Cost of fertilizer(Birr/qt)*	260	260
4	Gross Value of output**	730.00	416.00
5	Value-Cost Ratio(4/3)	2.80	1.60

Source: Computed from the econometric yield results in section 4.3.1 and 4.3.2.

*.It is assumed that only DAP is applied and its unit price is Birr 260 per quintal.

** . Obtained multiplying the total additional yield by the average annual prices of wheat and barely(Wheat= Birr 179.3/qt; Barely= Birr 149.6/qt).

application of fertilizer on barely crop provide a profitability of below 100%, i.e., 60 percent and therefore it is sensitive to risks to apply fertilizer. Finally, the financial analysis of wheat and barely crops, in all cases, has showed that wheat is more responsive to fertilizer application in generating sufficient income and profitability.

CHAPTER SIX

6. FACTORS AFFECTING TECHNOLOGY ADOPTION

Technology adoption has robust effect on crop yields. That is to say, the application of modern agricultural inputs notably fertilizer has significant impact on barely and wheat yield. The results of the study presented in section 4 and 5 clearly indicates that the use of improved agricultural technology resulted in higher crop yield and relatively better income for the adopters. In addition, the result further indicates that technology adoption is financially profitable. Although the application of improved technology has brought substantial yield increase, there are a number of problems associated with its adoption. Hence, examining these constraints is equally important.

The result of the survey data and information obtained from key informants showed that there are a number of policy and operational problems in technology adoption. The constraints in technology adoption in turn largely affect the overall increase in agricultural productivity. The major factors that affect technology adoption associated with the problems of input marketing and distribution, input credit, poor extension management and lack of linkages between research and extension. How these factors affect technology adoption in general and productivity in particular will thoroughly be discussed below.

6.1 Trends and Problems in Input Marketing and Distribution

6.1.1 Fertilizer Marketing and Distribution

Chemical fertilizer is one of the prominent agricultural inputs that help increasing the productivity of food crops. It is for this very reason that the new extension program recognized the wide spread of fertilizer application as a means of increasing cereal yield (Takele, 1996; Mulat, 1996; Mulat and Techane, 1999). The consumption of fertilizer increased both at the national and regional level since 1993.

In the study woreda, the amount of DAP and UREA distributed increased from 2366 and 424 qt in 1996/96 to 3905 and 2262 in 1998/99, respectively (Woreda agricultural Development Office, 2000). The use of DAP and UREA, therefore, showed an increase of 65 and 433 percent in 1998/99 over the 1996/97, respectively, over the 1996/97 period.

This exorbitant rise in the application of commercial fertilizer is mainly attributed to the broader expansion of the new extension program and the consequent increase in the number of the NEP participants. According to Basona Worana Agricultural Development Office (2000) the fertilizer consumption of the NEP participants increased from 70 qt in 1995/96 to 4826 in 1998/999 of which DAP and UREA accounted for 2851 and 1975 qt in the latter year. This figure clearly indicates that the most consumers of fertilizer are participants of the NEP. For instance, the fertilizer consumption of the NEP participant accounted for about 73 and 87.3 percent of the total DAP and UREA consumed in 1998/99 in the woreda, respectively.

Table 6.1.1 Trends in Fertilizer Use in the Study Woreda, and Survey Area.

(in quintal)

Year	Study Woreda ¹					Survey Area ²		
	DAP	UREA	Total	Participants' share		DAP	UREA	Total
				Total	As a % of the woreda			
1994/5	N.A	N.A	N.A	N.A	N.A	126.1	8.6	134.7
1995/96*	35	35	70	70	-	129.8	8.1	137.9
1996/97	2366	424	2790	974	34.9	128.0	9.2	137.2
1997/98	2351	819	3170	1288	40.6	144.8	22.5	167.3
1998/99	3905	2262	6170	4826	78.3	124.5	25.2	149.7

Source: 1. Basona Worana Woreda Agricultural Development Office, 2

2. Computed from Sample Survey Data, Dec. 19

Note: * includes only fertilizer used by the NEP participants.

Fertilizer consumption in the study area linearly increased with the increase in NEP demonstration plots. This increment can be manifested by the rise in the consumption of fertilizer by the NEP participants (Table 6.1.1). The fertilizer consumed by the sample households showed an increase of 11.2 percent in 1998/99 over the 1994/95 consumption level. Between 1994/95 and 1996/97 fertilizer consumption in the survey area appeared to be constant. However, when it is viewed from the type of fertilizer used, the consumption of UREA has constantly been increased over the years under reference. For instance, the consumption of UREA increased by 193 percent in 1998/99 as compared to the 1994/95 consumption level. The fertilizer distribution practice, therefore, tells us that non-adopters and/ or non-participant of the NEP may not have easy access to the input due to financial constraints. In this regard, most beneficiary of input credit are NEP participants. Therefore, the possibility of other farmers to purchase fertilizer on cash basis is too limited. Hence, giving more emphasis only to NEP participants that usually cultivate a demonstration plots of 0.125-0.5 ha could not bring substantial change in the

overall productivity of food crops. The issue, however, needs to be reconsidered so as to attain the objective of food security.

6.1.2 Problems Related to Fertilizer Marketing and Distribution

It is true that widespread application of commercial fertilizer help increasing cereal yields. Results of the NEP demonstration plots showed that wheat productivity increased, on the average, to 25 qt/ha during the last four years (Woreda Agricultural Development Office, 2000). The report further indicates that the maximum wheat yield during the periods vary between 30 and 58 qt/ha. Similarly, the average barely yield from demonstration plots was also reached about 20 qt/ha, the maximum yield being varied between 40 and 48 qt/ha. The rise in wheat yield resulted from the application of fertilizer, among others. The increase in barely yield signifies that the application of fertilizer with local seed can help increasing yield.

Although it seems that fertilizer use constantly increasing with the broadening number of the demonstration plots under the NEP, its overall application as compared to the total cropped area is to low to cause substantial yield increase. Therefore, it is necessary to expand the application of fertilizer through alleviating the existing distortions in the marketing and distribution practices.

Low and Absence of Competition

Until the period 1993, the marketing and distribution of fertilizer was controlled by the state enterprise and it was unthinkable to believe that there was competitive atmosphere.

The present government deregulate the market so as to create a multi-channel distribution system (Mulat and Techane, 1999). However, the deregulation of the market through the formulation of the National Fertilizer Policy could not yet brought competition though some private fertilizer importers and distributors were evolved.

In Amhara region, the dominant fertilizer supplier is Ambasel Trading Pvt. Ltd. Company-which is the regional parasatal. It monopolized the marketing and distribution of fertilizer in every corner of the region. Furthermore, the regional government provides it with sufficient support in that it provides credit purchase order. Such mechanism of input credit administration by the regional government heavily restricted other distributors to participate in the marketing system. Because considerable size of farmers purchase fertilizer on credit basis. For instance, out of the total fertilizer sales of Birr 23.7 million in the study woreda, cash sales accounted only for Birr 3.3 million or 13.9 percent of the total(Ambasel Trading House, 2000). Similarly the data obtained from North Shewa Service Cooperative Promotion Department(2000) indicates that of the total fertilizer sales of Birr 853.2 thousand by the service cooperatives in the woreda cash sales accounted for only about 4 percent during the same year.

The issue presented above manifests itself that there could not be competition under such environment. Therefore, it can be generalized that the effort to decentralize decision making process to regional level have made it difficult to liberalize the markets (Howard *et al*, 1999). In addition the findings of this study is analogous to what Howard *et al* (1999) concluded that “given the role that the government plays in allocating credit, it is

easy to for the agents to control which firm receives the supply orders for fertilizer purchased on credit.”

The data obtained through key informants showed the same result. All respondents believed that there is no competitive atmosphere in the marketing and distribution of fertilizer(see Table 6.1.3). they noted out that AISE cannot sell fertilizer in the zone except in some areas with insignificant amount. In addition, the survey result indicates that out of a total of 154 sample households about 8.4 and 48.1 percent explained that there is low and no competition, respectively (see Annex 3A). Further, about 65 percent of the sample households explained that they no right to decide from which supplier to purchase fertilizer. During discussion with the Ambasel Branch office on the main problem of fertilizer marketing, the existence of ‘illegal fertilizer trade’ or fertilizer infiltration to areas bordering the Oromia Region was explained as a problem. Such explanation provides an indirect insight that farmers are interested to purchase fertilizer from other sources where price is attractive for them. Therefore, the absence of competition in the marketing and distribution of fertilizer could force to receive higher prices that otherwise would not happen under competitive atmosphere.

Rising Fertilizer Prices

Given high import costs and large sum distribution costs incurred in retailing and wholesale activities, it is hardly possible to expect lower prices of fertilizer unless efforts are geared towards mitigating such factors. For instance, Ambasel’s effort to carry out retailing of fertilizer through its retail out lets forced it to incur personnel and other

overhead costs that finally be reflected in the selling price. To this end, the Company Branch pointed out that its selling price is higher than other fertilizer importers/distributors because of such overhead costs.

Table 6.1.2 Ambasel's Selling Prices of Fertilizer (Birr/qt)

Description	1994/95	1995/96	1996/97	1997/98	1998/99	% change 1998/99/1994/95
DAP	178	200	250	248	260	46.1
% change	-	12.4	25.0	-0.80	4.8	
UREA	168	190	240	195	175	4.2
% change	-	13.1	42.9	-18.7	-10.3	

Source: 1. Ambasel Trading House Pvt. Ltd. CO., 2000.

2. Basona Worana Woreda Agricultural Developmet Office, 2000.

The price of UREA tend to decline since 1997/98 that may be attributed to the decline in international price of the input.

Key informants explained that the rise in the price is one of the main problems in marketing and distribution of fertilizer. To this end, about 85.2 percent of the informants reported that price of fertilizer increase since 1992. The informants further explained that the price increase limited farmers' willingness to use the recommended fertilizer rate. The survey data showed that about 51.2 percent (see Annex 3B) of respondent households explained that the used less of the fertilizer than the preceding years. Furthermore, 87.6 % of respondent households explained the reason to use less quantity of fertilizer is that it has become too expensive.

Other Problems

There are also other problems such as supply shortages, packaging and underweight problems, lack of prior information on the price of fertilizer, limited number of sales

outlets and improper location of these outlets. Packaging as a problem is related to the current practice of selling a pack of 50 and 100kg of fertilizer. Such practice limited farmers' purchasing capacity of fertilizer in small packed quantities. About 51.9 percent of key informants stated this practice of packaging as a problem in the marketing and distribution of fertilizer. Furthermore, packed fertilizer in 50 kg quantity is found in lower weight, i.e., the weight ranges from 44-48 kg. In this respect, the survey data showed that about 3.2 percent of the total fertilizer adopters were faced market malpractice of which 50 percent of them reported underweight problem. Further, about 50 % of them reported that they faced a problem of poor quality fertilizer that reduced their yield.

Table 6.1.3 Responses of Key Informants on Major Problems of Fertilizer Marketing and Distribution.

Type of responses	Number of responses by Informants(N=27)							As a % of the total
	1	2	3	4	5	6	Total	
Lack /absence of competition	2	3	4	5	3	10	27	100
High price	0	2	4	5	2	10	23	85.2
Delay and shortage in the supply of fertilizer	1	2	4	5	3	9	24	88.9
Packaging problem (in 50 & 100kg only)	1	0	2	5	0	6	14	51.9
Lack of prior Information on Fertilizer price	1	0	4	4	3	0	10	37.0
Transportation problem	1	1	2	5	2	6	17	63.0
Limited number of Sales outlets and undesired location	0	0	3	4	1	7	15	55.6
Underweight, credit Scarcity, poor quality, etc.	2	1	3	4	1	7	18	66.7

Source: computed from the data obtained from Key Informants, Feb. 2000.

Note: 1= Zonal and woreda Council Officials; 2= Kebele Officials; 3= Office Heads; 4= Experts; 5= Extension Agents(DA's); 6= Farmers.

6.1.3 Improved Seed Distribution and Marketing

Although fertilizer application with local seed can increase cereal yield, the yield response of fertilizer application with improved seed is by far greater. Nevertheless, most adopters of fertilizer in the study area used fertilizer with local seed because of improved seed shortage. In addition, the existing scarce supply of improved seed is limited to only to few crop varieties such as wheat and *teff*. In the survey area, farmers and agricultural experts reported that the only improved seed made available is wheat variety with marginal quantity. Further, the wheat variety is also primarily goes to the participants to the new extension program. Therefore, it is after satisfying the demand of NEP participants that the rest of the farmers can acquire the improved seed.

Barely crop growers have no any alternative to use fertilizer with improved seed because of unavailability supply. Therefore, farmers use fertilizer with the local seed variety the relative consequence of which is low yield response. Table 6.1.4 provides information on the consumption and price of improved seed pattern.

Table 6.1.4 Trends in the Distribution of Improved Seed Varieties in the Study Area.

Year	Woreda level ¹		Survey area ²		Unit price(Birr/qt)	
	Wheat	Teff	Wheat	As a % of the woreda	Wheat	Teff
1994/95	52.5	-	1.0	1.9	274	371
1995/96	237	8.3	1.0	0.4	274	410
1996/97	311.3	1.1	2.9	0.9	236	410
1997/98	221.9	-	5.4	2.4	279	x
1998/99	275.8	-	4.3	1.6	284	x

Source: 1. Basona Worana woreda Agricultural Office, Feb. 2000.

2. Computed from the Survey data, Dec. 1999.

x- the price was unknown because teff seed was not supplied during the period.

The above table shows that improved seed varieties have been in acute shortage when one observes the quantity of seeds supplied. Given the current recommended application rate of 125kg/ha for wheat seed, the total consumption of wheat seed can only cover between 40 and 249 hectares.

6.2 Trends and Problems in Input Credit

Input credit is essential in agricultural activities to increase farm productivity. However, its critical shortage and distortion in the distribution aspect before 1992 had never benefited small holder farmers. The main input supplier in then period was the Agricultural and Industrial Development Bank-AIDB(recently renamed as Development Bank of Ethiopia-DBE). It provided input loan to producers' cooperatives that accounted for about 4% of the total land under crops(ONCCP, 1989; Brune, 1990; Hansson, 1995). Such system of supplying agricultural input credit supply did not bring any effect on increasing agricultural productivity.

Since 1992 input/fertilizer credit have been supplied to farmers by DBE and Commercial Bank of Ethiopia (CBE). However, in 1994/95 this responsibility was shifted to regional governments through which they borrow the money from the banks (Mulat, 1996).

Regional governments provide credit to farmers at a rate charged by the bank plus credit administration costs. Although such system of credit administration seem to avoid the collateral arrangement for farmers to the banks, it in turn increase the cost of capital.

In addition, regional input creditors were flourishing in the mid-1990's to supply credit to the rural farm households. In this regard, the Amhara Credit and Saving Institute (ACSI)

was established in 1995. Since then its supply of credit increased and at present it provides large amount of input credit in the region. Table 6.2.1 provides details of input credit supply in North Shewa Zone and in the study woreda.

Table 6.2.1 Input supply by ACSI in the zone and study Woreda

Year	Credit supply in the Zone(Birr)			Credit supply in the woreda(Birr)				Share of the woreda in credit supply
	Credit advanced	Credit collected	Collected as % of advanced	Credit advanced	Credit collected	Collected as a % of adv.	% change in supply	
1997/98	897216	889877	99.8	459799	456682	99.3	-	51.2
1998/99	6600831	5893910	89.3	662200	636779	96.2	10.0	10.0
1999/2000*	7458884	804664	10.8	652360	85261	13.6	-1.5	8.7

Source: North Shewa Amhara Credit and Saving Institute(ACSI), 2000.

*the outstanding loan is high because it was the period of loan repayment during the time of data collection.

Apart from ACSI's involvement in fertilizer loan disbursement, the regional government was also provide farmers input loan through Service Cooperatives. Table 6.2.2 presents the total fertilizer loan advanced in the woreda.

Available data showed that ACSI involved in fertilizer loan since 1997/98 and the amount of loan it advanced increased in terms of amount since then. For instance, ACSI's share in the total loan disbursed increased from Birr 45.98 thousand in 1997/98 to Birr 662.2 thousand in 1998/99.

The total amount of loan advanced in the study area increased by 54.9 percent in 1997/98 over the preceding year and linearly increased over the subsequent periods. With regard to loan repayment, more than 98 percent of the disbursed loan was repaid in the

completed cropping calendar. The repayment rate, therefore, seem to signify the efficient system of input credit administration. Nonetheless, loan repayment achievements largely accounted for coercive measures taken to collect the loan rather than efficient system of credit administration. Farmers who failed to repay the loan have no possibility of obtaining another loan for the next harvest season and even the failure of one member of the credit group to repay hinders all members to get another loan. Therefore, such measures may create disincentive for new entrants into the borrowing practice and thus largely discourage adoption.

Such measures are most indications of credit repayment. Moreover, the most noticing problems in the fertilizer loan allocation and distribution are discussed below and presented in table 6.2.3.

Shortage of Credit Supply

Although the amount of loan advanced increased over the years under consideration, it was not in a position to satisfy farmers' demand for credit. To this end, Howard, *et al* (1999) pointed out that loan disbursement and repayment have been improved over the early periods of 1990's situation but equally important is to question about the system to serve efficiently farmers' demand for input credit. In other words, the current credit supply could not satisfy the demand where more than 80 percent of the farmers in the country purchase fertilizer on credit basis (Mulat and Techane, 1999). With regard to this, about 81.5 percent of key informants accepted supply shortage as a major problem (see

Table 6.2.3). Therefore, the present level of credit supply disbursed is not in a position to sufficiently alleviate the problem of farm productivity.

Table 6.2.2 Total Fertilizer Loan Advanced, Collected and Outstanding in the Study Area.

Year	Source of Credit	Fertilizer Loan ('000 Birr)					
		Advanced		Collected		Outstanding loan	Interest Rate %
		Amount	% change	Amount	As percent of Adv.		
1996/97	CBE	187.5	-	187.5	-	-	10
1997/98	ACSI	45.98	-	45.67	99.3	0.31	10
	Finance Dept.	244.50	-	244.12	99.8	0.38	12.5
	Total	290.48	54.9	289.79	99.8	0.69	
1998/99	ACSI	662.2	-	636.78	95.6	25.4	12.5
	Service Coop.	204.85	-	199.67	97.5	5.2	12.5
	Total	867.05	198.5	836.45	96.5	30.6	
1999/2000 *	ACSI	652.36	-	85.26	13.1	567.1	12.5
	Service Coop.	867.22	-	68.74	7.9	798.48	12.5
	Total	1519.58	75.5	154.00	10.1	1365.58	

Source: ACSI, 2000; North Shewa Service Cooperatives Promotion Department, 2000.

*. Loan collection was in process during data collection and this is the factor for high outstanding.

Unattractive Loan Repayment Arrangement and High Interest Rate

Loan repayment schedule is inadequate to encourage farmers to borrow fertilizer credit.

In this regard, farmers were obliged to repay the credit soon after harvest. This repayment arrangement is not attractive for farmers because it is the period that grain prices are too low due to oversupply. Low grain prices means selling more of the produce to cover

fertilizer credit and thus largely hinders farmers to benefit from yield increase. In chapter five, it has been discussed that farmers could gain more income from storing and selling grains in the latter months. Selling grains when prices are high could sufficiently increase farmers' income more than offsetting the frequent rise in the prices of fertilizer. The problem of forcing farmers to repay fertilizer credit when prices are too low was also explained by more than 70 percent of key informants. Therefore, this discussion could lead to the conclusion that appropriate loan repayment arrangement has to be devised in order to alleviate rural poverty through increasing farm productivity.

Table 6.2.3 Major Problems in Input Credit

No	Responses	Number of Responses by Informant Types**						Total	As %of total
		1	2	3	4	5	6		
1	Credit supply shortage	1	2	4	5	1	9	12	81.5
2	Delay in loan repayment	1	0	1	3	1	2	8	29.6
3	Farmers' reluctance to borrow	0	1	0	3	2	1	6	22.2
4	Requested to repay when grain prices are low	0	2	3	4	1	10	19	70.4
5	Lack of clear guideline on loan disbursement and repayment	1	0	2	4	0	0	7	25.9
6	High interest rate	0	2	1	3	0	8	14	51.9
7	Others*	1	1	1	4	1	1	9	33.3
8	No Response	0	0	1	2	2	0	5	18.5

Source: computed from the data collected from key informants.

*. Includes limited number of creditors, high loan outstanding, low participation of ACSI in loan collection, lack of preparedness of creditors, low access to the poor, etc.

** . 1= Zonal and Woreda Council Officials; 2= Kebele Officials; 3=Office Heads; 4=Experts; 5=Development Agents; 6= Farmers.

High interest rate was also considered as limiting factor to borrow and has become one among many constraints of technology adoption. In the study area, about 52 percent on the informants (and 80percent of farmers' informants) described that high interest rate restricted farmers to borrow. Although the present level of interest rate seem too small as compared to the rate charged by the informal creditors, the cost of acquiring credit from

the formal creditors is too high and even too Bureaucratic. Moreover, due to the bureaucratic nature and the collateral formalities that formal creditors(the banks) request borrowers makes worse the situation for the poor and then become inaccessible (Gebrehiot, 1989). It is important to note that reduction in the cost of borrowing through enhancing institutional efficiency is called for to offset the rise in the interest rate.

6.3 Inadequate Extension service and Poor Linkages with Agricultural Research

Agricultural research and extension service is indispensable to augment production and productivity through improving farmers' ability to adopt improved technology. Like other factors of agricultural production extension service also tend to benefit the richer ones because they have the economic power to do so. Moreover, agricultural extension has been deviated from research activities. The current extension system advocated for enhancing greater interdependence between extension and research. Nevertheless, the hitherto practices showed that the extension part has steadily growing before research works. Therefore, this condition may further worsen the condition of technology adoption in the future unless favorable atmosphere is created to enhancing the relationship between extension and research.

Although essential extension education is it has been encountered by number of problems such as short period of training of the DAs and their acute shortage, material and financial shortage to run extension activity, poor linkages with research, and lack of incentive for extension agents, among others. Therefore, such problems constrained

technology dissemination thereby leaving the way for agricultural productivity to dwindle over time.

In assessing the major problems relating to technology adoption, the response of informants on the weakness or poor performance of the NEP is taken as a round about way to reflect the existing technology adoption. Table 6.3.1 provides the problems in question.

Table 6.3.1 Factors Affecting Yields from the NEP demonstration plots

No.	Responses	Number of responses by informant types**							Total	As % of the total
		1	2	3	4	5	6			
1	Environmental factors	1	2	3	3	1	6	16	59.3	
2	Inappropriate technology adoption	0	2	4	5	3	7	21	77.8	
3	Critical shortage of improved seed	1	2	4	5	2	8	22	81.5	
4	Insufficient extension education	2	0	3	4	2	7	18	66.7	
5	Poor follow-up and monitoring	2	0	3	4	2	0	11	40.7	
6	Others*	0	1	2	4	2	5	14	51.9	

Source: Computed based on the information obtained from key informants, 2000.

*. Includes shortage of land, lack of credit, lack of research support, delay in the supply of fertilizer, blanket recommendation of improved inputs, etc.

** . 1=Zonal and woreda council officials; 2= kebele officials; 3= Office Heads; 4=Experts; 5= Development Agents; 6= Farmers.

As it can be observed from table 6.3.1, inappropriate technology adoption, insufficient extension education, low monitoring and supervision , etc accounted for yield decline and

so do for adoption. To this end, about 82 percent of the respondents explained that shortage of improved seed supply affect the yield of the NEP. Further, 67 percent of the respondents also explained that insufficient extension education affect yield of the NEP plots and may be accounted for poor adoption practice of the participants. More than 50% of the responses again explained shortage of land, blanket recommendation of the proven technologies, lack of credit, delay in fertilizer supply etc were impediments to using the existing technology and hence reducing crop yields. In addition, 12.3 percent of respondent sample households explained that their holding size is declining and 3.6 % of them stated that decline in land holding restricted them to adopt fertilizer.

Given the existing amount of proven technologies, extension education could not properly serve the rural farm households in utilizing those technologies because of various reasons. The reasons are low capability of the extension agents, large area coverage by one extension agent, inadequate budgets, shortage of skilled professionals in agriculture, lack of incentive, etc. Further, it can also be said that the current extension practice steadily go ahead of research that prove the link between them have become substantially thinner. Consequently, this poor link could affect the level of technology adoption.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The agricultural sector plays a dominant role in the Ethiopian economy. It accounted for more than 50 % of the GDP, contributes to employment for about 85% of the population, and supplies about 70% of the raw material requirements of the domestic industries (MEDaC, 1999:145). Further, the crop production contributes to 60 percent of the agricultural value added (AGVA). Nonetheless, the sector suffers from low productivity resulting from natural and policy driven problems. The natural problems include land degradation, rainfall variability, recurrent drought, etc, whereas the policy environments mainly characterized by wrongly induced agricultural policies. The consequence of all these factors was deterioration in the production of food crops, i.e., and severe decline in agricultural productivity.

Different extension approaches were implemented to increase agricultural productivity through expanding technology adoption. The application of commercial fertilizer and improved seed varieties has been effected since the late 1960's but at different scale of adoption. Those extension approaches based their emphasis to increase the productivity of small holders. Nonetheless, due to lack of access to the basic means of production-the land and financial resources by the poor all package programs failed to meet the objective of increasing the productivity small holder peasants. It was alleged that the 1975 land

reform of the country to increase agricultural productivity. However, the implementing strategies that focused on the ideologically driven motives rather depressed the performance of the agricultural sector.

The present PADETES approach to extension service attempted to extend the service to large areas in contrary to the past approaches so as to promote the overall productivity. MEDaC (1999) reported that under the PADETES especial emphasis is given to small holder farmers through introducing incentive packages such as access to fertile land, credit, improving budgetary allocation on human resource development in agriculture, expansion of infrastructure, etc.

Although the adoption of improved inputs could not bring substantial rise in productivity of the sector, past and present adoption of these technologies proved the attainment of high crop yield on individual plots and research demonstration outreaches. For instance, under the NEP, it was reported that yield increased to more than 50 qt per hectare for wheat. Further, the most important issue in raising agricultural productivity is to attain sufficient from technology adoption, i.e., benefits should exceeds costs of implementation.

This study assessed the impact of adopting improved technology on crop yield and income of adopter farmers. In this regard, the multi-variate linear regression model was applied on survey data collected from 175 sample households that grow barely and wheat crops in Basona Worana woreda, Amhara North Shewa Zone. From 175 sample

households, 133 and 158 farmers were found to grow wheat and barely, respectively. Furthermore, 93 and 119 farmers were wheat and barely adopters, respectively. The results on household characteristics showed that households with better farm resources (land and draft oxen), educational status and relatively better access to extension service tend to adopt improve technology.

The regression analysis results demonstrate that fertilizer, improved seed, land area, and land quality have a powerful influence on farm productivity. Moreover, household education, rainfall distribution and frost occurrence also determine yield levels but with less or strong influence depending on the types of crops grown. The results showed that the application of fertilizer on wheat fields increased the average yield to 15.8 qt/ha as compared to 8.6qt/ha for non-adopters. Further, the average yield for adopters on barely crop was 13.4 qt/ha while it was about 8.7qt/ha for non-adopters. These yield results proved that technology adoption, on the average, increased wheat and barely yield by 83 and 50 percent over the yield of non-adopters, respectively. Moreover, these yield levels exceeded the national average by 29 and 12 percent. The results further explained that the application of fertilizer with improved seed resulted in marked yield increase in the case of wheat crop.

By and large, the application of technology increased both the yield and income of adopters as compared to the traditional farming practices. To this end, the results of the regression analysis for wheat crop showed:

- a) that application of 100kg fertilizer could increase yield by about 407 kg per hectare , other factors being constant;
- b) application of 100 kg improved seed could increase wheat yield by 466kg/ha.
- c) Land quality also greatly influence yield and farmland with *Lem and Lem-Teuf* category would increase yield by 322 kg per hectare;
- d) Access to extension service could raise wheat yield by 209 kg/ha.

Similarly, the regression analysis results for barely crop showed that :

- a) a 100 kg fertilizer application can increase barely yield by 287 kg per hectare;
- b) Good/Excellent rainfall distribution can also increase yield by 105 kg/ha, and
- c) Farmland with Lem and Lem-Teuf category could increase yield by 343 kg/ha.

The financial analysis on adopters and non-adopters of barely and wheat crop demonstrates that technology adoption could generate income sufficient to cover costs and help earning promising profit. In light of this, we can conclude the following:

- a) the net return from wheat and barely crops for fertilizer users at January level was Birr 1922 and 1261/ha, respectively, for adopters. On the other hand, it was Birr 1106 and 948/ha for non-adopters. Therefore, adopters gained more income than non-adopters, as the result of this

study demonstrates and the income from wheat is by far exceeded the income from barely.

- b) Farmers could further increase their income from crop storage and selling it out their produce when grain prices improved. For instance, if adopters supposed to sell at July 1999 prices their income could increase to Birr 2709 and 1905/ha for wheat and barely, respectively. Furthermore, with a 25% and 50% hypothetical drop in output prices below the January 1999 price level, the financial returns has still showed a positive direction for adopters and non-adopters.
- c) Under all the above scenarios, returns per labor days are higher than the average daily wage rate for the area.
- d) The benefit-cost ratio analysis has also showed promising financial returns but the ratio for non-adopters is relatively higher than adopters due to the low cost of production that they incurred.
- e) The value- cost ratio (VCR) result showed that the level of profitability under fertilizer application is promising for wheat while it is sensitive to risks for barely.

Therefore, it is possible to increase productivity with the application of fertilizer with local seed varieties. Although these yield determinants strongly influence farm productivity, they have been suffered from a number of problems. The most prominent factors that impaired problems on technology adoption and hence on farm productivity can broadly be categorized into input, credit and output markets,

etc. From the point of view of the input market lack of competitive atmosphere, delay and shortage in the supply of inputs, rising prices and poor quality of inputs accounted for the largest part of the problem. With regard to the output market the major difficulty is related to the repayment of input credit. In this case farmers were obliged to sell their produce when grain prices are too low. Such arrangement may create farmers' ambivalence towards input credit thereby implicitly weakening technology adoption.

Shortage of credit supply and its administration have become impediments to transform farm productivity through hobbling technology adoption. In addition, the current practice of credit administration by the regional government strongly restricted farmers' choice to purchase fertilizer from the possible cheapest sources thereby increasing the cost of farm production. Credit supply shortage also restricts non-participant farmers in the new extension to borrow because priority is given to the new extension program. This situation demonstrates that there is rival nature between the PADETES and the regular extension practices.

Lastly, poor linkage between research and extension, shortage of extension workers and poor institutional arrangement in input, credit and extension management arrested to a greater extent technology adoption and rising farm productivity. Hence, it can be concluded that the findings of this study are analogous to the existing theoretical and other practical findings on the subject under reference. In order to increase food crops productivity through widespread adoption of

technology, it is necessary to encourage the present positive actions and mitigate the overriding problems that arrest productivity and technology adoption.

7.2 RECOMMENDATIONS

In relation to the problems and positive results so far discussed in this paper, the writer owes to present the following statements:

Improving the input markets: the input market is the basis of agricultural policy, among others that has to be dealt thoroughly. The input markets in agriculture refer to fertilizer, credit, and human resources. Therefore, to encourage technology adoption, which is the basis for improving crop productivity, decision-makers as well as implementing institutions should pay attention to the following:

- a) Create competitive environment in the marketing of fertilizer through encouraging large importers and wholesalers. Furthermore, the regional government should create enabling environment for the existing importers and distributors to involve in fertilizer marketing within the region as opposed to the present rigid stand favoring one supplier;
- b) Institutions that involve in wholesaling and importing should get out of retailing business and small local traders have to be encouraged in fertilizer retailing so as to create efficiency in the distribution system. Moreover, credit should also be available for these small traders to mitigate the financial problems that they faced and this would promote their activity;

- c) Under conditions of high fertilizer prices, the government should provide farmers with price subsidy in order to increase fertilizer adoption;
- d) It has been stated by farmers that packaging fertilizer only in 50 and 100 kg bags and market malpractice were problems in fertilizer marketing, among others. Therefore, it is essential to pack fertilizer in different bag sizes so as to increase farmers' fertilizer purchase according to their demand. In addition, serious attention should be given during packing fertilizer so as to reduce the problem of underweight;
- e) The current acute supply shortage of improved seed should be mitigated and the input has to be made available to farmers at reasonable prices and at the required season;
- f) Improve credit allocation and administration: in this respect, it was observed that the regional government direct fertilizer credit sales in favor of Ambasel Trading House Pvt. Ltd. CO. Therefore, fertilizer credit sales should be made available for suppliers that provide the least possible price for the input. Further, it is advisable to increase the supply of credit and made it available to poor farmers at reasonable interest rate.
- g) Input loan repayment arrangement have to be improved in such a way that both borrowers and creditors could benefit. That is to say, input loan repayment should be relaxed to the period when grain prices are

improved as opposed to the current practice of loan collection immediately after harvest.

2. Encouraging Technology Adoption: results of this study signify that application of technology, notably fertilizer, increase substantially both the yield and income of adopters. Nevertheless, the number of adopters and the cropped area under fertilizer and improved seed use is considerably low to show greater impact on the overall increase of productivity. Therefore, the following measures should be undertaken:

- a) it is necessary to encourage farmers to apply fertilizer by introducing several measures as stated above;
- b) increase the income of farmers that grow barely through introducing new seed varieties suitable to the local condition.

3. Expand/ strengthen Agricultural Extension and Research: the regression analysis for wheat and barely crops has shown that agricultural extension could enhance productivity through introducing new methods of technology adoption and improving the agronomic practices. Therefore, it is essential to expand and strengthen agricultural extension service through:

- a) introducing incentives to extension agents
- b) increasing the number of extension workers and other agricultural personnel;
- c) enhance the institutional capacity of implementing office;

- d) provide short-term training and refreshment courses for the existing staff and newly trained agricultural personnel with improved quality of education;
- e) the current extension seems to isolate itself from research and technology adoption is simply disseminated without verification to the farmers' real environment. Therefore, extension should be supported by research and that in turn should be geared towards the generation of new technology. Further, the generated technology should be disseminated after verification. Expansion of extension service, therefore should keep pace with the expansion of research so as to attain desired change in crop productivity.

The introduction of the above measures into the picture of technology adoption, therefore, could enhance the number of adopters and the cropped area under improved technology. Hence, expansion in the level of technology adoption would consequently result in substantial agricultural productivity and income on a sustainable basis.

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ANNEX 1

Questionnaire Used to Complete Information from Key Informants.

General

Name of Informant _____

Institution _____

Job Status _____

Date of Information Completed _____

Major Questions

1. Discuss about the Agricultural extension practice / both the regular and the PADETES/ _____

2. Describe briefly the weaknesses and strengths of the extension program _____

3. Explain how participant farmers in the new extension program have been selected

4. Who are the major actors in the process of implementing the extension program? And describe their technical capacity to address basic issues in the implementation process

5. Explain the income and yield status of the users of the packages input (including the sustainability issues) _____

6. What were the major problems in the process of implementing the package inputs?

7. Describe in detail the major factors that constrained crop productivity growth under technology adoption?

8. Discuss the current status of extension agent-farmer ration and its impact on the Performance of extension education. _____

9. Do you believe that there is competition in the input market, i.e., in the supply and distribution aspects? _____

10. Discuss your overall view about agricultural input marketing practice

11. Do the required types of inputs supplied on time? _____ If no, give reasons _____

12. Do you believe that the existing number of input distribution outlets is sufficient and their location is in a position to serve the farm households? _____

13. Describe the names input (particularly) suppliers in your area _____

14. Do the stated supplier(s) provide fertilizer and other inputs on time and sufficient quantity?

15. Describe on aspects of the quality of inputs _____

16. How do you comment on the current blanket recommendation of input application?

17. Explain the major problems in the input supply and distribution _____

18. Describe the main source(s) of input credit in your area _____

19. What are the requirements to borrow the input credit? _____

20. Describe the main actors in input loan disbursement and repayment and the period that the loan is repaid. _____

21. Do you believe that all these actors have to be involved in the process of input loan repayment and disbursement? _____

22. According to your own opinion, who should involve in the input loan repayment and disbursement? (List them according to importance). _____

23. Is the input loan repayment arrangement appropriate? _____ If not, give the alternative repayment arrangement that you believe appropriate _____

24. Describe the types of action(s) taken on farmers that could not settle the input loan either due to crop failure or any other reasons _____

25. Do you believe that the actions you have mentioned above are the correct measures to encourage input loan borrowing? _____. Give reasons for either of your response _____

26. Discuss the major problems related to:

- a) Input loan disbursement and repayment
- b) input loan interest rate
- c) Selection process of borrowers

)).

ANNEX 3A

Sample Households' Response on the problem of Fertilizer Marketing

Level of competition in fertilizer market N=154				Is there delay in distribution N = 144		Faced problem of market malpractice N = 140		Type of market malpractice N = 4		Have you a choice from which supplier to buy the input? N = 140	
% of responses				% of responses		% of responses		% of responses		% of responses	
High	Average	Low	None	Yes	No	Yes	No	Underweight	Poor quality	Yes	No
20.8	22.7	8.4	48.1	6.9	93.1	3.2	96.8	50.0	50.0	35.0	65.0

ANNEX 3B

Level of fertilizer use compared to the previous years (N =127)			Are you using the recommended rate of fertilizer? (N= 127)			Reasons for using less quantity of the input (N = 65)				
% of responses			% of responses			% of responses				
The same	More	Less	Yes	No	No idea	Too expensive	Not suitable to the soil	Higher production risk	Decline in land holding	Change in farming system
26.8	22.0	51.2	29.5	69.0	1.5	87.6	3.1	4.6	3.1	1.5

Source: Both Annex 3A and 3B were calculated from survey data, Dec. 1999.

ANNEX 4

Descriptive Statistics

No	Description	N	Total	Mean	Minimum	Maximum	Std. Dev.
1	Adopters						
1.1	Wheat						
	Yield(kg)	93	146447	1574.7	533	4000	566.71
	Fertilizer Applied(kg)	"	11294	121.4	30	250	54.89
	Improved Seed (kg)		1535	16.5	0	150	40.60
	Total farm land size(ha)*		204.58	2.199	0.5	5.63	0.95
1.2	Barely						
	Yield(kg)	119	158820	1334.6	600	3200	434.62
	Fertilizer applied(kg)	"	14195	119.3	29	260	56.22
	Total Farmland Size(ha)*	"	254.02	2.13	0.50	7.0	0.99
2	Non-adopters						
2.1	Wheat						
	Yield(kg)	40	34445	861.1	400	1600	359.22
	Barely Yield (kg)	39	34950	896.2	240	2400	448.76
	Total farmland(wheat-ha)		80.53	2.01	0.5	7.0	1.29
	Total Farmland(Barely-ha)		60.67	1.56	0.5	5.63	0.91

Source: Computed from Sample Survey data, Dec. 1999.

*. Note that a household may grow at the same time wheat and barely so that the landholding size may appear in both barely and wheat growers simultaneously.

ANNEX 5

Wheat and Barely Yield Level frequency for adopters and Non-Adopters

Yield Levels(kg/ha)	Adopters		Non-adopters	
	Wheat	Barely	Wheat	Barely
< 700	2	1	13	15
700-1000	9	29	18	13
1001-1300	26	37	5	6
1301-1600	26	30	4	3
1601-1900	10	10	0	1
1901-2200	9	7	0	0
2201-2500	4	4	0	1
2501-2800	4	0	0	0
> 2800	3	1	0	0
Total	93	119	40	39

Source: Computed from Sample Survey Data, Dec. 1999.

ANNEX 6

Fertilizer and Improved Seed Application Rate Observations for Adopters by Crop Type.

Application Rate(kg/ha)	Adopters by Crop Type					
	Wheat				Barely	
	Fertilizer		Improved Input		Fertilizer	
	Number	%	Number	%	Number	%
0	0	0	77	82.8	0	0
1-30	1	1.1	0	0	1	0.8
31-60	12	12.9	1	1.1	19	16.0
61-90	9	9.7	1	1.1	19	16.0
91-120	34	36.6	9	9.7	29	24.4
121-150	15	16.1	5	5.3	22	18.5
151-180	6	6.4	0	0	8	6.7
181-210	10	10.8	0	0	16	13.4
> 210	6	6.4	0	0	5	4.2
Total	93	100	93	100	119	100

Source: Computed From the Sample Survey, Dec. 1999.

ANNEX 7

Conversion Factors of Labor into Adult Male Labor Equivalents

Age leve	Male	Female
Below 10	0.00	0.00
10-13	0.20	0.20
14-16	0.50	0.40
17-50	1.00	0.8
Over 50	0.70	0.50
Average *	0.72	0.56

Source: Abebe Haile Sellassie, (No date).

*. The average conversion factors are computed for male and female labor and this result is equal to the average given by Yotopoulos(1967). Note that the child adult equivalent labor is equal to 0.25 that are between the age of 10-14.

ANNEX 8

Total Labor Days Used in Farm Activities for Adopters and Non-adopters

Labor Days by Major Types of Farm Activities (in adult labor equivalents)								
Description	Land prep.*	Weeding	Fertilizer Appl.	Leveling(Boy)	Harvesting	Threshing	Others**	Total
Adopters								
Wheat								
Male labor	6988.8	4640.9	333.8	1108.2	3055.3	1671.0	2002.0	19800.0
Female la.	34.6	1044.2	-	49.1		209.0	338.8	1675.7
Child labor	29.0	173.9	-	46.7		110.0	112.7	472.3
Total	7052.4	5859.0	333.8	1204.0	3055.3	1990.0	2453.5	21948.0
Barely								
Male labor	8970.0	4196.1	273.12	400.0	2717.0	1024.0	1094.9	18675.12
Fem. labor	34.2	515.0	-	17.5	-	364.0	439.0	1369.7
Child labor	27.2	143.98	-	16.8	-	194.6	158.6	541.18
Total	9031.4	4848.1	273.12	434.3	2717.0	1457.0	1697.5	20586.0
Non-Adopters								
Wheat								
Male labor	1860.0	890.2	0	398.8	723.8	327.8	260.6	4461.2
Fem. labor	14.4	228.0	0	26.6		31.1	32.9	333.0
Child labor	12.5	17.4	0	20.8		44.6	28.2	123.5
Total	1886.9	1135.8	0	448.2	723.8	403.9	321.7	4917.7
Barely								
Male labor	1922.0	652.6	0	215.4	592.0	283.3	242.5	3907.8
Fem. labor	40.6	126.4	0	14.4	-	32.9	38.0	252.3
Child labor	33.2	7.8	0	11.2	-	43.8	34.5	130.5
Total	1995.8	785.8	0	241.0	592.0	360.1	315.0	4290.6

Source: Computed from Sample Survey Data, Dec.1999.

*. Includes planting/sowing.

**. Includes Transporting before and after threshing.

DECLARATION

This Thesis is the result of independent work. Where it is indebted to the work of others, acknowledgement has been made.

I declare that it has not been accepted in substance for any other degree, nor it is concurrently being submitted in candidature for any other degree.

Name

Dejene Minliku
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Mulat Demeke(Ph. D)
(Academic Advisor)

Signature



