EFFECT OF FARM SIZE ON TECHNICAL EFFICIENCY: A CASE STUDY OF THE MORETNA-JIRRU DISTRICT IN CENTRAL ETHIOPIA

By

Abate Bekele

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Faculty of Natural and Agricultural Sciences

Department of Agricultural Economics

University of the Free State

Promoter: Prof. M.F. Viljoen

Co-promoter: Dr. Gezahegn Ayele

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Declaration

I declare that the thesis hereby submitted by me for the Philsophia Doctor (Ph.D.) degree at the University of the Free State is my own independent work and has not previously been submitted by me at another university/faculty. I furthermore cede copyright of the thesis in favour of the University of the Free State.

Abate Bekele Adera

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MAPS

ABBREVIATIONS

AISCO	The Agricultural Input Supply Corporation (AISCO)
ANRS	Amhara National Regional State
BBF	Broad bed and furrow
BOA	Bureau of Agriculture
BOPED	Bureau of Planning and Economic Development
CDE	Center for Development and Environment
CRS	Constant returns to scale
CSA	Central Statistical Authority
DA	Development agent
DEAP	Data Envelopment Analysis Program
DZARC	Debre Zeit Agricultural Research Center
EPRDF	Ethiopian Peoples' Revolutionary Democratic Front
FDRE	Federal Democratic Republic of Ethiopia
HYV	High-yielding varieties
MOA	Ministry of Agriculture
N	Nitrogen fertilizer
P_2O_5	Phosphorus fertilizer
PA	Peasant Association
PADETS	Participatory Agricultural Demonstration and Training System
SF	Stochastic Frontier
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
UNECA	United Nations Economic Commission for Africa
VRS	Variable returns to scale

EXPLANATION OF TERMS

Ato/Wezero	An Ethiopian respect title given to a person and a woman, respectively
Areda	Homestead area
Belg	The period at which small rain falls(February to May)
Bushola	Light black clay soils
Debo	Group of farmers work together on each other's farms
Dega	High altitude
Derg	Military regime that ruled Ethiopia from 1974 until 1991
Kebele	The lowest level of administrative organization. A district (*woreda*) is divided into *Kebeles*
Kolla	Low altitude
Kremt	The period at which big rain falls (June to August)
Merere	Heavy black clay soil
Timad	Local unit of measurement for land (four *timad* is one hectare)
Woina Dega	Mid- altitude
Wonifel	A traditional self-help institution with a main function of labor sharing or exchange
Woreda	Local name for district (lower level of administrative organization)

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CHAPTER 1

INTRODUCTION

1.1 Background

Throughout most of sub-Saharan Africa (SSA), agriculture is in crisis. Frequent droughts, growing expenditure on food imports, falling export earnings and rapid population growth have been cutting into living standards and growth prospects. The effects have been pervasive, not only on incomes of agricultural producers, who include most of Africa's poor, but also on supplies of food and raw materials for industry, on employment, savings, government revenue, and on the demand for goods and services produced outside agriculture. Yet policy changes and planning for the resumption of growth in agriculture are hampered by a serious lack of country-specific information. Reform efforts all too often try to apply general remedies to Africa's diverse problems. In all the SSA countries, population growth has put intensive pressure on agricultural land and the size of land holding is inadequate to produce enough food for a whole family. As a result, population pressure has brought increasingly marginal land into cultivation, which possibly affects statistics on average yield per hectare. The need to increase land and labour productivity is becoming urgent (Uma, 1990). Moreover, a better understanding of the impact of farm size in SSA is important because, in this part of Africa, the human population is growing more rapidly than in any other region of the world. Population in this region is projected to reach 1.3 billion by 2025. Urbanization is also occurring and food demand is increasing while the cultivated land per household is decreasing. Furthermore, Africa is often cited as the only developing region where agricultural output and yield growth is lagging seriously behind population growth (Savadogo *et al.*, 1994; Islam, 1995). In SSA, for example, the population doubles every 25 years while growth in agricultural productivity has, in fact, declined from 1.9 to 1.5% per year during the past 15 years (World Bank, 1997).

Possible ways of solving the problem of food shortages are: a) increasing productivity per unit of land via technical change, b) bringing more land under cultivation, and c) improving the efficiency by which farmers use available resources. The first alternative is entirely dependent on applying improved farming techniques. The modern farmer can, to a large extent, increase production per unit by using appropriate inputs, such as high yielding crop varieties (HYVs), fertilizers and drainage, so that land can be partly substituted by know-how and capital. This can be practiced in areas where little land is available for crop production. The second alternative, to increase agricultural production by bringing more land under cultivation without changing traditional farming methods, can be applied to land-abundant areas. The third possibility, of raising agricultural output through improvements in technical efficiency without resorting to new improved technologies and extra inputs (land, labour, etc.) has not yet been exploited in developing countries due to a number of economic and technical reasons.

As long as the population pressure on the land is excessive, production increases will require effective use of agricultural inputs (fertilizer, seeds, etc.), efficient markets and investment in rural infrastructure. It is also conceivable, however, that technical change could only be considered a more appropriate option when efficiency regarding the utilization of existing resources is sufficiently high among users, thus limiting the scope for increasing productivity through reallocation of current resources (land, labour, etc.).

The livestock population in this region is also expanding and this pressure on a fixed land base has already promoted severe competition for resources, making agriculture progressively more intensive. In this context, greater interaction between crop and livestock enterprises may offer possibilities for increasing production and productivity through exploiting their synergies, e.g. using crop residues as the dominant feed resource and utilizing manure for soil fertility maintenance (Winrock International, 1992).

The food production potentials of SSA countries have been recognized and identified for research priority (Winrock International, 1992). Moreover, certain new agricultural technologies have been introduced in these countries. Though these technological packages are often of a general nature, they are targeted at farms and communities in different ecologies and at different levels of development of infrastructure and human capital, e.g. education, experience, technical skills and access to markets. Consequently, the technologies perform differently in the different locations and the overall outcomes fall short of the potential. In the dissemination of new technologies, farmers in the region are treated as though their constraints and opportunities are similar. Such an approach is also adopted for applied research, where the majority of farm productivity studies generally stratify farms only by farm characteristics, e.g. farm size, tenure and level of income, and then go ahead measuring efficiency for the average farms. Such methods presume that all farms produce under similar conditions, and as such the differences in output and productivity among farms are mostly due to the scale of operation. A methodology that ignores the environment in which the farms operate, biophysical conditions, population pressure and market access and their implications for farmers' resource allocation and consequent productivity, could be misleading (Sarah and Ehui, 1996).

Ethiopia is one of the sub-Saharan countries where agriculture plays an important role in the development of the country, and today the majority of the population still depends on agriculture for their livelihood. Agricultural production is based on a variety of smallholder farms with a number of parcels or plots of land. Agriculture accounts for 46% of gross domestic product (GDP) and 90% of exports, and provides employment for about 86% of the labour force of the country (CSA, 1996). The cultivated land per household is too small to meet basic family needs and the yield is relatively low. As a result, most of the peasant population is classified as having low incomes.

Various factors are responsible for the poor performance of agriculture in Ethiopia. One of the factors contributing to poor performance in the agricultural sector is rapid population growth. Every increase in population is accompanied by a corresponding reduction in cultivated land per household, and brings about excessive division and fragmentation of land. Due to high farming population growth rate (3.1% per annum), cultivated area per farmer has dropped, on average, from 5 hectares to 1.5 hectare since 1980 (CSA, 1996). Hence, policy measures should be implemented to ensure farm units of a reasonable size to sustain the basic living requirements of farm family members and to absorb the family labour force. Some holdings are so small that they deserve the name micro-plots or mini-farms and can not support subsistence farmers.

Population pressure leads to a reduction in cultivated land, which leads to a drop in per capita food production. Agricultural intensification and crop-livestock interactions have started to balance pressure of population growth in Ethiopia. Relevant questions are: Does agricultural intensification induce higher efficiency in resource use leading to higher output per unit of resources applied? What is the extent of efficiency gains that can be achieved either by reallocating resources or by improving technology, and what is the mechanism through which such potential gains can be translated into reality?

1.2 Statement of the problem

Population pressure causes land fragmentation and that manifests itself in smaller landholdings and increased land use intensity, e.g. monocropping or monoculture, more frequent annual cropping and shorter fallow periods to regenerate fertility.

In Ethiopia, policy reforms have strengthened the position of individual farms by allocating land to millions of farm households, but for all practical purposes this has created "small farm" agriculture. These small units are often too small to provide a target income and to apply highly productive technology to increase productivity and efficiency and to feed the farm family. Population pressure, which leads to smaller landholding, becomes a limiting factor to increasing agricultural productivity and efficiency.

Smallholders in the study area are known to contribute to the greater food supply, but they have limited cultivated land area to further increase production. Thus, to improve the life of the farmers in the study area, the effect of landholding on productivity and efficiency must be investigated. It is with this intention that this study investigates the differences in farm efficiency between farm groups (small and large).

1.3 Objectives of the study

The main objective of the study is to analyze the effect of farm size on farm efficiency at micro level in cereal-based farming systems. The specific objectives of the study are:

1. To determine the effect of farm size on technical efficiency of small-scale householders in the selected district;
2. To investigate whether the mean technical efficiency varies between small and large farm sizes;
3. To suggest policy recommendations for resource use options to increase farm efficiency of the least efficient farms.

1.4 Hypotheses of the study

For the traditional farmer, land is the most important means of production and his/her only guarantee of survival. All other conditions being equal, farm size (land holding) is considered to be an important causal factor in the creation of social and economic disparities.

Emanating from the above premises, it could be hypothesized that access to land is the most important driver of farm productivity and efficiency. Hypotheses directing or guiding this research are:

- Population pressure is manifested in reduced farm size. This, in turn, increases use of improved seeds, fertilizers, labour and animal traction per hectare to compensate for scarcity of land.
- Small-scale farms produce either a smaller number of crops or are less productive than large-scale farms.
- Small-scale farms adopt no or very limited technology, compared to large-scale farms.
- Small-scale farms earn less annual income than large-scale farms.

1.5 Significance of the study

The effect of farm size on productivity and efficiency of smallholders has not received much attention. It is imperative to describe and diagnose the existing farming systems and to analyze the effect of farm size on productivity and adoption of technologies (DZARC, 1996; 1997). Generally, smallholders face many trade-offs in allocating land for crop and livestock production. Making appropriate decisions regarding the allocation of scarce land to crops is a challenge for researchers. Therefore, the primary aim of the research is to contribute to scientific knowledge about land constraints in crop production. In the end, the study will contribute to further research, extension and development schemes.

1.6 Scope and limitation of the study

Due to financial and time limitations, the study focused entirely on the sample survey method and discussion with focus groups of farmers' leaders. Accordingly, the sample size was limited to 199 farmers in the selected district.

Despite the limited sample size and area, the study will contribute invaluable inputs for agricultural policy design and research with respect to smallholder farms, especially in regions where land is very scarce as a result of population density.

1.7 Organization of the study

This thesis is organized in seven chapters. The outline of the contents of each chapter is as follows.

Chapter 1. Introduction: This chapter presents the introduction, objectives and problem focus of the study.

Chapter 2. Literature review: Literature on the conceptual framework determining farm size and efficiency of farms is discussed. Factors contributing to farm efficiency are identified and discussed briefly.

Chapter 3. Research methodology: The primary purpose of this chapter is to provide an overview of the different phases of the research. The finding of a research problem, a suitable study area and the analytical model are described as well as questionnaire development, survey design and sampling, data collection and data analysis.

Chapter 4. Description of the study area: This chapter provides a description of the study district, highlighting location, land tenure, land use and fragmentation, population and farm size and farming systems.

Chapter 5. Characteristics of farm households: The surveyed data, demographic, socio-economic and institutional support services of the sample farmers, farm and herd sizes, farm productivity and adoption of technology in the study area are presented in this chapter.

Chapter 6. Technical efficiency analysis of wheat and tef production: Analyses of the effect of farm size on technical efficiency of wheat and tef production are presented. The econometric model selected for measuring farm-specific efficiency, dependent and explanatory variables are discussed and recommendations arising from the study are suggested and formulated.

Chapter 7. Conclusions and policy implications: This final chapter highlights the conclusions, policy implications and recommendations arising from the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, literature that is relevant and available on the subject of the research problem is discussed. Various debates on and approaches to the farm size-efficiency relationship and factors that could influence farm efficiency are discussed in detail. Different views on farm efficiency and characteristics of small farms, land fragmentation, heterogeneity of small farms, etc. are discussed briefly. Problems faced by small farmers in developing countries are highlighted.

Literature on farm efficiency and other related issues is highlighted on two dimensions: globally and in an Ethiopian context. For the purpose of the study it was deemed necessary to obtain an overview regarding these two contexts and how farm efficiency manifests itself on the two levels. The chapter ends with concluding remarks.

2.2 Overview of literature in global context

2.2.1 Reflections on population growth

When population continues to grow but land does not increase, a problem arises under the egalitarian land allocation rule. Thus the incremental demand for land can arise from population growth or labour growth.

Population growth can have positive and negative impacts on development. The net impacts of population changes vary from country to country and from locality to locality. The problem is to analyze how demographic changes interact with the existing resources of a country.

Population growth, to a large extent, seems to have negative resource-shallowing impacts that dominate induced feedbacks. Thus positive scale effects are required to overturn the net negative impacts of population growth. In the case of agriculture, the negative impacts of population growth will outweigh the positive effects, if there is neither expansion of land nor capital intensification. The key issue is whether and by how much such offsets respond to population size and growth (Boserup, 1965).

In many countries, population growth is exerting pressure on limited arable land area and other resources, such as forests. The adverse impacts are often felt more than the positive contributions of population growth. The problem may be more serious when property rights to land and other natural resources are poorly defined. The writings of Malthus and Ricardo predicted strong positive correlations between a rapidly growing population and increasing scarcity of resources. A population explosion may possibly result in agricultural stagnation and environmental degradation. Furthermore, population growth may bring few alternative off-farm activities, makes vital inputs insufficient, and may result in declining per capita production and caloric consumption.

Growth in agricultural production and population shows disparities, given the realties in many developing countries. In Africa, the growth of per capita agricultural production was 0.4 percent per year for the years 1980-85 (Tadaro, 1994). Per capita agricultural production decreased by 16 percent in the period between 1988 and 1990, compared to levels between 1979 and 1981 (World Bank, 1992). Thus, population is one of the issues to be addressed in relation to land use and land fragmentation.

Population pressure leads to various land use dynamics. Diminishing farm size, land fragmentation and expansion of arable land are examples of the responses to increase in population. Population growth and spatial distribution of the population affect land use patterns and agricultural productivity, which later exacerbates soil degradation and food insecurity problems. The long-term solution to the population problem lies in implementing strategies of fertility reduction and expanding family planning services and national population policies, with increased commitment on the part of the Ethiopian government. Measures to address these problems should be selected with care. Land redistribution measures based on local realities are essential. Land resource management should be integrated with other development policies for sustainable development of agriculture. Furthermore, a balanced spatial population distribution with a view to maintaining environmental security and extending the scope of development activities is identified as a specific objective of population policy. Temporary out-migration of population might be effective in reducing the number of landless and the pressure on land. However, spatial distribution involves resettling citizens in less dense areas, which by itself is an intricate issue affecting the social, cultural, political and economic aspects of survival (Abbi, 1995).

On the other hand, increasing population means a greater supply of labour. Over the long span of history, population growth has undoubtedly be the major source of output growth in the world. Especially, if the country has ample resources, the effect is more likely to be positive. Moreover, population growth can have the positive effect of providing a larger market for domestically produced goods (Norton and Alwang, 1993).

2.2.2 Reflections on land reform and farm size

Land reform gives poor people ownership or permanent cultivation rights to specific parcels of land. It makes sense when it increases their income, consumption, or wealth, and it fails if their consumption does not increase or is reduced (Binswanger and Elgin, 1990).

If efficient farms replace inefficient farms, there is a benefit, but if inefficient farms replace the efficient farms, there is a loss. Berry and Cline (1979) show that, in many countries, productivity is higher on small farms than on larger farms. However many question whether these findings really mean that transfer of land from large to small farms increase output. Some critics have tried to show that the observed differences in efficiency disappear when difference in land quality is accounted for, arguing that larger farms are often on poorer quality land. Bhalla (1983) used the Indian Fertilizer Demand Survey to eliminate the land quality differences statistically. He found that when soil quality variables are introduced, the inverse relationship declines for almost all the regions. This decline is observed for both the magnitude and the significance of the coefficient for land. Kutcher and Scandizzo (1981) conducted similar research in Northeast Brazil and found that productivity differences between large and small farms did decline, but did not disappear. Even after adjusting for proportion of farm land used for crops and for land value, they still found that productivity declined with respect to farm size, with an average elasticity of 0.69 (excluding the humid southeast, where sugarcane and cocoa plantations skew productivity in most large farms). This means that a 1% decrease in farm size will lead to a 0.69% decrease in productivity.

Many governments have tried to improve the tenancy terms of poor sharecroppers by legislation, but these attempts have largely had adverse results (Binswanger and Elgin, 1990)

Firstly, owners have many ways of getting around the legislation, for instance, by reducing the size of plots allocated to tenants or by reducing credit, fertilizer, or other inputs owners might provide the tenant. Secondly, if owners cannot circumvent the laws, they expel tenants and revert to self-cultivation. In this case, the impact of many of these tenancy reforms has reduced the welfare of tenants.

If land reform cannot be financed and tenancy reform has adverse results, other policies and programs must be pursued to assist the landless poor and small farmers. Such approaches, far from being new, are the reasonable standard of small farmer development programs, and they have enjoyed much success and continue to be valid for pursuing objectives (Binswanger and Elgin, 1990).

Firstly, governments should reform those policies favouring large farmers and which lead to large land premiums over the capitalized value of agricultural profit. Furthermore, they should eliminate income tax exemption for agriculture and subsidized credit for larger farmers.

Secondly, governments should eliminate explicit and implicit subsidies for machinery purchases. As an example, the 1986 U.S. Tax Reform Act lengthened the recovery rates on such depreciable assets as agricultural machinery from five to seven years and repealed the investment tax credit for favouring small farmers.

Thirdly, governments should undo negative tenancy reforms and labour laws, according to which people are allowed to rent out their land again or make more intensive use of labour. Proposal for the newly planned reforms in the Philippines calls explicitly for the abolition of all constraints on tenancy. In Latin America, the abolition of such constraints would greatly benefit self-employment in agriculture (Hayami *et al.*, 1987).

Fourthly, governments should redistribute the land they already own, but with some reasonable ceilings on the size of holdings. In the Brazilian Amazon, squatters can obtain up to 3,000 hectares of land if they clear trees from half of it. This accelerates deforestation and drastically reduces the land available to smallholders. A more sensible policy would be a land ceiling of 50 to 100 hectares. A good example of a successful redistribution scheme, using a smaller land allocation, is the U.S. Homestead Act, which opened new areas to settlers in the nineteenth century (Binswanger and Elgin, 1990).

Fifthly, efforts should be made to give smallholders adequate titles. Even if their claims to the land are secure, they cannot compete for official credit without titles. Feder's study of land titling in Thailand (1988) shows how large the disadvantages can be for small farmers lacking deeds of ownership. The recent land reforms (1996) in Algeria have not given firm guarantees of land tenure to new farmers, so the farmers there will continue to experience difficulty in raising loans from banks.

Sixthly, special efforts should be devoted to programs that assist small farmers. Very popular in the 1970s, these projects are still an integral part of the World Bank's poverty alleviation strategy. Such schemes as area development programs, the training and visit (T and V) extension programs, and the large dairy projects along the lines of dairy cooperatives have done much to help small farmers. Despite these successes, discussion in recent years has often focused on failed small projects. Projects failed where general economic policies were stacked against the farming sector or where the project design was too complex for the implementation capacity of the agricultural services. In sub-Sahara Africa, many projects have also focused on zones with very little agroclimatic potential and where no new high pay-off technology exists. The failures do not question the small farmer development program, but rather provide lessons that their design could be improved (Binswanger and Elgin, 1990).

Land reform is unlikely to be a major tool for improving the welfare of the poor in developing countries. Even where it would make considerable economic sense, land reform will not happen, because the beneficiaries cannot pay for the land reform, necessitating confiscations or imposing large tax costs, neither of which is politically palatable. Consequently, other measures have to be devised to improve poor farmers' access to land or increase their income from agriculture. These measures can help small farmers only if governments abandon those policies favouring large farms and that put premiums on land prices. A much stronger commitment from governments and agencies is thus needed to address these policy issues and thereby to reduce incentives to accumulate large ownership holdings, to increase agricultural production, and to assure greater equity and self-employment in agriculture (Norton and Alwang, 1993).

2.2.3 Farm efficiency: definition and concept

A farm is said to be technically efficient if it produces as much output as possible from a given set of inputs or if it uses the smallest possible amount of inputs for given levels of output (Atkinson and Cornwell, 1994, Amara *et al.*, 1998). Pioneering work on efficiencies was conducted by Koopmans (1951), Debreu (1951) and Farrel (1957).

Technical efficiency of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output, conditional on the levels of inputs used by that farm (Coelli *et al.*, 1998).

The concept of technical efficiency in smallholder agriculture may influence the success of development strategies. If most farmers obtain the maximum possible input-output ratios with the available inputs and technologies, then the new investment streams are seen as critical for any development. However, if some farmers perform much better than most of their neighbours with the same inputs and technologies, there may be considerable scope for increasing output without major new investments in the short term.

In the past, it was widely accepted that farmers operating in traditional agricultural systems are efficient, given the resources and technology available to them. This led to farm policies in third world countries which placed high emphasis on capital investment. This has been a topic of substantial interest since the 1960. In his work, Schultz (1964) advanced the efficiency hypothesis that states traditional farmers are "poor and efficient". There are comparatively few significant inefficiencies in traditional agriculture. Since Schultz's work, a number of studies have been undertaken to test his hypothesis further. Several empirical studies, for instance Bachman and Christensen (1967) and Ghose (1979), studying of technical efficiency of Indian agriculture, supported the Schultzian hypothesis.

In contrast, other empirical studies based in developing countries have recently shown the existence of a potential for boosting agricultural production through improvement of technical efficiency of farmers by using the existing resource basis effectively (Bezabih *et al.*, 1991; Getachew, 1995; Gimbol *et al.*, 1995; and Assefa and Heidhues, 1996).

Determining technical efficiency based on the production frontier function uses two main approaches, namely, the deterministic and the stochastic approach. In the former one, all farms share the same production frontier technology. Thus, any deviation from the established production frontier is attributable to inefficiencies in input use. Depending on whether its relation to the production inputs is implicit or explicit, this frontier may be non-parametric (Farrel, 1957; Afriat, 1972) or parametric (Aigner and Chu, 1968; Forsund and Hjalmarrson, 1979). The main shortcoming of the non-parametric and the parametric approaches is that the estimated frontier is sensitive to outliers. Aigner and Chu's (1968) probabilistic production frontier, which was later implemented by Timmer (1971), takes that problem into account. The frontier production is estimated using mathematical programming techniques and disregarding certain observations (Forsund and Hjalmarrson, 1980). A similar frontier function, called deterministic statistical frontier function, may be estimated using either maximum-likelihood procedures or other economic techniques.

As argued by Forsund and Hjalmarrson (1980), the deterministic approach ignores the fact that farms' performance may be affected by such factors as bad weather, poor performance by farmers or breakdowns in the input supply. Most of these factors are beyond the farmer's control. Thus, deviations from the efficient frontier may be of two origins: inefficiency regarding input use or random variations in the frontier across different farms. The stochastic frontier or the composed error model suggested by Aigner and Chu (1977) and Meeusen and Van den Broeck (1977) accounts for such occurrences. The error term in the production frontier is made up of:

- A symmetric random component that captures the effects of factors beyond the farm's control, measurement errors and any white noise; and
- A one-sided component that accounts for technical inefficiency.

Several empirical studies have used the stochastic frontier production method to estimate technical efficiency (Dawson *et al.*, 1991; Bravo-Ureta and Rieger, 1990, 1991; Parikh and Shah, 1994; Tran *et al.*, 1993; Kalirajan, 1991).

In agricultural economics literature, the stochastic frontier (econometric) approach has generally been preferred to Data Envelopment Analysis. This is probably due to a number of factors. The assumption is that all deviations from the frontier are associated with inefficiencies, despite the inherent variability of agricultural production caused by weather, pests, diseases, etc. Furthermore, because many farms are small family-owned operations, maintaining accurate records is not always a priority. Thus much available data on production are likely to be subject to measurement errors (Coelli and Battese, 1996).

There have been many applications of frontier production functions to agricultural industries over the years. Battese (1992) and Bravo-Ureta and Pinheiro (1993) provide surveys of applications in agricultural economics. The latter pays particular attention to applications in developing countries. Bravo-Ureta and Pinheiro (1993) also draw attention to those applications which attempt to investigate the relationship between technical efficiencies and various socio-economic variables, such as age and level of education of the farmer, farm size, access to credit and utilization of extension services. The identification of those factors that influence the level of technical efficiencies of farmers, is undoubtedly a valuable exercise. The information provided might be of significant use to policy makers attempting to raise the average level of farmers' efficiencies. Most of the applications which seek to explain the differences in technical efficiencies of farmers, use a two-stage approach. The first stage involves the estimation of a stochastic frontier production function and the prediction of the farm-level technical inefficiency effects (or technical efficiencies). In the second stage, these predicted technical efficiency effects (or technical efficiencies) are related to farmer-specific factors using ordinary least squares regression. This approach appears to have been first used by Kalirajan (1981) and has since been used by a large number of agricultural economists, a recent example being Parikh and Shah (1994).

2.2.4 Farm productivity and efficiency

Before discussing efficiency further, it would be useful to make a distinction between the terms efficiency and productivity. These words are often used interchangeably; however they do not have precisely the same meaning. To illustrate the distinction between the two terms, it is useful to picture a production frontier, which defines the current state of technology in agriculture. A farm in agriculture would presently be operating either on that frontier, if it is perfectly efficient, or beneath the frontier if it is not fully efficient. Productivity improvements can be achieved in two ways. One can either improve the state of technology by inventing new ploughs, pesticides, rotation plans, etc. This is commonly referred to as technical change and can be represented by an upward shift in production frontier. Alternatively one can implement procedures, such as improved farmer education, to ensure that farmers use existing technology more efficiently (Coelli, 1995). This would be represented by the farms operating more closely to the existing frontier. It is thus evident that productivity growth may be achieved through either technological progress or efficiency improvement, and that the policies required to address these issues are likely to be quite different. The discussion in this thesis is confined to measurement efficiency not to issues relating to the measurement of technological change and overall productivity growth.

Productivity is defined as the ratio of the output(s) produced to the input(s) used, whereas efficiency is the ratio of the observed output relative to the potential output defined by the frontier function (Coelli *et al.*, 1998).

When efficiency is measured, the question may be, why bother with econometric or linear programming frontier estimation? For example, what is wrong with using tonnes of wheat per hectare or liters of milk per cow as measures of efficiency? Measures such as tonnes per hectare have a serious deficiency, in that they only consider the land input and ignore all other inputs, such as labour, machinery, fuel, seed, fertilizer, pesticides, etc. The use of such measures in formulating management and policy advice is likely to result in excessive use of those inputs that are not included in the efficiency measure. Similar problems occur when other simple measures of efficiency, such as liters of milk per cow or output per unit of labour are used.

A variety of efficiency measures which can account for more than one factor of production have been proposed. The primary purpose of this thesis is to outline some of the measures and to discuss how they may be calculated relative to an efficient technology, which is generally represented by some form of frontier function. A key part of this exposition is a discussion of the two primary methods of frontier estimation, namely stochastic frontiers and data envelopment analysis (DEA), which involve econometric methods and mathematical programming, respectively (Coelli *et al.*, 1998).

Studies of the sources of farm productivity and efficiency are concerned with the role of farm and farmers' characteristics. The results are mixed. For example, several studies found a significant relationship between farm size and productivity (Bravo-Ureta and Rieger, 1991; Tauer, 1993; Wang *et al.*, 1996; Romain and Lambert, 1995). Yet some studies found no association between farm size and farm productivity and efficiency (Page and John, 1984; Bravo-Ureta, 1986; Byrnes *et al.*, 1987; Bagi, 1982).

2.2.5 Farm size - efficiency relationship

When farm size is evaluated in terms of productivity and efficiency, there are two schools of thought: the first school of thought argues that small family farms may be more productive, efficient and manageable than large family farms because the small farmers will devote more labour to preparing plots, weeding, harvesting, etc., than large farmers who are dependent on hired labour (Kanel, 1967; Grant, 1973, Van Zyl, 1996). A survey carried out in India indicated that average yield of farms of less than two hectares was found to be nearly 50% greater than that of farms of more than 20 hectares. In Taiwan, farms of less than one hectare have far higher yields than those of more than two hectares (Rane, 1983).

The second school of thought argues that the observed superiority of small farms in terms of yield is intimately linked to primitive technology, wage-labour based production, and insufficient market developments. Technical know-how and managerial ability are scarce in developing countries, and this is one reason why small family farms, under certain circumstances, may be more efficient than large family farms. Small family farms also apply labour intensive forms of production, but they use less scarce capital. This relationship has been tested and verified in Asia, Africa and Latin America (Dorner, 1973; Ghose, 1979). From these facts, it is possible to conclude that the introduction of chemical fertilizers, improved seeds, technical know-how, managerial ability, labour-saving technology and equipment, will most likely erode the superiority of small-scale production, even though it may remain more labour intensive than large family farms. The apparently conflicting results obtained from recent studies in India on the relationship between yield per unit area and size of holding, support the views expressed by different authors. In nine study areas that had adopted HYVs and fertilizers, and were producing rice, wheat and maize respectively, yields were found to be higher on large farms than on smaller ones in five areas, while the opposite was found to be true in four areas, but there was no significant correlation between farm size and yields (Dasgupta, 1987). These apparently inconsistent results could be explained by the differences between farms, irrespective of the size, in the use of inputs and cultural practices accompanying the adoption of HYVs.

In the production of certain crops, small family farms have proven to be able to compete effectively with large farms. For example, coffee and tef production in Ethiopia, and cocoa production in Ghana and Nigeria, which dominate the world market, is entirely in the hands of smallholders.

As indicated by many authors, a large farm *per se* is neither a prerequisite nor an obstacle to agricultural development. "A large farm unit is not in itself a guarantee of productivity" (Bachman and Christensen, 1967). However, when the available land for farmers is generally limited and the number of potential farmers is great, considerable political pressure may be exerted to adopt farm units of a size that is sufficient to provide adequate income. This process, followed by technological influences, has changed the relationship between farm size and land productivity from positive to negative because small farms are not able to adopt technologies due to low income. To overcome this problem, adequately sized family farms should be established. According to Powell (1972) adequately sized family farms are enterprises which control sufficient land resources to provide full-time employment to the farm family at a productive level and supply their basic life requirements. Such families do not rely on the labour market for employment, nor do they usually employ hired labour on the farm. The head of the family is both operator and worker.

Evidence from many countries indicates that economic progress in agriculture is possible under a great variety of farm size conditions. However, relatively small farm units must be large enough, not only to ensure efficient production, but also to produce an acceptable standard of living for the family members. In many cases, where political and social considerations have dominated, productivity and resource allocation have been virtually ignored or considered passively. Solutions that are socially desirable may be less productive economically. *Therefore, the main purpose of this comparative study of small farm size versus large farm size is to demonstrate which farm size contributes more to the overall technical efficiency of agriculture in a country. If farm size is the major source of productivity and efficiency differences (productivity or efficiency gains), then land reforms need to be instituted. If the analysis does not substantiate this, then efforts to develop technologies will be primary to land reform policies.*

In fact, agricultural productivity depends on three factors, namely efficient use of the existing resources, technological and institutional factors (Norton and Alwang, 1993).

Much has been written on the efficiency of resource allocation. It is one of the most widely discussed and controversial issues in the economic literature of underdeveloped agriculture. Many economists and other social scientists challenge the claim that agricultural production can be increased to a substantial degree through a more efficient use of resources. Schultz (1964) argues that there are few inefficiencies that can be found in the allocation of factors of production. He emphasizes the need for new investments for generating more productive technologies. In contrast to the Schultzian hypothesis, Lipton (1968) counters with his generalization of the peasant farmer's behaviour. Instead of maximizing profit, he portrays the small farmer as a single maximizing utility. It would not be surprising if the subsistence farmer's risk aversion took dominance over profit maximization in deciding which crops to produce and how to produce. Allocating resources in a way that trades a marginal gain in security does not signify economic irrationality.

The second most widely discussed issue is technological factors that help raise productivity substantially, such as improved seeds, fertilizers, pesticides and irrigation practices. Nonetheless, a sustainable increase in productivity cannot be attained unless it is accompanied by complementary improved institutional arrangements, like access to credit, marketing facilities, extension services, etc. Among the institutional factors that greatly influence agricultural development, land reform has been widely cited (Mali, 1989; Vasant and Chaya, 1993; Sharma, 1994).

2.2.6 Management- efficiency relationship

In Africa, a widely held view is that the land area suitable for growing food is virtually fixed and the supply of energy for tilling the land is being depleted. According to this view, it is impossible to continue producing enough food for the growing population. An alternative view is that man has the ability and intelligence to decrease his dependence on cropland, traditional agriculture, and depleting sources of energy and reduce the real cost of producing food for the growing world population. By means of research and human capital development, advances in knowledge and skills relating to the production of enough food for the growing population can substitute cropland. Thus, mankind's future is not determined by space, energy and cropland. It will be determined by the intelligent evolution of humanity (Schultz, 1990).

Although farmers differ in their ability to perceive, interpret, and take appropriate action in response to new information for reasons of schooling, health, and experience, their management quality is an essential prerequisite for increasing small-scale farm efficiency and productivity. Where resources are meager, there are two options for increasing farm efficiency and productivity: adopting new technologies and improving efficiency without increasing the resource base. These two options are still possible through better management quality. For instance, introduction of new technologies requires intensive input management and information. Farmers in developing economies with low literacy rates, poor extension services, and inadequate physical infrastructures have great difficulty in understanding new technologies, not to mention exploiting their full potential. Available evidence suggests that farmers in developing agriculture fail to exploit fully the potential of technology and/or make allocative errors. Consequently, yields show a wide variation, usually reflecting a corresponding variation in the management capacity of farmers (Ali and Chaudhry, 1990).

Nowadays, there is increasing concern about farmers' management skills. Factors that cause some farmers to be more efficient than others have been determined by some studies (Bonnen, 1990). The relationship between farm productivity, farming experiences and education levels has received attention. Results indicate that farming experience and education level of household heads are both significant variables for improving farm productivity and technical efficiency. Furthermore, efficient farmers are more likely than others to invest in technology. Two variables, namely farming background and education, are used as proxy variables for managerial inputs. Increased farming experience as well as a higher level of educational attainment leads to a better assessment of the importance and complexities of good farming decision-making, including the efficient use of inputs. In fact, both factors enhance farmers' ability to seek and make good use of information about production inputs (Amara *et al.*, 1998). Romain and Lambert (1995) report that post-secondary education was important in improving dairy farmers' efficient use of production inputs in Canada. Yet Wang *et al.* (1996) and Page and John (1984) report a negative relationship between farm productivity and formal education.

2.2.7 Measuring farm efficiency

Farm efficiency is generally measured using Data Envelopment Analysis (DEA) or stochastic frontier methods. DEA involves the use of linear programming whereas stochastic frontier methods involve the use of econometric methods (Coelli *et al.*, 1998).

Farrell (1957) proposed a measure of the efficiency of a farm that consists of two components: Technical efficiency, which reflects the ability of a farm to obtain maximal output from a given sets of input, and allocative efficiency, which reflects the ability of a farm to use inputs in optimal proportions, given the respective prices. These two measures are then combined to provide a measure of total economic efficiency.
Of the two efficiency measuring methods mentioned above, a stochastic method is possibly more appropriate than DEA for agricultural production, especially in developing countries, where the data are heavily influenced by measurement error and the effects of weather, disease, etc. Moreover, the stochastic frontier approach is only well-developed for single output technologies, unless one is willing to assume a cost minimizing objective. However, in the non-profit service sector, where random influences are less of an issue, where multiple-output production is important, prices are difficult to define, and behavioural assumptions, such as cost minimization or profit maximization, are difficult to justify, the DEA approach may often be the optimal choice. Selection of the appropriate method should be done on a case-by-case basis (Coelli *et al.*, 1998).

Measuring farm efficiency which converts inputs into outputs is a relative concept. For example, the efficiency of a farm in 1996 could be measured relative to its 1995 efficiency or it could be measured relative to the efficiency of another farm in 1996, etc. The methods of efficiency measurement can be applied to a variety of firms. They can be applied to private sector firms producing goods, or to service industries such as travel agencies or restaurants. Efficiency or performance measurement can also be applied to non-profit organizations, such as schools or hospitals. All of the above examples involve micro-level data. The methods can also be used for making farm efficiency comparisons at higher levels of aggregation. For example, one may wish to compare the efficiency of a farm over time or across geographical regions (districts, zones, states, countries, etc.). These methods differ according to the type of measures they produce, the data they require, and the assumptions they make regarding the structure of the production technology and the economic behavior of decision-makers. Some methods only require data on quantities of inputs and outputs while other methods also require price data and various behavioural assumptions, such as cost minimization and profit maximization.

Some of the advantages of stochastic frontier over DEA are (Coelli *et al.*, 1998):

- It is likely to be more appropriate than DEA for agricultural applications, especially in developing countries, where the data are heavily influenced by measurement error and the effects of weather,
- The existence of inefficiency and the structure of the production technology can be performed in stochastic frontier analysis,
- It accounts for noise,
- It can be used to conduct conventional tests of hypotheses.

However, stochastic frontier has some particular pitfalls for users, namely:

- The efficiency scores are only relative to the best farms in the sample. The inclusion of extra farms (say from other regions) may reduce efficiency scores,
- The mean efficiency scores for two samples/groups reflect the dispersion of inefficiency within each sample, but they say nothing about the efficiency of one sample relative to the other,
- Measurement error and other noise may influence the shape and position of the frontier,
- Outliers may influence results.

Finally, in the interpretation of the preliminary results, the researcher may observe that a particular farm has a lower efficiency or productivity relative to other farms. This could be due to one or more of the following:

- Technical (managerial) inefficiency,
- Scale inefficiency,
- Omitted variables,
- Quality differences in inputs and outputs,
- Measurement error,
- Unused capacity due to lumpy investment,
- Environmental factors (physical and/or regulatory).

2.3 Farms scenarios in developing countries

2.3.1 Definition and characteristics of small farms

In developing countries, the term "small farm" is precisely defined neither for the agricultural research community nor for the general public. The definitions of what constitutes a small farm and the concomitant categorization by size have gone through several metamorphoses in different countries. The definitions of small farms are arbitrary, numerous, and vary by type of farm, geographical location, and even by the individual researcher. Farm size has been defined by various criteria, including acres of land operated, units of livestock in operation, value of farm output produced, total assets controlled, level of farm income to level of total family income, and days of work off-farm and on farm (Lewis, 1988).

Most investigations of small farm characteristics combine two or more of these classifications to arrive at a more limited but conclusive definition. However, over the last several decades, small farms have generally been described as farms with limited resources, with small volumes of farm product sales, as family farms and part time farms. Furthermore, these farms have been, rightly or wrongly, identified closely with poverty situations. A common thread running through each of these characterizations is that somehow small farms fall outside the mainstream of commercial agriculture.

In developed countries a farm is considered small if its size does not allow for efficient utilization of existing agricultural technologies. Consequently, the definition of small farm requires review over time before it loses its functional relevance (Singh and Williamson, 1985). Hence, for developed countries acres of land cannot be used as a dividing line to distinguish between large and small farms. The gross product sales criterion is the best single measure available to distinguish between large and small farm groups. However, it also has shortcomings. Firstly, this definition can easily be misleading because of variation in input requirements among small farms and the extent to which inputs are produced on the farm or purchased (West, 1979). In addition, small farmers' objectives and ambitions do not usually coincide with those of large farmers. Small farmers are generally striving for survival, while the objectives of large farmers are usually dominated by income/profit maximization. Farm product sales also give little insight into the distribution of the total income within the farm, and conceal important information about the number and characteristics of farm households with low incomes.

This criterion on its own does not identify economically disadvantaged farm families because it is common practice for many small farm families to combine farm and non-farm income sources and other economic activities in order to make a living.

Secondly, the gross farm product sales measure is influenced by inflation. Thus, rigid adherence to monetary guidelines could mean that, due to volatile agricultural product prices, a farm cannot be considered small one year and large the next year.

Some of the common recognized problems associated with using farm product sales as a measure of farm size in any given year are (Gebremedhin and Christy, 1996):

- Small farms may produce enough for sale and domestic use in one year and only for domestic use in the next year;
- The effects of changing price levels are not easily accounted for in comparisons between years;
- Changes in crops and livestock inventories are not considered;
- Government payments are not included as a source of income; and
- Crop failures or livestock losses understate the size of a business when there are relatively few sales.

Despite these problems, gross product sales persist as the most commonly used method of describing farm size and presenting size distributions. The farm size definition should also take into account family size, acres in operation, labour involved, equity capital, economic incentives, and income based on farm and non-farm resources.

2.3.2 Heterogeneity of small farms

In assessing the structure of production agriculture, it appears that large farmers as a group are probably more alike than small farmers, since large farmers usually rely on the farm to provide family income and are expected to devote most of their time and energy to farm work and management (Hinson, 1996). Conversely, farms with a low level of farm product sales, or limited resources, make up a more diverse group. A few farms may have sufficient resources and growth potential to generate an acceptable level of family income. Farmers who farm full time and have few resource limitations may lack the basic economic incentives and motivation for farming or may be preparing for migration to towns. Other farmers farm part time, i.e. their income is derived mostly from labour or resources devoted to the non-farm sector.

On most small farms, one or more resources are limited. Farmers are able-bodied and young, but have low farm product sales because they have just started farming with a small operation, and may expand their farming activities as they gain experience. Some farms may be growth and goals limited, with low-skilled farmers who have few opportunities for additional farm and non-farm earnings. Other farmers may be aged and retired, have some physical disability, or may even depend on their family members for social welfare and social security. Many of these people live under deplorably poor conditions in rural communities. In many cases, these are people whom the government officials and researchers find most difficult to reach.

Many others situations that make the definition of small farms more complicated and ambiguous may exist. This diversity suggests that types of small farms are many and varied, and that a heterogeneous group exists. In view of this fact, it is advisable not to set criteria for defining the characteristics of small farms. In many cases, the criteria used should depend on the individual researcher's perception of the agricultural sector and understanding of the characteristics of the rural communities. However, it is essential that the working definition of small farm should have desirable attributes from a statistical perspective, in terms of its clarity and measurement capacity, feasibility for data collection, and capability of being implemented using conventional statistical procedures (Carlin and Saupe, 1979).

2.3.3 Land fragmentation

Small farm size and land fragmentation have been hypothesized to be impediments to economical crop production in developing countries. They are believed to be the principal causes of low productivity and major obstacles to the development of rain-fed agricultural regions (El Hurani and Duwayi, 1986, Ngwenya, 1997, Van Zyl *et al.*, 1995).

One factor which influences the development of small farms and land fragmentation is partitioning of land into a number of households who acquire ownership rights to land. Over time this partial sub-division of land to a number of households leads to a decrease in field size over time (Edwads, 1978; Burton and King, 1983; Yibeltal, 1995). Operating farms are often composed of a collection of spatially dispersed fields rather than a contiguous land unit.

Land fragmentation is defined as the division of a single farm into several separate, distinct parcels of land (Jabarin and Epplin, 1994). Many developed and developing countries encounter a land fragmentation problem. Some consider small farm size and land fragmentation to be the major impediment to efficient field crop production. Small and irregular fields increase the cost of moving family labour and draught animals and reduce their efficiencies relative to large and regular fields (Gebremedhin and Chirsty, 1996).

While there are costs associated with land fragmentation, under some circumstances, spatial dispersion may be beneficial. An individual farmer who manages several dispersed parcels of land may exploit differences in rainfall or soil type by scheduling planting to reduce risk and distribute labour requirements over time (Bentley, 1987).

Land fragmentation may facilitate risk management through diversification even in relatively homogeneous environments. For example, hail or snowstorms and frost are often localized, so that the probability of a total loss is less for a farmer with spatially dispersed land tracts. Similarly, rain from thunderstorms is often localized such that some fields may produce well in certain years, while others do well in other years (Carlyle, 1983; Heston and Kumar, 1983). Whether land fragmentation reduces economic efficiency or not remains to be determined. Thus, before arriving at a sound conclusion, intensive research should be carried out to determine whether land fragmentation brings more benefits or not to the farmers, whether at regional or national levels.

Farm efficiency or productivity improvement is influenced negatively by surplus labour. A major problem experienced by agriculture in developing countries is that too many people crowd on to too little land. With a large and ever growing population, the law of diminishing returns is in operation as more labour is applied to shrinking parcels of land. Clearly, if land division among new households continues over several generations, at some point, farms would become so small that they cannot be farmed with a pair of oxen. As a result, individual farmers may have limited options for increasing agricultural productivity, because farmers with small farms cannot afford to buy improved seeds and fertilizers to apply as recommended by research and extension. Thus, the minimum economic size of a landholding that can be divided into a separate holding must be determined by investigating the existing level of farm productivity and level of technology.

Land appears to be the most important scarce factor of production in developing countries. Reductions in land size will not only have a direct negative effect on productivity, but also an indirect negative effect on output by reducing the efficiency and productivity of non-land inputs. For instance, improved seeds and fertilizer are two major land augmenting inputs in the sense that they improve the quality of existing land by raising yields per hectare. At present, farm fields become smaller as a result of continued redistribution of land to landless, thereby increasing land fragmentation as farmers cannot afford to pay for the required seeds and fertilizer in order to increase efficiency and productivity (Yibeltal, 1995).

Measures of economic efficiency are average production per unit of land or production cost per unit of output. Hence it is necessary to estimate the average variable production per unit of land or average cost per unit of product and to determine if land fragmentation as measured by average farm size is beneficial, not beneficial, or an insignificant factor. The results may be of value to farmers and to those responsible for setting and modifying agricultural policies that influence farm size and land fragmentation.

The principal identifying characteristic of small farmers, as well as being a cause of low income, is their limited access to resources, generally land, capital and technology. If solutions are to be found for the problems of small farmers, better use must be made of their scarce resources. The solutions must be concerned with improving efficiency of resource use and adoption of technology on farms. It seems reasonable to argue that small farmers, living in poverty or close to it, will always strive to use their scant resources in what they consider to be the best way. Farm analysis must therefore be concerned with breaking the constraints that imprison small farmers. Some of these constraints are physical, some are technological, some institutional and others personal and subjective.

Thus minimum farm size depends on many factors. The concept of a "livelihood threshold" relates to farm size, which makes possible the production of family needs in calories plus a further 50% to be used or sold to purchase supplementary foods or other essentials (Pears, 1987). Despite this requirement, the family farm can vary considerably in size: the acreage required to generate the same level of income depends on the work potential of the family, the level of capital investment and the ecological conditions. A recent survey in Kenya, for example, found that for rain-fed agriculture, the farm size needed to produce approximately USD 40 per capita per year, increased progressively from 2.6 hectares to 16.6 hectares from better to less favourable ecological zones. In order to generate the same level of income in range areas bordering the Sahel, from 90 to 135 hectares are needed (World Bank, 1990). However, the survey results may not be applicable if the number of small farms increases steeply as a result of population increase. A case in point is that the proportion of small farms in most developing countries ranges from 51 to 100%. Those smaller than one hectare make up 46% of number of farmers in India, 52 % in Liberia, 57% in Philippines, and 67% in the Republic of Korea (FAO, 1987). Evidence from many countries indicates that these small farms can flourish spontaneously due to rapid population increases. Most of the occupants of such holdings are in dire need of modern farm inputs because income levels are hardly sufficient for mere subsistence only. Where farms are small, the only way to provide an acceptable standard of living for the family is to supplement it by employment outside the farm. In Japan, for instance, the high farm household income of small-size farms is mostly due to non-farm income. Part-time farming is practiced by 84% of all households in Japan (Kim, 1972).

2.4 Main problems faced by small farms in developing countries

The trend toward a greater number of small farms and the grim reality of continuing financial crises in agriculture is the result of the interaction between and changes in numerous economic and non-economic causal factors. Affecting all farm sizes, especially those with low equity, are the micro-level economic forces which cause economic concentration (Gladwin and Zabawa, 1985). Scarcity and a rapid increase in the value of farmland make it difficult for the beginning farmer to get started (Eginton and Tweeten, 1982). Inflationary increases in the cost of production inputs and credit decrease farmers' income margins and raise their levels of permanent indebtedness (Van Blokland, 1981).

Some of the principal forces that shape the structure of production agriculture and the survival of small farms are discussed below.

2.4.1 Technology and resource endowment

Applying economic principles to guide production, the larger farmer could, over time, adopt new technology and better cultural practices generated by agricultural research and development. Technological developments in agriculture have increased the national agricultural output and accrued benefits to large and rich farmers, but not without cost. As a result of these technological developments, displaced farm workers and small farmers have incurred massive social and economic costs (Singh and Williamson, 1985).

Small farms are often isolated from the mainstream of modern agricultural activities. They are confronted with many difficulties because they produce in an industry geared towards serving large-scale production units. Tradition also plays a role in the day-to-day management of small farms. New technology is very slow to replace old techniques that have been practiced for generations. Factors inhibiting adoption of technology on small farms include lack of knowledge, limited quantities of resources (land, capital, and skilled labour), fear of risk, limited managerial ability, as well as inability to justify economically the adoption of certain types of technology for use in small-scale farm operations (West, 1979). All these factors weaken the small farmers' survival and competitive position and cause many to abandon agriculture in search of off-farm jobs. Price and technology, along with initial resource endowment, managerial ability and environmental factors determines the ability of individual farmers to generate income. The process of adjustment to price changes and technology explains changes in the size and productivity of farms and farming industry over the years. In a competitive market economy, low productivity and low-income often involve small farms in a long-run situation of disinvestment and eventually relocation into other off-farm economic sectors.

2.4.2 Farm credit and financing

Small farmers are continuously plagued by credit problems. Without an adequate source of credit, they cannot invest in land or modern technology to increase production and expand the farm base. Capital investment has become an issue of survival for many small farms. Traditionally, most small farms have financed the major share of capital requirements for farming operations from own savings. A few small farms that have no off-farm incomes minimize credit requirements by reducing input use and selecting low cash cost enterprises. Other farms have cut back production by selling land when faced with huge debts and no other alternatives.

Despite the fact that there is a low borrowing rate observed among small farmers, the small farm business community experiences an overwhelming need for credit. In spite of this, few small farms express an interest in borrowing for production purposes, as they prefer to remain debt free and possess a complacent attitude regarding the present pattern of farm capital investment for production purposes. Family subsistence and risk avoidance are necessarily priority considerations for survival of small farm families and this rationalizes their attitudes (Gebremedhin and Christy, 1996).

Even though there is no shortage of loan funds in the farm sector, marginal farm operators who perceive credit financing as an essential factor in farming continue to experience problems obtaining farm credit from conventional lending institutions. The small farm operators are usually disqualified from farm credit loans because of their disadvantaged economic condition and the generally conservative lending practices of financial institutions. The farmers have low equity positions and can offer little security, which implies high cost/risk for lenders. The low asset and small acreage owned by small farms are stumbling blocks for credit finance. To obtain loans, small producers may have to pay a higher rate of interest. Since most small farmers possess limited information about available sources of credit, they seldom compare interest charges or other measures of the true cost of credit (Gebremedhin and Christy, 1996).

Only a few lending agencies currently have the ability and mandate to serve low-equity or beginning farmers. In general, many lending institutions seek only large borrowers in order to minimize their service cost per dollar loaned. These lending institutions often limit the access small farm operators have to the capital market by imposing rigid rules for credit lending in order to protect the loan capital fully, thereby restricting the risk of loss. Nevertheless, small farm operators continue surviving with traditional capital financing practices and sources for reasons of convenience and choice (Singh and Williamson, 1985).

2.4.3 Farm input prices

In recent years, the cost of agricultural inputs has risen more rapidly than that of agricultural output, causing a cost-price squeeze. Consequently, the net income earned by small farmers has declined. Small and large farmers are affected alike by the cost-price squeeze, but its impact is felt more severely by small farmers (Gebremedhin and Christy, 1996). In general, small farms produce at higher cost per dollar of output than large farms due to low level of technology. Indeed, the survival of small farmers is based on the changing factor/output price ratios. Farmers are not being offered fair prices by input suppliers and marketing firms monopolists who manipulate prices and absorb income that should have gone to farmers. To solve problems, many small farms have turned to production activities that rely heavily on labour resources rather than significant levels of capital (Gallacher *et al.*, 1994).

The price paid for inputs varies among individual farms and it changes over time. Large producers typically buy inputs from suppliers at lower prices than small producers do, either because the farmer's size yields simple market power in the market, or because the supplier charges actual lower costs for moving a large volume of inputs to an individual producer. Changes in input prices are the result of changes in basic supply and demand conditions, as well as changes in competitive conditions in the input market. As input prices vary among firms or change over time, the relative competitive positions of a farm business are affected. The optimum input mix changes and farms may be better or worse off depending on their use of the input involved (West, 1979).

2.4.4 Market structure and activities

Small farmers do not produce enough output to influence price, and they have larger input cost relative to large farmers because they do not buy farm inputs in bulk. Small farmers, with their relatively low volume of sales, find it difficult to gain access to centralized markets on an individual basis, and are severely restricted with regard to marketing alternatives. They have been forced to seek other means to gain access to systems, such as pooling production to gain the advantage of a high volume, or using other marketing outlets for their products. Direct marketing outlets, such as roadside markets, farmers' markets, and pick-your-own operations, have increased market access for some small farms (West, 1979).

Another market problem faced by small farmers is a lack of bargaining power and market information. They be aware of the advantages and disadvantages of each market outlet, the ease and difficulty of access to each outlet, and the relationships of price levels among and within outlets. Variations in prices in each market outlet translate to income variation. Since small farmers have very little reserve to carry them through a bad year, price variation is important to their survival.

2.4.5 Non-farm income and employment

The most critical problem confronting small farmers today is maintaining a sufficient level of income. As a growing proportion of the total farm family's income originates from non-farm sources, off-farm employment has become a critical and an important alternative income source to small farmers (Brown, Christy and Gebremedhin, 1994; Sharples and Prindle, 1973). Off-farm work is common among operators of all farm sizes, but more on smaller farms because families operating small farms usually depend more on off-farm employment than families operating large farms. In many cases, the availability of off-farm employment is essential for the continuation of small farm operations. The lower the total farm families' income, the more dependent farm families are on off-farm income to maintain family well-being.

Currently, most small farm operators seek jobs away from their farms for at least a short time in order to earn supplementary family income. Some small farm operators hold full-time jobs in cities and do their farming at night and on weekends. But many of the off-farm jobs they hold in rural small towns are in the secondary labour market, paying low wages in accordance with basic educational backgrounds and practical experience. In some cases, off-farm earnings provide small farm families with an adequate standard of living, in addition to providing them an opportunity to continue operating their farms and living in the communities of their choice. Furthermore, for these farmers, the farm business is used as a means of reducing tax liability and serving residential, community, or other needs (Lin *et al.*, 1986). Many small farmers have chosen farming as an occupation because of the values they attach to farm work, including the opportunity to work for oneself.

2.4.6 Research and extension services

Most agricultural research has been directed towards the development of crops, livestock and agricultural machinery and equipment, but this research has not necessarily addressed the needs of small farmers (Marshall and Thompson, 1976).

In general, established means of communication, both in research and extension, have failed for low-income farmers. Agricultural research and extension services are supposed to be responsible for disseminating research results to all categories of farms. However, small farms do not seek information from government agencies as readily and frequently as do large farmers. Although government personnel have claimed to work with the most receptive farmers on the premise that knowledge would "trickle down" to others, this strategy has proven unsuccessful over the years (Singh and Williamson, 1985; Marshall and Thompson, 1976).

2.5 Farm efficiency and technological change

One of the requirements for increasing farm productivity and efficiency is technological development or change. The rapid technological advances of the past two decades, especially in wheat and rice, represents an extraordinary period of growth in world food production, especially in Asia (Byerlee, 1990).

The main sources of yield increases in recent years are: i) the spread of modern varieties, ii) increased fertilizer use, and iii) improved supplies of irrigation water. Effective application of these three main sources increased the productivity of existing resources, and generated ways of producing food, and designed new or improved institutional arrangements. Technological outputs such as higher-yielding plant varieties, better methods for controlling insects and disease, increased knowledge about, for instance, the manipulation of plant or animal genes and improved agricultural policies increased farm productivity and efficiency (Norton and Alwang, 1993).

Furthermore, technology creates the potential for increased agricultural production, moderate food prices, increased foreign exchange, reduced pressure on the natural resource base, and many other benefits. Increased agricultural productivity not only creates the potential for higher real income for producers/consumers through lower food prices, but also helps a country's agriculture to become more competitive in world markets. Efficiency gained through higher agricultural productivity can be turned into foreign exchange earnings or savings as a result of additional exports or reduced imports (Norton and Alwang, 1993).

New technologies allow the same output to be produced with fewer resources (land, labor and capital), thus freeing up these resources for use elsewhere in the economy of the country. For example, the labour released from agriculture can be a fundamental source of industrial growth. However, the effect of technical change on the demand for resources is influenced by the inherent nature of the technology and by the nature of product demand. In fact, if the industry does not absorb the labour released from agriculture, it leads to unemployment.

Some new technologies result in proportionate savings of all inputs, while others save labour and require more land or vice versa. For example, a new machine to cultivate the land may save labour and require a farmer to use more land to justify the cost. A higher-yielding crop variety may require more labour but produce more per unit of land. If a technology is neutral with respect to its effect on land and labour use, and if the demand for the product is elastic, the demand for both land and labor may grow proportionately. The reason is that, with elastic demand, total revenue increases with a shift out in the supply curve, providing increased returns to all resources. On the other hand, if product demand is inelastic, a neutral technological change can reduce the demand for all inputs proportionately (Norton and Alwang, 1993).

Agricultural technology can influence human nutrition through several mechanisms. First, if new technologies are aimed at poor farmers, a high proportion of the resulting income streams will be spent on improving the diet. If the technologies are aimed at commodities produced and consumed at home, the effect will be direct. It the technologies affect export crops produced by small farms, the extra income may be substantial as the price farmers receive may decline very little with the increased supply. Even if new technologies are suitable only for large farmers producing export crops, the influence on the nutrition of the poor may be positive if the demand for labour increases (reference).

An important nutritional effect of technology is caused by the increased availability of food at lower prices. Thus, technology can be used to reduce fluctuations in food supply, prices and income, thereby improving nutritional status. In this context, increasing farm productivity and maintaining the resource base in less favourable areas of remote rural sectors will pose a special challenge for new technology. In these areas, rapid technological progress is possible, but a new research strategy focusing on input efficiency, must be organized and managed to reduce malnutrition.

2.6 Factors affecting farm efficiency

There are several factors that affect farm efficiency and productivity. Some of the crucial ones are mentioned below:

2.6.1 Farm size and income

Whether improved agricultural technologies benefit large farms more than small farms has been the subject of substantial debate. Evidence suggest that farm size is a major impediment to the adoption of new biological technologies. However, large farms tend to adopt new technologies first, probably because it is cost-effective for large farms to invest in obtaining information about the technologies. Owners of large farms may have more formal education, enabling them to process the information, and a greater ability to absorb risk. Large farms almost always have better access to credit needed to purchase modern inputs. Most small farms in the same region as large farms eventually adopt the technologies, but large farms frequently adopt first and thereby receive greater income gains than the small farms. In addition, late adopters often are faced with lower producer prices because the supply curve shifts outward as early adopters increase output. If all producers in a given region adopted a scale-neutral technology at the same time, absolute income differences would widen because the increased returns per hectare would be spread over more hectares on large farms.

It is important to note that not all technologies and institutional changes are scale-neutral. For example, certain types of mechanical technologies can be used on large but not on small farms. Differences in transaction costs cause large farmers to press research systems for research results suitable for them even if the country's resource base on average would dictate a different type of technology. Furthermore, while many technologies are scale-neutral and some are biased toward large farms, it may be difficult to generate technologies biased toward small farms. All this means that reducing transaction costs through improved information is important.

The "Green Revolution" has enabled densely populated Asian countries to meet the food demand arising from both rapid population growth and increased income. Whereas its impact on productivity is recognized, its impact on income distribution is equivocal. Some studies found that where the income from modern technology was unequally distributed, larger farmers benefited more than small farmers. Some studies showed that the technology was scale-neutral and its effect on household income depended on the household's access to the necessary inputs, including credit (Lin, 1990). Research also suggested that, although small farmers and tenant farmers might initially lag behind larger farmers in the adoption process, they soon caught up, and eventually a farm's size and a farmer's tenure status become irrelevant with respect to the technology's adoption and income distribution. A few studies argued that the Green Revolution could benefit the poor in the long run because of the fall in food prices (Griffin, 1974; Ruttan, 1991; Polson and Spencer, 1991). Most studies mentioned above focused solely on the distribution of income between adopter and non-adopter and between labourer and landowner. Some recent studies have shown that farm size significantly affected farm productivity and efficiency, and adoption of technologies (Pears, 1987; Polson and Spencer, 1991; Kebede *et al.*, 1990; Kidane and Abler, 1994).

One of the final conclusions (Norton and Alwang, 1993) was that in order to develop farmers to a level where they are able to exploit new technologies, land development and redistribution programmes must be designed to give as many farming families as possible access to enough land to enable them to produce enough to feed their family members and to rise above the poverty line.

Inequalities in farm size will always exist in any free economy. People are not the same, therefore equal development will never occur (Agarwal, 1990). Gibbons *et al.* (1980), however, do not agree because they found that farm size is relatively unimportant in relation to the utilization of agricultural aid (extension, infrastructure, inputs, credit, assistance with marketing and membership in agro-based organizations). Where new technologies are available and the opportunity exists, farmers take advantage of it and adopt and use it. The early adopters are normally those who get the highest remuneration for adopting new technologies (Binswanger & Von Braun, 1993). Shand (1987) refers to studies conducted by Hayami (1981) and Kalirajan and Shand (1982) who reached the same conclusion. Farmers achieved substantial income gains from crop intensification and the introduction of new production technologies, which were obtained without any significant alteration of distributional equity of farm income.

2.6.2 Age of the farmer

Research has shown that age of the farmer is related to farm efficiency and the adoption decision. Younger farmers have been found to be more knowledgeable about new practices and may be more willing to bear risk due to longer planning horizons (Feder, 1988; Feder and Slade, 1988; Polson and Spencer, 1991). Farmers with fewer years of farming experience can be efficient and adopt new technology quicker, suggesting that they are more aware of current technology in production and/or are better at managing their resources. Following earlier empirical findings, the maintained hypothesis is that age is negatively related to farm efficiency and adoption of technology.

2.6.3 Years of farming experience

Years of farming experience is one of the factors included in the farm and farmer specific characteristics, but it should be distinguished from general farming experience that is not relevant for the empirical outcome, since most farmers judge their total experience as starting on the first day they started going out with their parents to the crop fields. What is important is experience since the farmer became a decision-maker on his own fields (Mueller and Jansen, 1988). Thus years of farming experience are expected to be related to the ability of the farmer to obtain, process and use information relevant to cultivation. A positive relationship is hypothesized between this variable and the probability of efficiency and adoption of modern technology.

2.6.4. Education of household head

In most cases, education of the household head is expected to have a positive effect on farm efficiency and adoption of new production technologies. Farmers with more years of formal education tend to be more efficient in agricultural production. Higher levels of educational attainment may lead to a better assessment of the importance and complexities of good farming decision-making, including the efficient use of inputs. In fact, level of educational level enhances a farmer's ability to seek, interpret and make good use of information about production inputs (Norton and Alwang, 1993).

Therefore, the educational level of the farming population must receive attention if countries aim to produce domestically, adapt and transfer new technologies successfully. According to Lyne (1985), improved education enhances the farm efficiency and adoption of new technologies. Venter, Vink and Viljoen (1993) conclude that countries that are unable to develop the skills and knowledge of their farmers and their families find it difficult to develop anything else. The development and utilization of new technologies and institutions are critically dependent on an educated and developed workforce.

2.6.5 Parcels of land

In developing countries farms are small and often fragmented. Land fragmentation involves long distance travelling and hence time and effort to move labour, inputs, draught animals and harvested crops, making supervision difficult.

Another problem of land fragmentation is the difficulty of applying farm-yard manure to distance fields and using distant fields for the production of crops requiring frequent attention, or for crops which are liable to be stolen.

Moreover, the small size of farms and parcels of land has an adverse effect on the adoption of soil conservation practices due to the fact that conservation structures are space consuming. The construction of soil conservation structures is seen as a factor reducing the size of farms (Norton and Alwang, 1993).

2.6.6 Ownership of oxen

The livelihood of rural people in developing countries is often dependent on the ownership of draught animals. In many developing countries, draught animals are the principal source of power. They plough the fields, transport products to the market, and carry out processing tasks like grinding sugarcane and threshing crops (Norton and Alwang, 1993).

The number of oxen not only determines the annual production and income (food security) of rural households, it also broadly determines the coping abilities of households in timely ploughing of the land, sowing and threshing of crops. Economic differentiation among rural households is a function of differential access to draught oxen, land and available active family labour.

Tractors are a very recent phenomenon in developing countries. The large investments needed to purchase tractors make them prohibitively expensive for small-scale farmers. The small farm size, the steep slopes and rough terrain in parts of some developing countries make it very difficult, if not impossible, for mechanical power to replace animal power.

2.6.7 Family labour

The variable "family labour" is perhaps one of the most important groups of predictors of farm efficiency and new technology adoption. It includes, amongst others, age, family size, gender, experience, knowledge, management, farming efficiency (technical, economical and financial), farming skills, level of entrepreneurship and creativity.

Wheeler and Ortmann (1990) as well as Roche (1988) argue that the most important success-determining factors for adopting new technology are those relating to human capital endowments (family labour, level of education, experience, knowledge and farming efficiency) and economic status (income, farm size, credit use, etc.) of the farming household.

2.6.8 Extension services

Extension visits or availability of extension services is perhaps the single variable that emerged significantly in most of the research on farm efficiency, technology transfer and adoption. According to Mijindadi (1995), the following lessons may be learnt from experiences concerning technology transfer by Nigeria's extension services:

- Effective extension services with a good extension approach and well-trained and experienced extension officers will encourage research systems to become more farmer demand-orientated and transfer new technologies more efficiently;
- Extension advice on its own cannot develop a nation's agriculture;
- A combination of different extension services must be applied and utilized;
- Specific extension programs for women and using a group extension approach have been proven feasible and useful;
- For extension programs to be sustainable, a total political commitment at the very top is essential.

A strong technical institutional basis is essential if agricultural extension services in African countries are to be sustainable in the long run and assist in the technology transfer and adoption process.

The availability of appropriate technology and extension services is essential in the establishment of profitable agricultural enterprises (Binswanger & Deininger, 1996). Kirsten (1994) refers to Eicher and Baker, who came to the conclusion that over the past 20 years in Africa, most extension services and officers have been poorly equipped and under-trained, when compared to their counterparts in Asia or Latin America.

Most extension services in Africa are orientated toward technical problems and are ill equipped for farm management or social aspects that are necessary for technology transfer and adoption. Nagy *et al.* (1988) found that experienced extension officers are one of the most important components of technology transfer and adoption support programs.

2.6.9 Access to credit

An important aspect of a support program is the functionality of credit programs to adopters of new technologies (Nagy *et al.*, 1988). Farmers without cash and no access to credit will find it very difficult to attain and adopt new technologies. Livestock production systems are not as capital intensive as crop production systems, which makes the availability of credit for buying veterinary technologies less important than for crop technologies, especially medication technologies, where the medication to be purchased is not so expensive. However, if the farmer wants to purchase registered or graded rams, access to credit can play a more important role.

According to Pinstrup-Andersen and Pandya-Lorch (1997) there is, however, an urgent need for effective credit and savings institutions in rural areas, to enable small-scale farmers and emerging farmers to invest in new modern technologies and sustainable agricultural intensification. Birowo and Qasem (1987) mention that an extended credit policy made it possible for farmers in Indonesia to increase input purchases (mainly fertilizer and pesticides) and an appropriate price policy (subsidies) stimulated farmers to adopt new rice technologies.

Desai, Gupta and Singh (1988) came to two major conclusions in their study of technology adoption in India, namely that agricultural progress and the volume of credit are positively related, and credit repayment among co-operatives is positively related to the level of agricultural progress. Charreau and Rouanet (1986) stress that the availability of credit is a precondition for persuading farmers to adopt new technologies. In the Ukraine the major constraint for adopting new technologies by farmers is access to credit or financing (Sohatsky, 1955). This finding is shared by Coetzee, Kirsten and Van Zyl (1993), as well as Venter *et al.* (1993), who found that credit was much more important to emerging commercial farmers (who have adopted more modern technologies) than to subsistence and sub-subsistence farmers in South Africa.

2.7 Overview of literature in Ethiopian context

2.7.1 Rationales to study effect of farm size on efficiency

There are many reasons for carrying out this type of study in Ethiopia. The following are among the changes that necessitate research: (a) the relative importance of land use increases over time, largely due to an increase in the farming population; (b) as the farming population increases, farm size becomes smaller and smaller and farmers find their units uneconomical to cultivate; (c) as the size of operational holdings changes, methods of production should change to be more efficient than before; and (d) to a certain extent, technology keeps changing and farmers tend to adopt it to meet family needs. All these changes motivate researchers to conduct research on the size of operational holdings, the types of enterprises to be combined, the types of crops and varieties to be grown, the types and amount of fertilizers to be applied, the implements to be used and the way farmers carry out farm activities are varied so that improved farming practices should be introduced to enable poor farmers to produce more output from limited or smaller areas.

So far, little is known about the farm size–efficiency relationship of small-scale farmers in Ethiopia. Only a few studies have been conducted on the effect of farm size on farm efficiency. Even less is known about what farmers do to produce enough for family consumption when land is scarce and they are financially or logistically unable to use improved technologies.

Some argue that farm size has little bearing on productivity or efficiency. This debate will continue as long as there is insufficient evidence to support the arguments.

Based on these premises, the expected outcomes of this study will attempt to fill research gaps regarding the relationship between farm size and efficiency in order to halt subdivision and fragmentation of land in the study area.

As indicated by a large body of literature, land holding (farm size) of a given country plays an important role in regional development of agricultural production. This is because farm size has social, political, and security implications in addition to technical and economic considerations.

2.7.2 Population growth in Ethiopia

Ethiopia's population was relatively small until the 1950s and 1960s. Subsequently, successful control or eradication of human diseases (malaria, smallpox, typhoid, etc.) led to a large decline in mortality. Thus, the population and the number of households increased very rapidly per village. At present, population pressure is one of the major contributors to the decline in farm size and agricultural productivity in the highlands of Ethiopia (TGE, 1993; McCann, 1987 and 1990). The fragmentation and diminution of land as a result of continuous land distribution and a growing population create a sense of insecurity among peasants. Tenure insecurity has been exacerbated by the absence of any limit to the redistribution and minimum land holding size. Peasants do not feel secure about their long-term tenure.

In addition, increasing population pressure on agricultural land has created two problems: unemployment or underemployment among peasants, and has left most of the peasants with mini plots, which reduce the proper utilization of peasant labour and technology. The magnitude of fragmentation has increased over time. Natural, cultural and demographic factors and hasty implementation of land reform and subsequent agrarian policies have contributed to increased fragmentation.

The unfavourable man-land and population-agricultural output ratios have made Ethiopia a chronic food deficit nation. To feed the increasing population, food production should be increased by more than 3 percent per annum. Moreover, land is becoming infertile and productivity has been declining due to demographic and environmental factors.

Population growth results in overgrazing, over-cultivation, deforestation and desertification. Ethiopia is facing a challenging future with its huge livestock and human population. Population growth and the corresponding increase in demand for food leads to increased land fragmentation and more intensive use of land. Cultivation will become continuous and fallow periods will become too short to enable soil to regenerate. Therefore, population pressure hinders agricultural development by exacerbating the land degradation problem.

Farming families face declining fuel supplies due to diminishing tree stocks. People resort to burning crop residues and dung as fuel, which are basic elements for fixing nutrients in many farm lands. This chemical degradation leads to a decline in soil fertility. The burning of crop residues and dung also leads to a decrease in livestock feed and animal productivity.

Under the existing farming system the major factor influencing the need for more land is demographic pressure. The Ethiopian population is increasing at 3 percent per annum while agricultural production grows at less than 2 percent. In order to maintain this expanding population under the existing low growth rate of agricultural production, land has to be expanded. Using an equation Hurni (1988a) estimated the relation between population and crop land and provided a projection of required cultivated land for the projected population (Table 1).

The available land will be exhausted in the year 2015 and the growth of the population beyond 2015 requires more land than what is available in the country. Controlling population or a high level of family planning is thus needed to balance the land-population ratio. Hurni (1988b) shows the importance of family planning together with other inputs for postponing or avoiding a crisis, defined as cropland shortage and grazing land shortage. According to Hurni (1988b) there are four types of inputs for addressing population growth: family planning, environmental rehabilitation, agricultural and livestock development. When there is no usage of any of the above motives, cropland and grazing land crises are expected to occur in the near future. Specifically, cropland crises or shortages will occur in the year 2010. The grazing land crisis or shortage has been in progress since 2000. With a medium input in family planning, environmental rehabilitation and agricultural development and a high input in livestock development, the cropland shortage could be pushed beyond 2030 and the grazing land crisis postponed until 2040.

Table 1. Population and cultivated land relationship in Ethiopia (1984-2020)

Year	Population projected (million)	Required cultivated land (in million ha)
1984	47.8	19.15
1990	51.7	19.91
1995	60.6	21.56
2000	71.4	23.40
2010	100.8	27.81
2015	118.9	30.10
2020	138.9	32.64

Source: Hurni (1988a)

2.7.3 Population targeted measures

In the short-term nothing can be done about the population pressure. There are only long-term solutions to the problem. Some of the solutions are: synchronizing or harmonizing population growth with natural resource utilization, controlling population growth by emphasizing fertility reduction, increasing contraceptive prevalence rate (CPR), expanding family planning services and increasing literacy rates. Using innovative approaches and making modern educational systems accessible to women would contribute to effective fertility regulation programs. Information, education and communication programs have significant impacts in changing perceptions and attitudes of individuals towards fertility. The national, regional, zonal and district structures outlined in the population planning policy can lay the foundation for the success of such programs (Warriner, 1964; Ellis, 1992).

In Ethiopia, efforts should be pursued with strong commitment. The priority areas, namely improving the scope and quality of the existing family planning services, should be adhered to in the national population policy.

Boserup (1965) maintains that an increase in population in a given area is the key factor that determines the shift from extensive to intensive systems of cultivation. There are three ways of utilizing the available land intensively (Ganguli, 1938). Firstly, increase the intensity of cropping, i.e., cultivating the land more frequently within a given period. The highest intensity can be achieved by reducing the fallow period to zero. Secondly, the intensive cultivation of the land per crop season through greater application of labour inputs, and thirdly, the cultivation of more labour intensive and high production crops.

Under increasing population pressure, peasants do not remain passive but adopt certain strategies to counteract these problems. The major responses to land scarcity by rural populations are the application of new agricultural technology, land use intensification, change in the cropping patterns and cropping intensity.

2.7.4 The land tenure arrangements and issues since 1975

Land reform policy involves a wide range of social changes, such as access to land, ownership structure of land, size of land holding, and legal or contractual forms of land tenure. Due to a number of social, economic and political considerations, land is more than just "another resource" in farm production; land ownership structures are inseparable from structures of social status and power in the agrarian economy and land reform is often associated with social upheaval and dramatic change rather than with the relatively stable political and social conditions; furthermore land reform is often politically controversial in nature (Warriner, 1964; Ellis, 1992).

Land reform alters three aspects of the man/land interface. These are the question of: (1) who controls land; (2) who benefits from land use; and (3) who bears the cost of land use. Warriner (1964) defines land reform in two ways: one is the redistribution of land for the benefit of small farmers and agricultural workers. The other is "the wider definition of land reform", as he calls it. This refers to any improvement in agricultural economic institutions. The reasons for using this broader definition is to widen the concept of reform policy and indicate that governments that undertake measures should not confine their policies merely to the redistribution of land but should also undertake other things like the regulation of rents, conditions of tenancy and farm wages, the improvement of farm credit systems, methods of land tuition, cooperative organization and agricultural education. Furthermore, Warriner notes that land reform, in the wide sense, confuses the real issue. The redistribution of property in land is a difficult change to carry through, far more difficult and controversial than other measures, and one cannot really consider it on the same level as other institutional changes.

Land reform and land systems affect the socio-economic development of a country in many ways. It determines the distribution of income, power and the use of land. Its influence goes beyond the economic sphere to determine social attitudes and social satisfaction. Land systems are interwoven or linked with national tradition and national character (Warriner, 1964; Ellis, 1992). Land reform will be successful if it is accompanied by greater land tenure security. There is a widespread belief among development specialists that tenure security is an important condition for economic development (Bruce *et al.*, 1994).

2.7.4.1 The March 1975 Land Reform

The March 1975 Land Reform legislation, issued by the Derg regime, had the following main features: it abolished all forms of private ownership of land and put land under state control; individual farmers were allowed to cultivate up to 100 hectares of land; it entitled peasants to usufruct right over land. Peasants did not have the right to transfer by sale, lease or mortgage; rents and other forms of obligations to the land lord were abolished; and land was distributed among farmers on the basis of household size (Dessalegn, 1984).

Following the land reform proclamation of 1975 (Provisional Military Administrative Council, 1975), the income of small-scale farmers (former tenants) in some areas increased. This was believed to be a result of the abolition of rents and other forms of obligations to the landlord (Alemneh, 1990). The abolition of tenancy could mean retention of an increased part of the surplus by the peasants. Thus, it was believed that, the nearly egalitarian reform of March 1975 had partly contributed to "greater economic equality" of the farming population.

2.7.4.2 Current land issues

Land issues specific to the Derg period (e.g. periodic redistribution of land, allocation of the best land to cooperatives, the villagization program, reduced planting of trees on individual plots, etc.) had been largely resolved by the Mixed Economy Policy of March 1990 and subsequently by the Transitional Government of Ethiopia (TGE). In its economic policy document of 1991, the TGE ruled that further redistribution of land ownership would be determined by a referendum after the general election. However, there are a number of issues pertaining to rural land. These issues could be classified into three broad categories: questions of efficiency, equity and sustainability.

The existing tenure system has no mechanism to make land relatively accessible to the more efficient farmers *vis-a-vis* the less efficient farmers. Today no value is attached to rural land. This may cause distortions in resource allocation. Some of the existing policy instruments fail to induce farmers to save land through further intensification.

Equity issues include such questions as the growing number of landless people, differential access to land by female-headed households, and disputes over irrigated land in the Awash Valley in the Eastern part of Ethiopia.

Growing population pressure has resulted in ever increasing landlessness. A sort of demographic differential has been taking place in rural areas; young people are increasingly being denied access to land. The problem has been compounded by developments that took place in the early 1990s: increased demand for land caused by demobilized soldiers, former refugees and by other returnees. According to group discussions held with farmers, 17 percent of the total number of households were landless in the study area. The group discussion also indicated that women accounted for 9 percent of those who lodged application to the peasant association office to obtain land.

Sustainability of the environment is another issue. The existing land tenure system has not succeeded in contributing to the conservation of natural resources. Deforestation and overgrazing of the land have remained major problems. Investment in land is very limited (Bruce *et al.*, 1994):

- Currently, policy concerning land endowments for churches, schools and non-profit organizations is unclear, and needs review and clarification;
- There are no viable criteria for regions for identifying unutilized land for lease to large-scale commercial farmers or farmer resettlements. Criteria vary from region to region and there are opportunities for corruption. The role of regions in formulating land policy and in administering land is not clearly defined. Should regions play greater roles in land policy and land tenure arrangements?

- The current land tenure system does not clearly define property rights with respect to community forestry and household forestry;
- There are no strategies for accommodating competing land uses in pastoral areas;
- Existing capability in government for design and analysis of policies for land tenure and administration is not clear. No single ministry is responsible for matters related to land tenure, and a ministry should take a clear leadership role for effective use of available land resources in the country;
- The capacity for undertaking cadastral survey and registration has remained poor; and
- The current land taxation system is regressive and flat, falling as heavily on poor as on wealthy households. It does not distinguish between land in high potential and low potential areas.

In dealing with these shortcomings over the last three decades, land distribution in rural Ethiopia has been basically resorted to an administrative choice of dealing with land shortage. However, land distribution practice on a repeated scale diminishes the size of holding and increases fragmentation and cannot sustain or increase agricultural productivity over time. Official statistics for the 2000 cropping season indicates that 87.4% of rural households operate on holdings of two hectares or less. The number of households who operate on holdings of one hectare or less constitutes 64.5% of the total. Of these 40.6% of households command holdings whose sizes are 0.5 hectare or less (CSA, 2000). The national average holding size is estimated to be about 0.79 hectare with substantial inter-regional variations.

While land distribution was meant to serve primarily as a social security function, its ultimate disincentive effects on agricultural investment in fact contravened the economic security function. The combined effects of these caused many peasant households to fail to produce enough to meet their minimum consumption requirements (Berhanu, 1991; Tesfaye, 1989), let alone to producing a voluntary marketable surplus.

2.7.4.3 Land policy options for Ethiopia

The literature provides three alternative options for dealing with the land question. Firstly, there are those who assert that rural land should remain state property and that usufruct rights be granted to peasants. A variant of this idea is that peasants be granted lease holding for a certain period. This thinking seems popular among government officials. Secondly, there are those who recommend that a freehold system be instituted. This idea, which is popular among foreign experts and aid donors, seems to be in agreement with studies conducted in Africa in recent years, namely that indigenous land tenure arrangements provide considerable security for investment and continue to have strong impacts on land markets even when they are no longer in effect according to the law (Pinckney and Kimuyu, 1994). Thirdly, there is a proposition by Dessalegn (1994), that he calls "associate ownership", to deal with the unfinished business of land reform. "The underlying premise behind associate ownership is that land belongs to the community and the individual land user in it" (Dessalegn, 1994). This type of tenure combines freehold with communal control and management of land. It replaces the state by a "democratically constituted" *Kebele*. The latter is expected to impose "restrictions" on the land market so that land does not fall "into the hands of outsiders" or "urban elites".

Currently there is a heated debate among intellectuals over the land question in Ethiopia. A land market cannot be competitive if restrictions are imposed on public or associate ownership. Land cannot be efficiently allocated to alternative uses if its market is made imperfect. By keeping away outsiders or urban-based elites, the system of associate ownership could discourage investment from outside the community. The case of Kenya and Zimbabwe demonstrates that this section of the society can contribute significantly to agricultural growth (Dessalegn, 1994). Thus, associate ownership imposes restrictions on the land market as well as the capital market.

What is the rationale for imposing restrictions on the factor market? Perhaps this assisted *Kebele* (the lower level of administrative organs) to avoid the possibility of land speculation and consequent economic and social problems. If so, is it not possible to discourage land speculation by alternative means?

What the literature fails to provide is a discussion of alternative policy instruments to deal with the land question. Changes in land tenure arrangements alone can never resolve the land question. Alternative policy instruments should be used in combination with appropriate land tenure arrangements in order to achieve both efficiency and equity objectives and environmental sustainability. For example, land speculation can be discouraged by employing land taxes. Peasant eviction due to mechanization can be reduced by using appropriate technology policies. Therefore, instead of using administrative means to deal with land issues, why not use policy instruments together with appropriate land tenure arrangements?

In choosing different policy options, the following objectives should be considered (Bruce *et al.*, 1994):

- Land tenure policy should build upon the positive achievements of land reform to maintain smallholder agriculture and avoid high concentrations of land ownership;
- It should foster a unimodal pattern of agricultural development which encourages and permits efficient smallholders to intensify production, invest in sustainable improvements and, within limits, expand their agricultural operations and land holdings;
- Responsibilities of administrators, technical ministries and the courts must not exceed their modest capacities;
- The land tenure system should ensure security by minimizing possibilities for manipulation of access to land by local, regional, or national political leaders;
- Land policy must be flexible enough to take account of regional and local agro-ecological, cultural, and economic differences;
- Government must retain the right to protect ethnic minorities, women and natural resources where conflicts with local traditions arise;

- Land policy should make available mechanisms for land titling transfer and mortgaging in pre-urban and market-oriented areas without necessarily mandating a regional or nationwide transformation of tenure;
- Reconcile social and political objectives of land tenure policy with economic objectives; and
- Current land holdings of individual farmers must be correctly measured and determined.

Three possible types of tenure arrangements can be distinguished in Ethiopia: (i) private ownership, (ii) state leasehold, and (iii) limited ownership. Each one of these has its merits and demerits (Bruce *et al.*, 1994). The literature indicates that no single tenure arrangement could be satisfactory for Ethiopia, a country of great diversity. The appropriateness of tenure arrangements would change over time and space. For example, in the short-term, private ownership could be suitable for peri-urban areas, where the value of land is high and where possibilities for highly intensive farming activities exist. State leasehold, with all its defects (including possible corruption and bureaucracy) could, in the short-term, be suitable for large-scale commercial farms in areas where land is currently underutilized. Limited or regulated ownership could be appropriate for densely populated areas with strong communal solidarity. In these areas, the community can impose restrictions on the land market. Customary tenure has its own advantages. In the long run, private ownership could be appropriate for most areas.

It is also important to establish a lead ministry responsible for land tenure, land administration and land policy analysis. Prior to the land reform of March 1975, there existed a Ministry of Land Reform. Today there is no institution responsible for land administration and policy analysis. A lead ministry could be responsible for generating and collecting information on land, undertaking cadastral surveys, land registration, encourage research on land, etc.

Immediate actions need to be taken in the following areas:

- Granting land endowments to churches, schools and other non-profit organizations;
- Defining the role that regions could play in land tenure and land administration;
- Setting criteria for granting land to investors in different regions;
- Defining property rights with respect to community forestry and household trees
- Protecting the interest of pastoral people in such areas as the Awash valley; and
- Liberalizing the land market in peri-urban areas.

2.7.5 Studies on land holdings

Following the March 1975 land reform in Ethiopia, land was periodically allocated to landless households through peasant associations (PAs). However, considerable inequity often existed between land holdings in the different associations and consequently in the average size of holding held by their respective members (FAO, 1984).

In fact, disparity has escalated with rapid population growth and in the absence of well-elaborated policy measures. In addition, no comprehensive study has been conducted at national level, basically due to the huge financial resources needed to undertake such an assessment. Hence, the question of equity in land holding is either lacking or constrained by several limitations.

The study of land holding distribution has important policy implications as it relates to resource productivity and efficiency in agriculture. This is because the availability and size of holdings affect the adoption process and the relative economic position and prosperity of various groups of farmers. According to Van den Ban and Hawkins (1996), for instance, the reasons why small farmers use less fertilizer might not be their traditional attitude towards this innovation, but that they are afraid to borrow more money at high interest rates. Furthermore, they get only a small return when they sell the additional crop because they are in debt to the government and the merchants. Neither can they afford the risk of not increasing the yield by applying more fertilizer. Bedassa

(1998) concludes that the adoption of technology is positively correlated with larger size units.

Disparity in production efficiency and income among farm households is a function of differences in asset possession, particularly land (Bennet et al., 1986). In rural areas land is an important asset for earning income and food. Since land maintains its capital value over time and offers security, variation in size of holdings is likely to result in a sustained inequality. In this context, Vasant and Chaya (1993) state that disparities in land holding beget disparities in income and technical efficiency. Among the most important causes of inequalities is thus the distribution of productive assets such as land.

Ownership of land in agrarian societies is not only a symbol of entitlement, power and privilege, but is also synonymous with the economic status of farm households and their social status (Sharma, 1994). In developing economies, where agricultural land holding is inequitably distributed among its cultivators, measures against land redistribution are commonly justified, as they provide a sense of justice (Sirohi, 1976). Access to facilities like financial resources, both in formal and informal institutions, also depends on the size of the land holdings. This, in turn, has led to disparities in income and technical efficiency among farm households. Therefore, if a policy measure aimed at achieving economic growth is to be safeguarded from favouring growth without equity or escalating disparity in asset possession, assessing the pattern of holding distribution is imperative.

In Ethiopia land has been redistributed to tillers (Land Proclamation of March 1975) in order to provide them with a sense of participation in rural life. It was the outcome of factors related to the existence of feudal relations-small farms, subdivisions and fragmentation of farms, insecurity of tenure rights, and high rent rate, which act as disincentives to raising production (Mali, 1989). However, there is a shortage of cultivated area in many parts of the country, particularly in the highlands. As a result, extensive cultivation is no more possible. Thus, to supply the ever-increasing population with grain, resource productivity and efficiency must be enhanced, which depends on the effective use of resources, technological and institutional factors. These factors are related to and are affected by the nature of land holding distribution among different classes of farmers.

2.7.6 Studies on farm efficiency

Many problems affect the development of Ethiopian agriculture. The major obstacles to solving the problems are: Shortage of skilled manpower, technological backwardness, fragmentation of holdings, the growth of population at a rate faster than production, political instability, drought, environmental degradation, poor cultural practices, limited accessibility and use of improved technology, insufficient infrastructure, ill- considered policies and low levels of productivity and efficiency (Yibeltal, 1995; Mulat, 1989; Amare, 1998). In spite of all these problems, limited research has been conducted both at national and regional levels. As a result, farmers fail to exploit the full potential of technology and the natural resource base.

In a country like Ethiopia, where agriculture is the dominant sector of the economy, conducting micro-level studies on productivity and efficiency are an essential prerequisite for the economic prosperity of smallholders. Little is known about how and in what ways different factors of production are used, and what are land, labor and capital efficiency at farm levels. In fact, such studies would have helped researchers and policy makers how to improve farm efficiency without increasing the resource base.

Reviewing the relevant literature of the last ten years brought to light only five articles on farm productivity and efficiency. Firstly, Amare (1998) attempted to analyze the efficiency of small-scale farming in the Tiyo district of the Arsi zone using quadratic risk programming techniques. The study examined the possibilities of increasing production through an optimal allocation of available resources by incorporating farmers' behaviour under risk, and the potential of improved technologies in increasing farm income and productivity in the Ethiopian highlands. Secondly, Getu et al. (1998) carried out a study on technical efficiencies of small holder annual crop production in the moisture stress area of Eastern Oromia using stochastic frontier analysis. This study verified that the total output of the sample farmers could have been increased by up to 30-40 percent above the actual output levels attained in the 1993 and 1994 cropping seasons, if greater efforts are directed at the allocation of the existing resource rather than being restricted to creation and transfer of new technologies. Thirdly, Assefa and Heidhues (1996) estimated the technical efficiency of small holder farmers in the central highlands of Ethiopia using the stochastic frontier production function approach. The analysis showed that fertilized farms are technically more efficient than unfertilized farms. Fourthly, Seyoum et al. (1997) conducted a study on the technical efficiency and productivity of maize producers in eastern Ethiopia. The empirical results indicate that farmers within the Sasakawa-global 2000 project are technically more efficient than farmers outside the project. Fifthly, a study on technical efficiency of small agricultural producers in central Ethiopia (Nsazugwanko *et al.*, 1996) found that: i) substantial technical inefficiency of production exists on peasant farms in Ethiopia, ii) land fragmentation and insecure tenure arrangements probably contributed to technical inefficiency, and iii) the technical efficiency of farmers who applied fertilizer was found not to be significantly different from those farmers who did not apply fertilizer.

Although the problem of lack of productivity and efficiency is acute in Ethiopia, very few studies have been conducted during the last ten years.

2.7.7 Is land fragmentation a problem?

Various factors are responsible for land fragmentation in the study area. Among the main causes of land fragmentation are: (a) provision of land for newly married couples; (b) the variation in topography, the types and fertility status of soils; and (c) the traditional system of land inheritance.

There are different arguments against and in favour of land fragmentation. The most often heard arguments against it are (a) walking long distances and hence the waste of time and effort in moving animals, farm inputs and harvested crops; (b) the difficulty of supervising fields; and (c) the loss of land in boundary making.

Contrary to the arguments against land fragmentation noted above, some argue that in a subsistence agricultural economy, fragmentation is an ecologically adaptive strategy to offset variations in soils and climate. It also helps peasants spread the risks created by climatic or other environmental factors (Blum and Abate, 2002). In Ethiopia there is a great variation in soil types and fertility status and peasants have access to the various soil types for the production of different types of crops. In addition, land fragmentation can be used as a risk averting mechanism against the unpredictable impact of climate. On the other hand, fragmentation could also be considered a poverty sharing mechanism in a district with growing population pressure (Alemneh, 1990). This has already been observed in many parts of Ethiopia where the fixed land fund in the respective peasant associations has been distributed continuously to accommodate newly married couples, the landless and land hungry farmers.

The magnitude of fragmentation has increased over time. Natural, cultural and demographic factors and the hasty implementation of the land reform policy have contributed to increased fragmentation.

The continuous land distribution and fragmentation of holdings due to population pressure have resulted in small sizes of farms and plots which hinder the proper utilization of labour, and leads to landlessness, insecurity of tenure, and environmental degradations. In contrast, the abundant rural labour force has a positive effect on intensifying use of the agricultural land through multiple cropping, changing crop mix, crop rotations and the use of more agricultural inputs. However, the scope of agricultural intensification is not fully exploited due to economic, institutional and ecological constraints.

2.8 Concluding remarks

In this chapter the basic theoretical and practical issues associated with farm size and efficiency are outlined. Relevant books and journal articles on farm size, efficiency and related issues were consulted. From the literature review, the following is emphasized, in conclusion.

2.8.1 Relation of literature to the empirical study conducted in this thesis

The purpose of this study is to assess the level of technical efficiency of small-scale farmers in the central highlands of Ethiopia. The relationship between output and various socio-economic factors will also be investigated. Therefore, a brief overview of literature in the international arena and especially in the developing world (Asia, Latin America and Africa) is given to relate those findings to the empirical study conducted in this thesis.

2.8.2 Relevance of the empirical study

This study considers farm efficiency because it is an important subject in developing agriculture where resources are limited but high population growth is common. A study of the efficiency of these small-scale farmers is important because they are producing the greater proportion of food consumed in the third world, especially sub-Saharan Africa (Odulaja & Kiros, 1996).

In Ethiopia, knowledge regarding farm efficiency is very low. The lack of research on farm size and efficiency is of great concern and requires more research. From the literature review, the question of the relationship between the size of land holding and productivity is a much debated topic. Some studies state that the relationship between farm size and efficiency for grain production is an inverted U. But the topic of farm size is a relative concept. For instance, 2 hectares in Java or Indonesian, 10 hectares in the Punjab of India, 400 hectares in the corn belt of the United States and 600 hectares in the wheat belt of Ukraine are the most efficient sizes for their purposes. Thus, farm size is determined by the relative factor costs and induced innovation (Binswanger and Elgin, 1990).

2.8.3 Importance of the land-man ratio

Rural economies in developing countries have been experiencing a rapid deterioration in the land/man ratio, with the average number of farmers per hectare of arable land doubling within a fifty-year period. Thus, one critical effort, among others, should aim to develop land-saving and labour-using technology, or at least neutral technology, in order to raise the marginal productivity of labour on limited land resources.

Land reform gives poor people (landless) ownership rights or permanent cultivation rights to specific parcels of land. It would make a lot of economic sense when it increases their productivity, income, consumption or wealth. To achieve these objectives, other measures such as credit and market facilities have to be devised to improve poor peoples' access to land, which will in turn increase their income from agriculture.

The inherent uncertainty of property rights created by current land allocation rules in Ethiopia makes farmers hesitant to undertake long-term and land specific investment. Opening up free markets without providing the necessary supportive institution to regulate them also restrains farm supply response.

Ethiopia's population is basically rural and dependent on agriculture. With a rapid rate of increase in population, the country has experienced a rising demand for land and food grain. This has increased the pressure on land resources over the past few decades, and at present there is a scarcity of cultivable land in many parts of the country.

2.8.4 Intensification of the agricultural sector

Land expansion for agricultural purposes is not always possible. Therefore other solutions must be sought. The solutions are:

1. Fostering intensive cultivation and enhancing productivity of resources through efficient use of existing resources. Intensification is not widely practiced in Ethiopia. Most farmers use little or no modern inputs. Agricultural research institutions have conducted various studies, which give clues to the effect agricultural intensification would have in Ethiopia. For instance, with improved seeds, commercial fertilizers and improved soil and water management, it has been shown that an increase in crop production of at least 100 percent is possible on dry lands (ADD and INFU, 1986-89). The increase in output is higher in higher and more reliable rainfall regions.

2. Another alternative to land expansion is intensification of irrigation. Ethiopia has a potential for small-scale irrigation. It is estimated that about 165,000 to 300,000 hectares could be irrigated through small-scale irrigation (Kloos, 1990). Ethiopia's experience of small-scale irrigation is, however, far from adequate and has remained relatively unimportant.

3. In Ethiopia, population pressure on arable land has been intensified further due to newly formed households, returnees from refugee camps and ex-soldiers after the overthrow of the previous government. Returnees and militia men returning to their previous dwelling localities faced difficulties in obtaining land. At present, one- fifth of the farming population of the study area are returnees and ex-soldiers (Group discussion with farmers' leaders). Intensification and creating off-farm employment within the district remain the most practical solutions to solve the problems created by land scarcity.

2.8.5 Factors considered in the empirical analysis

From the literature review it is evident that a number of factors are known to affect efficiency and productivity. The dependent variables of the study are wheat and tef yields, which are hypothesized to have association with efficiency and productivity. Five input factors and eight socio-economic variables included in the stochastic frontier analysis are as follows:

Land

This variable measures the area of wheat and tef cultivated by the respondent at the time of the survey. Increasing the production and productivity of wheat and tef depends on the land area allocated to each crop. Farmers in the study are expected to allocate land efficiently because it is scarce. Therefore, land size is hypothesized to positively influence wheat and tef production by the sampled farmers.

Seed

Farmers in the study area try to increase the usage of improved seeds in order to increase the output per unit area. As land becomes scarcer in the study area, farmers seem to substitute land with improved seeds and fertilizers. Thus, use of seed is expected to affect output positively.

Use of chemical fertilizer

Diammonium phosphate and urea are the two common types of fertilizers available to farmers and extensively used in the study area. In particular, improved crop varieties are alleged to perform better with chemical fertilizer. Hence, use of chemical fertilizer is hypothesized to be positively related to wheat and tef productivity.

Labour

Labour input per hectare is perhaps one of the most important predictors of wheat and tef output in the study area. Labour shortage is expected to affect wheat and tef outputs negatively whereas having enough family labour is expected to affect them positively. Thus, use of family and hired labour is hypothesized to have positive and negative influences on wheat and tef production.

Oxen traction

The livelihood of rural people in developing countries is dependent on the ownership of draught animals. In many developing countries, draught animals are the principal sources of power. Therefore, amount of oxen traction (oxen-hours) per hectare is hypothesized to positively influence the production of wheat and tef of sample farmers.

Age of household head

This variable measures age of the household head in years. It is hypothesized that age of household head can be positively or negatively related to farm efficiency.

Farming experience

Farming experience of household heads could affect their confidence. With more farming experience, farmers can avert risks by adopting alternative solutions, so this variable can positively or negatively affect efficiency of farmers.

Level of education

This variable represents the level of formal schooling completed by the household head. The level of education of the household head is assumed to increase farmers' ability to produce and use information relevant to farm efficiency. Education is therefore expected to increase the efficiency of sample farmers.

Land parcels/plots

Land parcels/plots per household are hypothesized to be negatively related to farm efficiency. The more the number of land parcels or plots per household, the longer the distances travelled and hence a larger requirement of time and effort for moving labour, inputs, draught animals and to harvest crops; this also makes supervision difficult.

Distance between parcels/plots

The further the distance between land parcels/plots, the more time farmers need to spend to move inputs and outputs between plots. This is expected to be inversely related to farm efficiency and productivity.

Ownership of oxen

Owing one or a pair of oxen per household enables the farmer to cultivate the land in time. Depending on the farm size, adequacy of draught power is hypothesized to influence the farm efficiency of farmers positively.

Family size

Farm labour availability depends on household size. Large households may be able to provide the labour required for planting, weeding, harvesting and threshing, whereas small households may encounter shortage of labour during peak periods. Therefore family size is expected to be positively correlated with farm efficiency.

Income

Income per household consists of farm and non-farm incomes. It is often assumed that farmers with larger farm sizes have more cash to buy the required modern inputs, which in turn increases farm efficiency. On the other hand, given that farmers are aware of the benefits of modern inputs, as farms become smaller, there are more incentives to carefully manage the declining land resource base by adopting more of the recommended inputs (Boserup, 1965). However, low income per household reduces farmers' ability to introduce newer practices if those practices involve risk.

2.8.6 Analytical technique used in the analysis

From the literature review, two analytical techniques qualify for possible application in the study area, namely data envelopment analysis (DEA) and stochastic frontier methods (SF). DEA involves the use of linear programming whereas SF involves the use of econometric methods (Coelli et al., 1998). In this analysis, the stochastic frontier model is applied, and the general expression and specification of the model is described in Chapter 6.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The purpose of this chapter is to provide an overview of the different phases and steps followed to conduct the research.

3.2 Finding a research problem

The first step of the research methodology was to find a real (suitable) problem to be researched. During the last 30 years, the average farm size in Ethiopia declined consistently due to population pressure. The periodic land distribution to newly formed households resulted in land fragmentation which has added greater distances for farmers to travel from field to field, making it very difficult for peasants to be technically efficient (Wolde-Mariam, 1991).

The level of efficiency of small farmers has important implications for development strategies (Ali and Byerlee, 1991). For instance, if farmers are reasonably efficient, then increases in productivity require new inputs and technology to shift the production function upward. On the other hand, if farmers are inefficient, there are significant opportunities for increasing productivity through more efficient use of farmers' resources and inputs by introducing better technology, institutional arrangements, infrastructure, and improving farmers' skills. Against this background the aim of this empirical study is to determine the technical efficiency differentials between small and large farm groups in the central highlands of Ethiopia. Policy analysts, researchers and extension agents would benefit from the study results, which should assist in making better decisions at macro and micro levels (for detail see Chapter 1).

3.3 Choice of the research/study area

The survey was conducted in the Moretna-Jirru district of Ethiopia during the 2000/2001 cropping season. The district was selected for this study on the basis of the long recorded experience of farmers in using new technologies, the number of crop growers and the region's high potential for crop production due to better soils, longer growing seasons and higher rainfall than other districts in the Semien Shewa zone.

The surveyed district is dominated by cereal farming systems. Wheat and tef are the major crops, which occupy 75 percent of the total cropped area (wheat covers 44% and tef 31%). Virtually all lands are cultivated and farmers use improved seeds and fertilizer to replace land scarcity (the study area is described in detail in Chapter 4).

3.4 Literature study

Numerous empirical studies related to productivity and efficiency measures were reviewed in Chapter 2. Coelli et al. (1998) indicate that farm efficiencies have been estimated using different approaches over the past 40 years. Lovell (1993) provides an excellent introduction to this literature. The two principal methods used for estimating or measuring efficiency of production in recent years are the stochastic frontier approach (involving the use of econometric methods) and data envelopment analysis (involving the use of linear programming). This study utilizes the stochastic frontier approach for measuring and analyzing the technical efficiency level because of the following reasons:

- The stochastic frontier approach involves the construction of a best practice frontier and measuring the level of technical efficiency relative to the frontier;
- Stochastic frontier does not require prices and leads to simple efficiency comparisons between small and large farm groups;

- Tests of significance on technical inefficiency effects and input coefficients are easy to do in a stochastic frontier analysis; and
- Stochastic frontier is more appropriate for agricultural production analysis, especially in developing countries, where the data are heavily influenced by measurement errors and effects of weather, diseases and pests (Coelli *et al.*, 1998)

3.5 Analytical model

The empirical model used for estimating the technical efficiency of smallholders in this study is the stochastic frontier production function, given by the following equation (consult Chapter 6 for detail):

$$\ln(y_i) = X_i\beta + v_i - u_i \qquad i = 1,2,----,N$$

Where

y_i denotes the output for i-th firm;

x_i denotes a vector of values of inputs and other appropriate variables associated with the model;

The βs are unknown scalar parameters to be estimated;

The v_is are random errors, assumed to be independent and identically distributed and have (0, σ_v^2) distributions; independent of the u_is; and

The u_is are the technical inefficiency effects in the model

3.6 Questionnaire development

The researcher developed the questionnaire used to collect the farm data during August to November 2000. Relevant literature was studied to enrich the questionnaire. Finally, to facilitate communication between farmers and enumerators, two versions of the structured questionnaire were developed: English and Amharic (local language) (see Appendix A for the English version of the questionnaire).

3.7 Survey design and sampling

The study is based on farm-level data of 198 sampled farm households in the Moretna-Jirru district, which is one of the major wheat and tef producing districts in the central highlands of Ethiopia. The survey was conducted between January and September 2001. The sample farmers were selected randomly from the smallholder farmers in the study area. A two-stage selection technique was employed. The first stage involved the random selection of peasant associations (villages) and the second the random selection of sample farmers who were registered as members of a peasant association and who had official access to at least 0.5 hectare of arable land through the peasant association. A census carried out in March 1994 provided a sampling framework to select randomly the households who had official access to state land. The total sample of farmers was then classified into two groups based on farm size. Farm size is designated as the size of total cultivated land operated by the farm households. Farmers whose farm sizes were larger than two hectares were classified as large farm size households while those whose farm sizes were equal to or less than two hectares were classified as small farm size households. Out of the total 198 sampled farmers, 95 were classified as large farm size (group) and 103 as small farm size (group).

For the purposes of efficiency analysis, information was collected on wheat and tef outputs, as the dependent variables in the analysis. Six input categories and eight inefficiency effects that might explain efficiency differentials among farm households were defined and used in the production function model.

3.8 Data collection

3.8.1 Secondary data

Relevant data were collected from secondary sources. The secondary sources of information include published and unpublished documents about agricultural production in the study area. This information was collected from regional, zonal and district level offices of agriculture, planning bureaus and knowledgeable individuals (see Appendix C).

3.8.2 Primary data

The primary data on which the study was largely based were collected from sampled farmers in the study area. A formal survey method was employed using a structured questionnaire. Before starting the actual data collection, the questionnaire was pre-tested and on the basis of the results obtained, the necessary modifications were made to the questionnaire.

Primary data on yield, labour and oxen use, and application rates of inputs such as seed and fertilizer were based on farmers' responses to enumerators' questions (they were not measured directly). Farmers in Ethiopia measure area in *timad* (1 timad = 0.25 ha). Each sampled farmer's land area was however directly measured with a measuring tape (standard unit of measurement) during the survey period, because it was a very important issue of the research (see Chapter 5 for detail).

3.9 Conducting fieldwork

The actual fieldwork was organized in three phases. In the first phase, the local development agents who knew the culture and language of local people interviewed 300 randomly sampled farmers from six PAs on their farms. The enumerators were trained to complete the questionnaires.

In the second phase, group discussions were carried out with farmers' leaders. The main issues of the research were discussed with six groups of seven farmers' leaders from each of the six PAs involved in the survey. A researcher led the discussions and two experienced extension staff were present to keep the minutes. These discussions made it possible to interpret the data and explore topics raised by farmers which had not been dealt with in the individual interviews, because farmers complement each other during group discussion.

The third phase involved an in-depth group discussion with stakeholders (experts in the MOA, development agents and researchers). The main aim of this group discussion was to obtain a more complete picture of the farming situation in the district.

3.10 Data analysis

Following data collection, the data were coded and entered into the SPSS Version 10.1 computer software package for analysis (analysis of the surveyed data is described in detail in Chapter 5). Data were initially analyzed using descriptive statistics such as percentages, means, frequencies and standard deviations. Frequencies and means were computed for different variables. The t-test was run to detect statistically significant differences in the continuous variables between small and large farm groups, while contingency tests were conducted for discrete variable.

The coefficients of inputs, inefficiency effects and technical efficiencies of sampled farms were then determined by applying the Stochastic Frontier Model using the computer program FRONTIER version 4.1 (Coelli, 1996) (consult Chapter 6 for a detailed discussion).

3.11 Phases of research

This study started in 2000 and was organized in three phases. During the first phase, course work was undertaken in the Department of Agricultural Economics at the University of the Free State. At the same time, the research proposal and questionnaire were developed. A seminar on the research proposal was presented to the departmental staff and postgraduate students. Comments and suggestions from the seminar enriched the proposal and the title was also endorsed. An intensive literature study was also executed during this phase.

In the second phase (between December 2001 and May 2002), fieldwork was conducted in Ethiopia. The main activities during this phase were conducting the survey, data capture into the computer and cleaning and preliminary analysis. Both the promoter and co-promoter of the researcher/student visited the study area with the student and conducted group discussions with farmers.

The third phase was conducted at the University of the Free State in South Africa. The phase comprised data analysis by application of different models and writing the thesis. These activities started during May 2002 and were concluded in June 2003.

CHAPTER 4

DESCRIPTION OF THE STUDY AREA

4.1 Introduction

In order to foster agricultural development, it is necessary to understand the current farming systems of the study area. Without this awareness, it would be impossible to understand the types of changes required to promote the development of agriculture, and how these changes will affect the farming community involved. In this chapter some of the characteristics of traditional agriculture, natural resource bases available to the farmers, the technology farmers use, and the level of farm productivity and efficiency will be examined.

First, the Amhara National Regional State, in which the study area is located will be presented and discussed. Then, the location, population, soil type, land, labour use, and farming systems of the study district will be described briefly. The chapter concludes with a summary and conclusions.

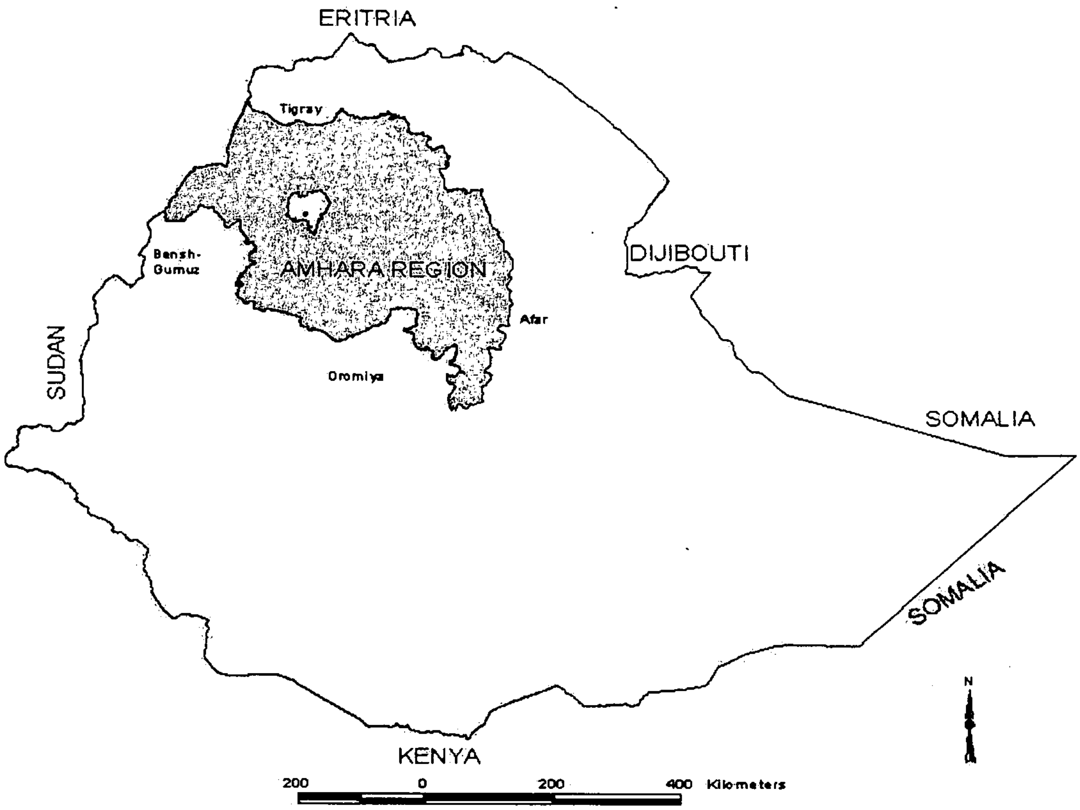
4.2 Amhara National Regional State

Amhara National Regional State (ANRS) is one of the constituent states of the Federal Democratic Republic of Ethiopia. The ANRS is located in the north-western part of the country between 8^0 45' and 13^0 45' North latitude and 35^0 46' and 40^0 25' East longitude (Map 4.1). The boundaries of the ANRS adjoin Tigray in the north, Oromiya in the south, Afar in the east, Benishangul Gumuz in the southwest, and Sudan in the northwest. The state is divided into 11 administrative zones, including the capital city of the region, Bahir Dar. The other 10 administrative zones are East Gojam, West Gojam, Awi, North Gonder, South Gonder, Wag Himra, North Wollo, South Wollo, Semien Shewa and

Oromiya. The region consists of 101 districts and 5,300 rural and urban associations (BOPED, 1999).

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

The population of the region was estimated to be 15 million in 1998/99. Of these, 90.3% live in rural areas. Mean population density is 91 persons/km^2 and ranges between 39 persons/km^2 in Wag Himra to 151 persons/km^2 in West Gojam. Persons below 25 years of age form more than 65% of the population (BOPED, 1999).



Map 4.1 Amhara National Regional State, Ethiopia

Source: MOA and CDE (1999)

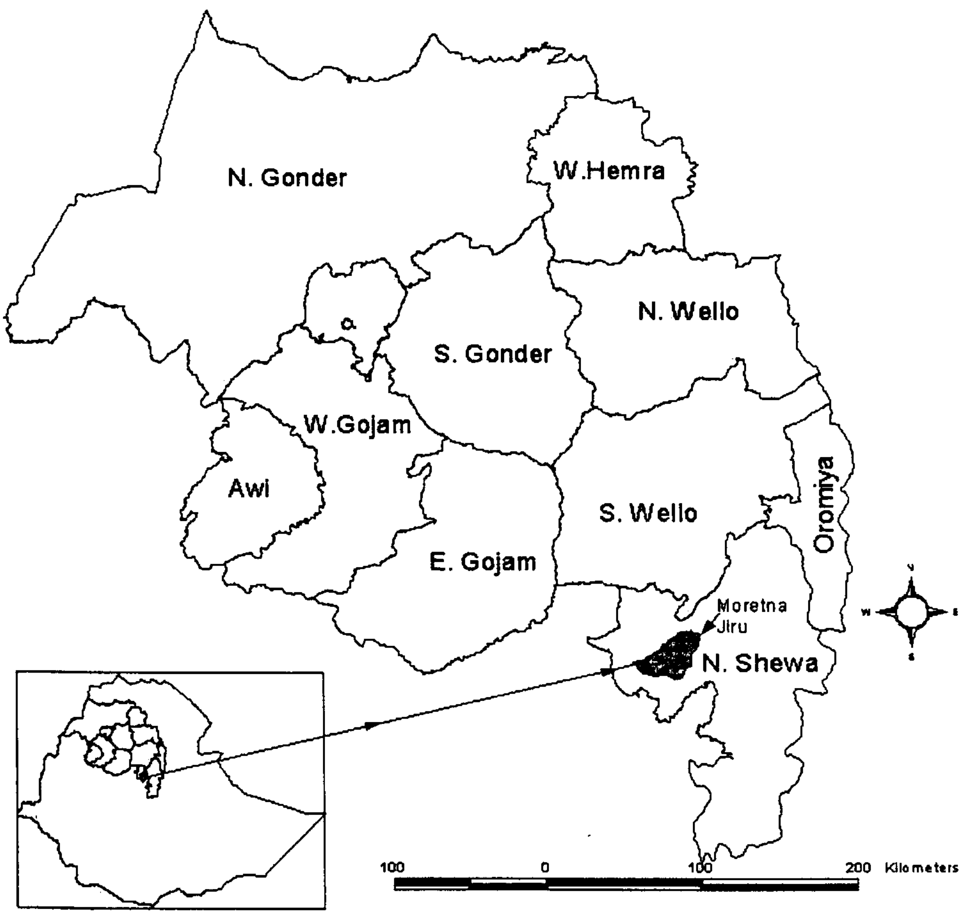
A large proportion of the population in ANRS depends upon crop and livestock farming. Cropping systems are predominantly rainfed. Moreover, due to population pressure and poor land husbandry, the level of land degradation and environmental depletion is increasing. Despite this, some regions have very fertile farmland and water resources suitable for crop production and livestock husbandry. High potential, densely populated and surplus producing regions of the ANRS include Gojam, Gonder and part of Semien Shewa (UNECA, 1996). Farmers in these regions produce a combination of cereals, pulses and oilseeds. Cereals account for the largest percentage of cultivated area (84.3%) and total production (85%). Currently, The Moretna-Jirru district in which this study was undertaken, is one of the high potential and densely populated areas of the Semien Shewa Zone.

4.3 The study district

The study area, Moretna-Jirru district, is located in Semien Shewa Zone (Map 4.2). District boundaries are the Merabeti district in the west and southwest, Barso Wrana and Gera Kaya district in the east, Ensarona Wayu in the east and the Menz district in the north. According to the Department of Agriculture, the topography and terrain of the district consists of gorges and flat lands. Total land area of the district is estimated to be 30,213 ha, accounting for about 10.6% of the total area of Semiem Shewa Zone.

Moretna-Jirru district comprises altitudes ranging from 1,500 to 2,600 meters above sea level (masl). Based on the local agro-climatic classification, the district is classified into three agro-climatic zones: *Dega* (high altitude) covers 60% of the area and ranges between 2,400-2,600 masl, *Woina dega* (mid-altitude) at 1,800-2,400 masl encompasses about 25% of the area, and *Kolla* (lowland) at 500-1,500 masl covers 15% of the area.

The mean maximum temperatures in Mortena Jirru District range from 22.1°C in August to 28.8°C in April. The mean minimum temperatures range from 5.2°C in January to 11.6°C in September. The rainfall pattern in the study area is bimodal. According to data from MOA's meteorological station, mean annual rainfall in the study area over a ten-year period was 850 mm. The majority of rain falls in the period June to August (*Kremt* or big rain) while 20% of rain falls in the period February to May (*Belg* or small rain). Rain usually starts in March, but the effective rainy season is from June to October with the peak in July, receiving a monthly mean of 431 mm of rainfall. The mean seasonal rainfall during the growing period (June to October) is 680 mm. From mid-October to January, dry weather prevails and extends to May.



Map 4.2 Location of the study district in the Amhara National Region Zonal administrative division, Ethiopia.
Source: MOA and CDE (1999)

4.4 Population of the district

According to the 1994 Census, the total population of Moretna - Jirru District is 93,837, or 13.8% of the total population of Semien Shewa Zone. The census reported that 85,040 persons resided in the rural area and 8,797 in urban areas of the district (CSA, 1994), and that the population was growing by 3.3% per annum. The majority of the people of the district are from the Amhara ethnic group and the dominant religion is Ethiopian Orthodox Christian.

Moretna-Jirru district consists of 13 peasant associations with about 20,000 farming households. A peasant association has, on average, 1,540 households with an average family size of 6.5 (MOA, 1998). Population density in the district is one of the highest in the central highlands of Ethiopia. The major occupation is farming and over 95% of the total population live in the rural areas.

As more and more people become engaged in agriculture, rates of growth in yields per hectare and returns per labour decrease. This is strong evidence that low productivity is caused by high congestion of population. Consequently, as farms become smaller and fragmented, intensifying production, both crop and livestock, is seen as the only way to bring about an improvement in agricultural production and productivity. It is visualised that a shift to land saving technology will cause rapid gains in productivity initially, followed by a phase of input intensification. However, with respect to input intensification, empirical studies are lacking on the study area. This study, which covered 31.38 percent of the total population, 34.62 percent of the farming population, 68.71 percent of farm households and 52.40 percent of the cultivated area in the district, expected to narrow the gap (Table 4.1).

Table 4.1 Population of the Moretna-Jirru district and the study area in 2000/2001

Description	District	Study area	Study coverage (%)
Total population	93837	29442	31.38
Male	47444	14898	-
Female	46393	14544	-
Farming population	85040	29442	34.62
Male	43030	14898	-
Female	42010	14544	-
Number of households	18767	12894	68.71
Cultivated area (ha)	30213	15831	52.40

Table 4.1 Continued

Cultivated area/ household (ha)	1.61	1.23	-
Area covered by main crops (ha)	15711	10607	-
Area covered by main crops (%)	52.00	67.00	-

Source: MOA in the district

4.5 Soil type

Black clay soils (vertisols) covers 12.7 million hectares in Ethiopia, of which 7.6 million hectares are in the Ethiopian highland. This area also accounts for the highest percentage of the crops grown in the country.

Moretna-Jirru consists of predominantly vertisols, which are recognised by their propensity to shrink when dry and to swell when moist. This property is due to the nature of the parent material, which is characterised by at least 30 percent clay (Tekalign, 1998). Poor internal drainage is a major problem associated with vertisols in high rainfall areas of the Ethiopian highland. As a result of this, the roots of the crops grown in vertisols are poorly aerated and nutrient uptake for growth and development is impaired.

Where vertisols are cultivated, the common crops grown under rainfed conditions are tef, durum wheat, chick pea, lentil, vetch, linseed, barley, faba bean, field pea, fenugreek and flax (Berhanu, 1985), but the yield of crops traditionally planted on vertisols is quite low. This can be attributed to the following:

- Seasonal waterlogging of vertisols;
- Use of low yielding local varieties. Seed used commonly are the local variety. The seed rate is high, generally seeds used are not clean and germination is low. Sowing is done by broadcasting. In almost all cases the local varieties perform much better than the improved high yielding varieties in the waterlogging vertisols;

- Late planting to avoid waterlogging exposes the plant to terminal stress. In other words, traditional planting does not fully exploit the growing period of the crops;
- Damage caused by cutworms, root rot, etc. is serious on vertisols;
- Inefficient use of fertilisers due to the problem of leaching and denitrification; and
- Shortage of land and the problem of land degradation.

The yield of crops in the Moretna-Jirru district is relatively higher due to the fact that all crops, except tef, were grown on manually constructed broadbeds and furrows (Efrem, 2000). Since tef tolerates waterlogging, it is sown during the wettest part of the rainy season, i.e. from late July to mid August. Planting of crops that require well-drained soils at the time of planting is delayed until August/September, once the fields have drained naturally. The disadvantages of this practice are that the full length of the growing period is not utilized, and that soil degradation occurs since the cultivated fields are exposed to erosion during the early part of the growing season. Vertisols on higher slopes drain faster and hence crops can be planted relatively earlier. Faba bean and barley are the main crops grown on higher slopes.

Despite the above facts, vertisols are of crucial importance for improving and sustaining food production in Ethiopia. Bull (1988) estimated that about 11.9 million hectares (over 90% of total) of vertisols in Ethiopia are potentially arable. He further estimated that Ethiopian vertisols could produce about 12 million tonnes of food grain if improved management practices could be widely adopted. This could be accomplished partly by expansion of the crop area (only about two million ha (25%) of the total vertisols in the Ethiopian highlands are presently cultivated) and partly by increasing yields per unit area. At present, total grain production from Ethiopian Vertisols is probably less than two million tonnes and there is an urgent need for changing this scenario.

4.6 Land use in the study district

Farms in the study district are still traditional, namely very small, usually only 1 to 3 hectares. Land is a limiting factor and is become more limiting over time as the population continues to grow. Land use and land occupation is influenced by physical characteristics (climate, land resources, topography, etc.) and population pressure. Steep lands are cultivated in areas of heavy population pressure.

When one thinks of land use in relation to farm productivity, it is important to take population growth into account because it exerts pressure on economical use of natural resources available to farming. Population growth is not only exerting pressure on the limited arable land area but also on other resources, such as forests. The adverse impact of population is that it contributes to absolute soil degradation.

In the study area, all potential lands suitable for cultivation are exhausted and land appears to be the most important scarce factor. In fact, over the years the average farm size has reduced. When land is limited, there is a need to increase production per hectare and to diversify into activities such as poultry and possibly other livestock that do not require much of the scarce land resource. This may increase non-farm activities, so that the landless farmers will benefit from non-farm employment.

Table 4.2 The land use situation of Moretna-Jirru district in 2000/2001

Use type	Area (ha)	Percent
Cultivated area (rain fed)	30213	46.96
Annual crops (irrigated)	584	0.91
Perennials (irrigated)	130	0.20
Grazing/pasture	3256	5.06
Forest	383	0.59
Natural	253	0.39

Table 4.2 Continued

Human-made	130	0.20
Bush	10073	15.66
Rivers and ponds	427	0.66
Settlement area	1370	2.13
Urban	54	0.08
Rural	1316	2.05
Others (gully and rocky)	17906	27.83
Total area	64342	100.00

Source: MOA in the district

The total land area suitable for cultivation amounts to 30,810 hectares, which is about 48.07 percent of the total land area (Table 4.2). The land identified as cultivated includes rain fed crops (46.96%), irrigated annual crops (0.91%) and irrigated perennial crops (0.2%). Grass land covers 3,256 hectares (5.06 %). Water bodies and area allocated for settlement together account for 1,797 hectares (2.79%). The natural and human-made forestland covers only 383 hectares (0.59 %). Scattered forest remnants and bush land covers a total of 10,073 hectares (15.66%). Eucalyptus species constitutes about 90% of the total plantation area and the remaining 10% of the plantation area is covered by acacia species. Fuel wood and construction poles are the major wood products, which are in great demand. As a result, people are forced to use cattle dung for fuel to cook food.

Most of the non-arable lands (27.83%) is gully, rocky and faces severe moisture stress. Most of these lands are found in the lowlands of the district. Thus, the actual cropped land does not to increase from year to year as the area of cropped land shows constancy.

4.6.1 Regional land tenure policy

Amhara Region State covers about 15% of Ethiopia and the population size is about 15 million. Cultivation and grazing take up about 30% of the total area. The average land holding of the farmers is 1.7 ha. About 35% of the total livestock in Ethiopia is found in this region (Lakew *et al.*, 2000).

The Amhara Region and the study area have the same history concerning the land tenure policy that existed before the Derg. Since the Ethiopian Revolution in 1991 nothing essentially changed concerning land tenure policy. The government maintained state ownership of land. Land is the property of the state and is not to be sold (Yigremew, 1997). There have been some changes, though, which should have a positive effect on land tenure security (Kifle, 1999). Unlike the Derg, the present government permits land to be leased and labour hired (Yigremew, 1999). Peasants and pastoralists have the right to obtain land without payment, to use it for cultivation or grazing purposes and that enjoy protection from eviction or displacement from the land. However, in practice the peasants and pastoralists are no more protected from displacement than during the period of the Derg; they can still lose land through land distribution (Kifle, 1999). Land distribution is organised at the Peasant Association (PA) level. After the establishment of the Federal Democratic Republic of Ethiopia (FDRE) in 1995, a new federal constitution was established. Article 40 of the 1995 constitution states that "the right to ownership of rural land and urban land, as well as of all natural resources, is exclusively vested in the state and in the peoples of Ethiopia. Land is a common property of the Nations, Nationalities and Peoples of Ethiopia and shall not be subject to sale or other means of exchange" (Sub. Art.3). Ethiopian peasants have the right to obtain land without payment and enjoy protection against eviction from their possession (Sub. Art.4).

Land is given to farmers for free and they pay tax on the amount of land they are given. Regional governments have to administer land and other natural resources according to the federal law. They have the power to administer land, which means the assignment of holding rights and the execution of distribution of holdings. Holding rights are defined as "the right any peasant shall have to use rural land for agricultural purposes as well as to lease and, while the right remains in effect, bequeath it to his family members; and includes the right to acquire property thereon, by his labour or capital, and to sell, exchange and bequeath same" (Art. 2, Sub. Art. 3).

4.6.2 The application for land

Farmers in the study area have several ways of obtaining access to land. The most common way to obtain use right to land is redistribution between households. At regional level land redistribution measures taken at interval benefits landless farmers, enabling them to produce to feed their family. To be eligible for land at the time of the next distribution, a farmer is required to meet the following criteria:

a) He or she should be a resident of the PA's area;
b) The farmer should be independent, meaning that he or she has established a household of his or her own;
c) He or she should have registered with the Peasant Association at age 18 years or when he or she married.

The regional administration gathers all applications and applies to the district level, requesting for land distribution to landless farmers. Upon the decision of the district, rural land allocation is implemented, with a view to assigning holding rights in a fair and proportionate manner. The second source of land in the study area is the gift. The only way for farmers to obtain gifts is from parents or children. Land is usually given to children by parents. A piece of land, mostly 0.25 to 1 hectare in size, depending on the amount of land and children the parents have, is given by parents.

The third and fourth sources of land are cash renting and sharecropping. Farmers rent land in or out and make sharecropping arrangements to obtain access to land or to increase production. The way to obtain access to land is to find farmers who are willing to rent out land. Mostly these would be farmers who have land or much land, but own no oxen or only one ox. Most of the agreements made for rent are for one to four years, and for sharecropping, for one year.

In the study district, farmers prefer renting land to sharecropping arrangements. They say that sharecropping is more expensive. With renting, the farmer pays about 300-500 Birr per hectare per year (2000), depending on the fertility of the land, and gets the whole harvest. With sharecropping, the harvest is shared, based on the labour and the resources the two parties supply. They share the harvest equally, if the parties contribute most of the inputs equally, otherwise two thirds of the share goes to the user.

As land becomes scarce, a farm operates by using land with any combination of the above forms of tenure. But land renting and sharecropping is of secondary importance because these are informal tenure arrangements; farmers use these options when land is inadequate to support their livelihood. Lease or renting and sharecropping are becoming common in the study district. However, laws prohibit farmers from leasing/renting their land to someone else who might use it more efficiently.

In fact, farmers with small farms cannot afford to lease or rent in land, because it involves costs. Thus, small farmers prefer to farm their tiny, scattered land plots, supplementing income by off-farm and non-farm activities.

Thus, land tenure arrangements affect the primary occupation of the farmer and his/her livelihood is positively related to farm size. The extent of renting and sharecropping varies and depends on farm size. As farm size increases, rented and sharecropped land increases proportionally to own land. This implies that using additional land through renting and sharecropping demands cash sources. The proportion of farmers operating only owned land decreases as farm size decreases. This entails abandoning farm activities when better income can be obtained from off-farm and non-farm activities, and thus farmers move to off-farm and non-farm activities. Thus, in line with the appropriate land tenure system, policy must be developed to reduce inefficiency resulting from the institutional rigidity of the land market.

4.6.3 Land redistribution policy

The current land tenure, as it has existed for the last 25 years, involves farmers having usufructuary rights on the land they till, but that the government can redistribute it to others.

The implementation of the land allotment policy of 1996 was limited to the areas that had experienced no land redistribution under Ethiopian Peoples' Revolutionary Democratic Front (EPRDF). This land allotment policy forbids the holding of land by farmers outside their residential administrative area, the *Kebele*/PA. Four committees were established for the purpose of enforcing the redistribution, namely the land possession verifying committee that registers all the land under the possession of the *Kebele*/PA members; the family size verifying committee that registers the household sizes and the landless in the *Kebele*/PA; the land allotting committee that distributes the land (Yigremew, 1997); and the grievance hearing committee that heard complaints from people who were not satisfied with the redistribution (Wolde-Giorgis, 1999). Members of the committees were appointed by election. Each *Kebele*/PA had its own four committees chosen by the inhabitants of the *Kebele*/PA. The regional council issued the policies and the necessary directives for the implementation of the redistribution and the *Kebele*/PA administration was responsible for the overall execution of the redistribution (Yigremew, 1997).

In the constitution family size is a criterion for redistribution, but in the 1996 Land Allotment, other criteria were applied to redistribute land among households. Farmers were categorised according to four classes. The first was the class of bureaucrats who served in politics or the army during the Derg. They were bound to lose land. The second class was that of the feudal remnants who were born from land-rich families during the imperial rule. The third class was that of rich farmers. These farmers had more than 3 hectares at the time of redistribution. The last class was that of poor farmers who were considered to be the victims of the Derg rule. They became land distributors and the major beneficiaries in the 1996 land redistribution (Wolde-Giorgis, 1999).

From the group discussions conducted (see Appendix B), it was found that rules determined the size of land that farmers of those four classes were permitted to own. Bureaucrats and feudal remnants were permitted only one hectare of land regardless of family size. They could choose the part of the land they possessed that they wanted to retain. The rich farmers were allowed to own three hectares, so their land holding was cut down to one hectare. For poor farmers, the criterion of family size was applied. The minimum size of land holding was set to a quarter of a hectare, but even so there was not enough land to allocate to all poor landless farmers. An attempt has been made to ascertain the number of landless households in the study area. By the time of the survey, 2,500 households were landless and all land for redistribution within the respective peasant associations' jurisdiction areas had already been allocated. The number of landless households is expected to increase in the years to come.

In spite of this problem, the government has stated that the 1996 land redistribution has been completed successfully. The goals have been achieved; it was democratic and participatory, and consequently the redistribution was fair and just. It was also stated that land tenure security was assured by this redistribution (Yegremew, 1997).

Periodic redistribution of land to landless farmers achieves political stability and reduces economic hardship and dependency, but does not give enough land or economic power to generate widespread growth in the study district. With little land, peasants are forced to live very close to the margin of survival. Drought, floods or other disasters can quickly push these small farmers below subsistence.

4.6.4 Informal land market

Land has social status, since it is the main source of income for most farmers in the study district. It is very difficult for them to obtain another source of income without land. The Bureau of Agriculture (2000) in the district estimates that 90% of farmers are dependent on land. Some landless farmers cut trees in the woods to make charcoal to generate income. This activity often takes place secretly in the study district, and is not mentioned by the farmers, because it is illegal.

Farmers obtain access to land if they are registered as resident members of a peasant association. Land is periodically allocated to these farmers according to their household size. To meet this need for extra land, the peasant association has several sources: part of farmer's land can be given to others; secondly, land can be acquired from families who have abandoned farming, and thirdly, new land can be available for cultivation from reserve land and communal grazing. The first measure is the main source of land used in redistribution. The total available land in the PA is distributed in proportion to the most recent count of registered members (MOA, 2000).

By law, nobody may sell or buy land, but an informal land market appears to exist. Unfortunately not much is written about buying and selling land, but the group discussions held with farmers' leaders and stakeholders provides a clear picture of renting agreements.

In the study area, there were three types of farmers: farmers who have too little land for optimal use of own labour and capital; farmers who have relatively too much land for optimal utilization of their labour and capital; and thirdly farmers who have enough land to make optimal use of their resources. The informal market emerges as a result of these differences in farmers' resources.

The main tendency is for farmers to balance their land and the amount of labour and capital they have, but most farmers are dependent on the land they were given by the peasant association (Tesfaye *et al.*, 1999).

Four different transactions among farmers were identified in the study area, namely:

1. Leasing land for oxen
2. Leasing land for labour
3. Sharecropping
4. Renting land for cash

The last transaction is not very common, but becoming common as land is becoming scarcer in the study area. Rental contracts apply mostly for one cropping season, or for a period of 1 to 4 years. The creation of such an informal land market provides land-constrained farmers with an opportunity to expand their production and it influences the equity status of the different farmers in the study district.

From the group discussions carried out it can be concluded that most farmers are using only the land distributed by the PA, but there are also more and more farmers who rent in and out land for cash in order to optimise their income. Unfortunately, it was not stated clearly how the transactions were organised and what agreements farmers made. One can safely say that this kind of transaction can happen without official verbal contracts, because of the illegality of the practice.

4.6.5 Land tenure security

Security of land tenure is an important element in creating incentives for increased investment and production. Insecurity deters an individual peasant from making additional investment to increase production.

One of the most important questions is whether farmers feel secure about the current land tenure and how it could be improved. In the study area, there are two different groups (some disfavour and other favour the current land tenure) of farmers and each group has its own opinions. Farmers who disfavour the current land tenure gave the following reasons for their opinion:

1. The fragmentation and diminution of land as a result of continuous land distribution and growing population create a sense of insecurity among peasants. Tenure insecurity has been exacerbated by the absence of any limit regarding to the scale of redistribution and minimum land holding size;
2. Farmers who have more land than others feel insecure about the foreseeable future, because they could lose their land in the next redistribution;
3. The lack of security of land tenure, among other things, has a disincentive effect on undertaking conservation measures and other permanent improvement to the land;
4. The recurrent redistribution and allocation of land reduce peasant plots and farms to uneconomic sizes, which is likely to further increase insecurity of tenure for individual peasants;
5. Farmers feel that the current land tenure made them tenants of the government. As a result of this, land cannot be used as collateral to borrow money for further investment.

The second group of farmers are those who are young and have received no land from the peasant association. This group favoured the current land tenure system and feels secure because they will obtain land in the near future. Poor farmers with no or little land may also favour this system because they might gain land in the next redistribution.

4.6.6 Needs for land reform

The broad economic and development goals of land reform include desire for improved income growth (efficiency), equity (income distribution), and security (political and economic stability).

Land is the scarcest resource in the study area because of population pressure and because farms are too small to provide an adequate living. These extremely small holdings of one or two hectares or less may have employed labour to the point at which its marginal product is close to zero. In accordance with Norton and Alwang (1993), reducing the size of relatively large farms and increasing the size of small farms may be the only way of raising the marginal product of labour in agriculture. The marginal product must go up if income per worker is to increase

As farming population density increases, share or cash rents must be changed as new technologies became available, or longer lease periods must be established to encourage permanent improvement/investment on the land.

In addition to efficiency and equity concerns, the reason for land reform in the study area is obvious: to accommodate young and landless farmers. However, the question of relative productivity and efficiency is not the highest priority for discussion by policy makers and little or no empirical research has been done on this issue. Therefore, the question whether land tenure or farm size constrains agricultural productivity in Ethiopia still needs to be studied. A few studies on the relative efficiency of alternative land tenure contracts in a mixed crop-livestock system have been done (Place and Hazell, 1993; Besley, 1994; Gavian and Fafchamps, 1996), but the policy makers did not benefit from these rigorous empirical analyses.

4.6.7 Land fragmentation

The process of subdivision of farms due to partitioning of land to new households eventually reaches a point at which holdings are too small to support a family, even at minimal subsistence level. Some holdings are so tiny that they deserve the name micro-plots or mini-farms. It is under this condition that the acute problem of productivity arises, where farmers can do little or nothing to improve the land scarcity.

An attempt was made to determine the attitude and perception of peasants towards land fragmentation. The farmers in the study area perceive land fragmentation both as an advantage and a problem. To analyze the extent and impact of land fragmentation, it is important to consider total population, the number of households, arable land area and land-household ratio of the district and study area over time.

Table 4.3 Number of households and cultivated area of the district and the study area, 1996-2000 copping year

	Number of households		Cultivated area (ha)		Area/household (ha)	
Year	District	Study area	District	Study area	District	Study area
1996	16482	6949	30213	15831	1.83	2.28
1997	17026	10329	30213	15831	1.77	1.53
1998	17587	11185	30213	15831	1.72	1.42
1999	18168	12041	30213	15831	1.66	1.32
2000	18767	12894	30213	15831	1.61	1.23

Source: MOA in the district

Average land use shows the land used by the average household and is calculated by dividing the area of land by the number of households. Because both population and the number of households increased over the years, while the amount of land remained about the same (Table 4.3), the land-man ratio declined, thereby depressing productivity and income per household. The average land per household declined from 1.83 to 1.61 ha in the district and from 2.28 to 1.23 ha in the study area. Concurrent increase in marriage and divorce rates contributed to growth of household numbers, decrease in farm size and increase in land fragmentation.

4.7 Labour use

One means of generating increased agricultural production in the study district is to expand the use of labour. Abundant labour and continued growth of the labour force can generate increases in total agricultural output. However, most growth in per capita agricultural output would have to come from intensive use of existing resources: more intensive crop rotations, green manuring, forage-livestock integration, better drainage and small-scale irrigation.

When compared to other regions of Ethiopia, the labour used per hectare planted tends to be high in the study district. This is partly explained by the fact that planting, weeding, sowing and harvesting operations are virtually done by hand. In practice, farmers rarely use herbicides to control weeds because weeds are feed for livestock.

The average family has seven members. Most of the farming activities are done by family members (80 percent), and unlike many areas in Ethiopia, most of it is undertaken by adult males. Females provide less farm labour because they are involved in household chores, food preparation, child rearing and fetching water for the whole family in rural areas.

Children also are a major source of farm labour in the region, and their tasks increase as they get older. They typically begin working on the fields by following their parents and they rapidly become involved in hoeing, weeding, harvesting and other tasks. Young boys feed and otherwise care for animals, while young girls often care for younger brothers and sisters to free their mother for other work.

Although family labour is important, some farms hire labour as well, at least during the busy times of the year. The other sources of labour during peak seasons are *wenifel* (exchange of labour) and *debo* (groups of farmers work together on each other's farms).

Moreover, family members supplement their incomes by working off the farm during slack seasons. Larger farmers with better economic and social status hire the landless and the tenants of small farms for weeding and harvesting.

Labour use in the study district tends to exhibit marked seasonal variations in accordance with agricultural cycles. During slack seasons, those immediately following planting or preceding harvest, labour is abundant, and is often underemployed during this time of the year. During peak seasons, especially during weeding and harvesting, labour is in short supply. Wages often exhibit similar seasonal fluctuations.

The seasonal nature of agricultural production also causes seasonal variations in consumption and nutritional status. Consumption patterns tend to follow agricultural cycles in the study area. It is common to find “lean seasons”, when consumption is low and short-run malnutrition high, especially immediately prior to harvest (Norton and Alwang, 1993).

4.8 Farming systems

Agriculture of the district is predominantly mixed farming, with crops being produced and livestock raised for multiple objectives. Agriculture is the main stay of the majority of the population in the district. It is rainfed farming using age-old means and methods of production. This, coupled with ever-diminishing farm size, land degradation, inadequate support facilities and unavailability of inputs, has caused production and productivity to grow at a low or constant rate.

4.8.1 Crop production

The district is characterised by oxen culture. The predominant crops grown are wheat, tef, chickpea and lentil. The major crops, wheat and tef, occupy about 45 and 30 per cent of the total crop areas, respectively, while pulses take up 25% of the total arable land. Wheat and tef are the staple food, whereas chickpea and lentil are important cash crops in the region. Crops can be grown only once a year due to rainfall and temperature limitations.

In the district two major production systems can be identified, namely a cereal-dominated production system, and a pulse-based production system. The cereal-dominant production system is by far the largest in terms of area coverage, whereas the latter is becoming highly integrated with the market economy and restoration of soil fertility. The area is characterised by three year cropping sequences: a grain legume, commonly lentil (Lens culinaris L.) or chickpea (Cicer arietinum), in succession with tef and wheat (Gezahegn and Tekalign, 1996). Nearly all the land in the study area is cultivated. Land size holding ranges between 0.5 and 2.33 hectares. Two-thirds of the farmers produce on farms smaller than the average.

To assess the importance of each crop grown, it is necessary to consider the breakdown of cultivated land, total production and yield of main crops in the district and the study area (Table 4.4).

Table 4.4 Cultivated land area, total output and yields of the main crops grown in the Moretna-Jirru district and study area, 1996-2000.

	Cultivated land area (in thousand hectares)									
	Wheat		Tef [2]		Chick pea		Lentil		Grass pea	
Year	D	SA	D	SA	D	SA	D	SA	D	SA
1996	7.05	5.90	6.88	3.38	1.08	0.58	1.92	1.81	1.06	1.06
1997	7.56	5.93	10.64	4.10	1.85	0.68	2.06	1.84	1.09	1.09
1998	7.16	6.21	7.36	3.63	1.21	0.49	2.04	1.98	1.16	1.16
1999	7.70	6.88	12.64	4.18	1.39	0.49	2.08	2.03	1.28	1.21
2000	7.78	7.00	8.79	3.64	1.35	0.49	2.11	2.04	1.29	1.21
Mean	7.45	6.38	9.26	3.64	1.37	0.55	2.04	1.94	1.18	1.15
Mean of SA to D (%)	100	86	100	39	100	40	100	95	100	97

Table 4.4 Continued

Year	Total output (in thousand quintals)									
	D	SA	D	SA	D	SA	D	SA	D	SA
1996	116.67	102.40	78.58	43.07	8.64	4.77	16.88	16.20	9.03	9.03
1997	139.89	121.18	103.01	64.50	13.32	5.32	14.04	12.68	7.34	7.34
1998	133.91	124.90	79.65	41.31	6.40	2.36	9.38	9.02	6.98	6.98
1999	153.18	144.23	132.63	67.74	13.88	5.12	22.77	22.46	15.09	14.48
2000	159.00	150.41	73.69	47.02	12.51	4.06	*	*	2.41*	1.81*
Mean	140.53	128.62	93.51	52.73	12.52	4.07	15.77	15.09	8.11	7.93
Mean of SA to D (%)	100	92	100	56	100	32	100	96	100	98
Year	Yield per hectare of cultivated land area (quintal[1]/ha)									
	D	SA	D	SA	D	SA	D	SA	D	SA
1996	16.55	17.36	11.42	12.74	8.00	8.22	8.79	8.95	8.52	8.52
1997	18.50	20.44	9.68	15.73	7.20	7.82	6.82	6.89	6.73	6.73
1998	18.70	20.11	10.82	11.38	5.29	4.82	4.60	4.56	6.02	6.02
1999	19.89	20.96	10.49	16.21	9.99	10.45	10.95	11.06	11.79	11.97
2000	20.44	21.49	8.38	12.92	9.27	8.29	*	*	1.87*	1.50*
Mean	18.13	20.16	10.10	14.49	9.14	7.40	6.23	6.29	6.87	6.90
Mean of SA to D (%)	100	112	100	144	100	81	100	101	100	100

Note: D = District SA = Study area [1]Quintal(qt) = 100 kg

** No or less yield was obtained due to outbreak of pests and diseases*

[2]Tef is a small seeded cereal grain indigenous to Ethiopia

Source: MOA in the district or District's Agricultural Office

The data in Table 4.4 indicate the cultivated land area, total output and yields of the main crops grown in the district and study area during 1996 to 2000. The yield per hectare is calculated from the cultivated land area and total output data collected from MOA. Cultivated land area for all crops remained unchanged because there was no more land for expansion. The mean area for wheat was 7450 hectares in the district and 6380 hectares in the study area over the period 1996 to 2000. This confirms that the study area has a share of 86% of the total cultivated land area and 92% of the total wheat output produced in the district. The average wheat yield per hectare increased in the district and the study area by 13.9 and 15.6 percent per year, respectively. The change in wheat yield per hectare was due to application of modern inputs such as fertilizer and high-yielding varieties.

Tef, chick pea, lentil and grass pea in the study area represent 39, 40, 95 and 97% of the total cultivated land area, and contributed 56, 32, 96 and 98% of the total district output, respectively. Tef yield per hectare in the study area was 44% more than that of the district. The main reason for high yield differences was the difference in the application of fertilizer.

4.8.1.1 Use of fertilizer

In the cereal-dominated production system, fertilizer is one of the critical inputs used for improving farm productivity and the food security status of households. Due to rapid population growth, there is a decline in land supply, which leads to a decrease in farm size. The introduction of fertilizer with improved seeds since the 1960s has enabled farmers to substitute fertilizer for land in order to meet their food demand. In the study area, where fertilizer application is common, the average amount of DAP and urea applied was reported to be 100 kg/ha and 150kg/ha, respectively (MOA, 2000).

Table 4.5 Estimated urea and DAP distributed to farmers in the Moretna-Jirru district, 1996-2000 cropping years

Year	Urea (qt)	Annual growth rate from 1996	DAP (qt)	Annual growth rate from 1996
1996	7597.5	1.00	7825.5	1.00
1997	9465.75	1.25	8569.00	1.10
1998	10863.75	1.43	8829.38	1.13
1999	13585.79	1.79	9220.75	1.18
2000	13834.00	1.82	10322.11	1.32
Mean	11069.36	1.46	8953.35	1.14

Source: MOA in the district *qt = Quintals*

From 1996 to 2000, 55,346.80 quintals of urea and 44,766.75 quintals of DAP were distributed to farmers in the district. If this is divided on yearly basis, farmers were on average supplied with 11069.36 quintals of urea and 8,953.35 quintals of DAP per year. The annual growth rate from the base year is estimated to be on average 1.46 for urea and 1.14 for DAP.

4.8.1.2 Use of improved wheat varieties

In the 1980s improved wheat varieties were scarce in the study area and were distributed to a limited number of farmers. The majority of farmers grew the local wheat varieties on a large proportion of their land.

An informal assessment made in the district in 1995 revealed that improved bread wheat varieties had mostly been introduced after 1988. Before this time, local durum wheat (as reported by 48% of the farmers in the survey sample) was the dominant wheat crop produced in the district. During the intervening 13 years, many improved bread wheat varieties have been tested in Amhara National Regional State of Ethiopia in general and the study area in particular. Bread wheat varieties have been demonstrated and popularised by district agricultural offices through package demonstrations on the farms of producer co-operatives, and by demonstrations on the research station and farmers' fields by Debre Zeit Research Center (Aleligne 1988; Aleligne and Regassa 1992). On-farm variety trials showed that improved bread wheat varieties could significantly increase wheat grain yields relative to farmers' varieties (Asmare et al. 1997). The following varieties were extended to farmers: Dashen, Enkoy, ET-13, Kilinto, Boohai, Israel, HAR-604, and HAR-710. Optimal cultural practices were recommended, including a seed rate of 150-175 kg/ha, application of 92 kg N and 46 kg P_2O_5 per/ha, control of weeds using 2-4-D (one litre/ha) and supplemental hand weeding depending on the locality (Asmare *et al.*, 1995).

4.8.2 Livestock population and its role

Moretna-Jirru district comprises mixed farming zones where crops are grown for food and cash, and animals are kept for draft, transport and complementary purposes to meet farmers' cash needs. Livestock have many important roles in the farming systems of the study district. Several of the more important roles of livestock are:

1. **Power and transport:** In the study district, livestock are the principal source of power and transport. Animals plough fields, transport farm products and inputs to and from market, and carry out processing tasks like harvesting and threshing of grains. In some remote areas of the district, animals help to market crops by eating grain (crops are marketed through the animals) and other plant products and then walking to market.

2. **Buffer and extenders of the food supply**: Farm animals provide a special protection to farm families, acting as a buffer between the family and the precarious food supply. Animals are like a savings bank. Farmers can invest surplus in them, they grow, and they can be consumed or sold if crops fail.

In the study area, livestock do not directly compete with land and crops because they eat crop residues and graze on steep slopes and marginal lands. Many types of animals are ruminants (cattle, sheep, goats, etc.) that eat grass and other forages and convert the forages to products suitable for human consumption.

Furthermore, livestock make an important contribution to extending the quality of the diet, by providing meat, milk, and eggs. Small amounts of these high-protein foods can have a significant impact on human health.

3. **Fertiliser, fuel, hides and skins**: Animal manure is a vitally important source of both fertilizer and fuel in the study district. For example, in the remote lowlands of the district, it is difficult to obtain chemical fertilizer. In this case, animal manure adds

both fertility and organic matter to the soil. In areas where wood is scarce, animal dung is dried and burned for fuel. These two uses of animal manure compete with each other. Dung that is burned cannot be used to increase soil fertility. The other contributions of livestock are skins and hides for cash. Moreover, clothing and blankets are made from animal hides and skin.

4. **Social and cultural values**: Livestock, particularly sheep and goats, are highly valued in society for social and cultural reasons. A family's social status may be measured by the number of animals it owns. Sheep and goats are given as gifts during ceremonial occasions. Thus, the social and cultural values placed on livestock have evolved over the years because of their importance as capital and income-earning assets.

In general, cattle are the most important asset that provides income, draft power and food in the study district. The livestock are herded on crop by-products and small private grazing or a stable depending on the season. These feed resources are low in amount and nutritional value and hence shortage of feed and overgrazing are serious problems throughout the year (BOPED, 1994). During the dry season (February to early June) animals are traditionally permitted to graze freely, including on private grazing lands. Individually owned grazing lands are quite small (0.1 ha). As a result, they produce little milk, meat and draft power for the farmer and his/her family. Therefore, increased quantities of high quality forage is urgently needed to improve livestock performance of the study area.

About 35 per cent of the sample households in the study area were engaged in fattening livestock. This indicates that farming families could earn additional income from animal production if assistance could be extended to them in terms of better performing breeds and vaccines and medication, coupled with better management practices.

Table 4.6 Total number of livestock in the Moretna-Jirru district, 1996-2000

Year	Oxen	Cows	Heifers	Sheep & goats	Horses & mules	Donkeys
1996	17667	8806	3587	23550	1480	9895
1997	16757	8910	3755	24165	1537	10253
1998	15743	8923	3630	25513	1585	10651
1999	16751	9266	3922	26725	1631	11445
2000	15835	9419	4034	27783	1681	11967
Mean	16551	9065	3786	25547	1563	10842

Source: MOA in the district

Of the total cattle population (Table 4.6), on average 9,065 are cows and 16,551 oxen. The presence of significant numbers of oxen and donkeys indicate the important role they play in ploughing and transportation in the area where the road network is extremely poor. Besides, donkeys are widely used to transport marketable products, inputs, water and fuel wood (dung) from relatively remote areas.

4.9 Farming problems in the study district

In the study district, farmers faced three major problems related to farming during this study period: scarcity of farm land, the high price of fertilizer and the low price of the produce. Fertilizer and other inputs are bought on credit at the farmers' service co-operative. If the price of the produce and harvest are not good, farmers face problems at pay-back time.

Farmers and stakeholders (MOA, input suppliers, traders, development agents, etc.) in the study area suggested (in group discussions) two alternative solutions for land scarcity: intensification and out-migration. Neither solution works in practice. The farmers clearly indicated that intensification is closely linked to the high price of farm inputs (fertilizer and improved seeds) and the low price of the produce mentioned earlier. As a result they cannot afford fertilizer and improved seeds. On the other hand, out-migration cannot be applied as a solution for land scarcity because of ethnic-based regional separatism.

4.10 Summary and conclusions

Agriculture in the study district is characterized by small peasant farms in which farming and family decisions are intermixed. Farm families consume most of the produce and sell small portions of surplus to local markets in exchange for buying basic needs such as salt, kerosene oil, sugar and clothes.

Although the land area per farm is small, family labour is very important. Labour input per planted hectare is high in the study district in comparison with other regions of Ethiopia.

The main reason for land redistribution in the study district is to accommodate the young and landless farmers, but frequent redistribution and allocation of land has resulted in fragmentation, tenure insecurity, and farms too small to supply a livelihood. Although most of the farmers use the land they have been distributed by the peasant association, there are a few farmers who rent land in or out, and who do sharecropping in order to optimise their income. This practice creates an informal market in the study district.

There is strong evidence that high population pressure in the study district is the cause of land scarcity. One way of combating population congestion other than intensification could be out-migration, but ethnic-based regional separatism has had a long-term negative impact on the country's ability to combat congestion of the farming population. As a result, creating off-farm employment within the district and improving the level of intensity remain viable solutions for the problems created by land scarcity.

An attempt has been made to determine the number of landless households in the study area. At the time of the survey, 2,500 households were landless because all land for distribution available within the respective peasant associations' jurisdiction area had already been allocated. The number of landless households is expected to increase in the years to come.

Because of the sample's representative nature the micro-level results of this study can be generalized to other areas in Semien Shewa Zone. Representativity is reflected in that the study area contains examples of other districts in terms of socio-economic and agro-ecological conditions.

CHAPTER 5

CHARACTERISTICS OF FARM HOUSEHOLDS IN THE STUDY AREA

5.1 Introduction

This analysis is based on data obtained from the questionnaire survey. The questionnaires of 199 farms which remained after all questionnaires had been scrutinized for incorrectness and missing data, were grouped (classified) into two groups, namely a small (103 questionnaires) and a large (96 questionnaires) farm group. The data presented in the following discussion will draw a distinction between the two groups of farmers.

This chapter presents the socio-economic, demographic and institutional support services as well as farm management practices of the study area. The chapter concludes with a summary and conclusions.

5.2 Socio-economic characteristics of the sample farmers

5.2.1 Land holding

Land holdings in the study area are very small, mainly due to high population density (Table 5.1). The mean farm size per household is 1.5 hectares for small farms and 2.81 hectares for large farms, varying from 0.5 to 3.5 hectares depending on the family size. Because crop production predominates, farmers allocate very limited area for grazing, forest and fallowing. For such land uses, the mean area of grazing land was 0.07 ha while fallowing was virtually nonexistent due to land scarcity.

Table 5.1 Average land holding in the Moretna-Jirru district, 2000/2001 cropping year

Description	Small (n = 103)		Large (n = 96)		Total	
	N	Mean	N	Mean	N	Mean
Farm size, ha	103	1.50	96	2.81	199	2.13
Cultivated area, ha	103	1.49	96	2.78	199	2.11
Area of Merere soil type, ha	102	0.83	96	1.35	198	1.08
Area of Bushola soil type, ha	96	0.68	95	1.31	191	0.99
Area of Areda soil type, ha	10	0.27	22	0.58	32	0.48
Grazing land area, ha	8	0.07	15	0.11	23	0.09
Forest land area, ha	1	0.13	5	0.18	6	0.18

N = number of respondents, n = number of sampled farmers

Source: Survey data, 2001

About 29% (30 farmers) of the small farms and 17% (16 farmers) of the large farms cultivate the land obtained through the peasant association. To alleviate land shortage, 14.6% of the small farms and 30.2% of the large farms rented-in land for crop production (Table 5.2). The mean area rented-in was 0.46 ha for small farms and 0.89 ha for large farms, with a contractual arrangement for 2-3 years and a rent of Birr 350-600 per hectare, depending on the soil fertility.

Sharecropping arrangements are also common in the study area. About 47% of the small farmers and 34% of the large farmers reported that they shared-in land for crop production to mitigate land scarcity and to ensure adequate food production for their households. The mean area shared-in was 0.40 ha for small farms and 1.01 ha for large farms. Two farmers from the small group and one farmer from the large farm group rented-out land for crop production. Similarly, no farmer from the small group shared-out land while one farmer from the large group shared-out land for crop production.

Table 5.2. Main forms of land use arrangements in the Moretna-Jirru district, 2000/2001 cropping year

Description	Small (n=103)		Large (n=96)		Total	
	N	Mean	N	Mean	N	Mean
Cultivated land, ha	103	1.49	96	2.78	199	2.11
Land owned, ha	103	1.19	96	1.75	199	1.46
Rent-in-land, ha	15	0.46	29	0.89	44	0.74
Rent-out-land, ha	2	0.31	1	0.50	3	0.38
Share-in-land, ha	48	0.40	33	1.01	81	0.75
Share-out-land, ha	0	0	1	1.00	1	1.00
Family land, ha	10	0.46	17	0.66	27	0.59
Relatives land, ha	0	0	1	0.50	1	0.50

Source: Survey data, 2001

5.2.2 Soil types

Soil type strongly influences the production decisions of a farm household. It is an important technical factor for determining the crop species or variety the farmer plants or the uses for a field. To provide an overview of the different soils in the study area, farmers were asked to give their views on the types of soils on their farms.

Traditionally, farmers in the study area classify the soil into three main groups (Table 4.11). The dominant soil type is the heavy black clay soil, locally called *Merere* soil, followed by light black clay soil known as *Bushola* and Areda soil. As perceived by farmers the *Merere* soil type is the most productive on which all crops can be grown. In 2000, the majority of farmers (80%) produced cereals on the *Merere* soil. Most farmers in the study area have a field of *Merere* soil (Table 5.3).

Table 5.3 Soil types and their characteristics as perceived by sample farmers in the Moretna-Jirru, 2000/2001 cropping year

No	Soil types	Characteristics
1	*Merere*	Grows all types of crops, but preferred for cereal crops Most productive
2	*Bushola*	Grows all types of crops except chickpea and lentil Light soil Waterlogging problem
3	*Areda*	Found around homestead area Grows all types of crops except wheat and tef Weed problem

Source: Survey data, 2001

5.2.3 Crop production

Basically, farmers grow multiple crops to satisfy family food and cash requirements. Cereals, particularly wheat and tef, predominate in Moretna-Jirru district), mainly due to the high proportion of favourable highland environments for the production of these crops. Chickpea, lentil and grass pea production follow wheat and tef in terms of importance (Table 5.4). Other crops such as faba bean, field pea, linseed and fenugreek are cultivated to a lesser extent.

The survey revealed that there are variations in the distribution of crops across the district. Wheat is the dominant crop, extensively grown by almost all farmers. The mean land area allocated for wheat was 0.61 ha for small farms and 1.22 ha for large farms. From the total cropped area, wheat occupied 40% of the cultivated area on small farms and 43.89% on large farms. Small and large farms allocated on average 0.36 and 0.56 ha of their farm land to tef production. Average total farm land shared to household members was estimated to be 0.28 and 0.42 ha for small and large farms, respectively. The results revealed that there is significant difference (at P=.001) between farm groups.

Table 5.4 Average land allocation to main crops in the Moretna-Jirru district, 2000/2001 cropping year

	Small (n=103)		Large (n=96)		
Description	N	Area	N	Area	T-values
Cultivated area, ha	103	1.49	96	2.78	16.76*
Wheat area, ha	103	0.61	96	1.22	11.99*
Tef area, ha	102	0.36	95	0.56	7.99*
Lentil area, ha	9	0.29	10	0.47	3.69*
Chick pea area, ha	4	0.18	6	0.22	3.93*
Grass pea area, ha	9	0.21	4	0.37	5.82*
Faba bean area, ha	5	0.16	7	0.29	3.63*
Cultivated area per household members (ha/person)	103	0.32	96	0.46	5.63*

* *Indicates statistical significant difference at 1% test level between groups*

Source: Survey data, 2001

5.2.3.1 Area allocated to wheat and tef varieties

Areas allocated to individual wheat and tef varieties are presented in Tables 5.5 and 5.6. Of the improved wheat varieties, ET-13 was the most widely adopted. The survey results reveal that 93% of the total sampled farmers planted ET-13 on an average of 0.81 ha per farm during 2000/2001 cropping year. This accounted for 88% of the total cultivated wheat area. In terms of farm size, the area reported for ET-13 was on average 0.57 ha for small and 1.06 ha for large farms (Table 5.5).

Local wheat varieties were grown by 18.09% of the total sample farmers, on an average area of 0.36 ha per farm. The most common reasons given for growing local varieties were that they need a lower rate of fertilizer and the straw is more palatable to livestock. The survey also revealed that farmers grew local varieties in addition to improved varieties.

Table 5.5 Average area (ha) sown to wheat varieties in Moretna-Jirru district, 2000/2001

Land area	Small (n=103)		Large (n=96)		Total	
	N	Area	N	Area	N	Area
ET-13	96	0.57	90	1.06	186	0.81
HAR-710	7	0.29	15	0.41	22	0.37
Kenya	1	0.38	2	0.75	3	0.63
Pavon	1	0.25	6	0.48	7	0.45
Kilinto	4	0.22	4	0.53	8	0.38
Dashen	3	0.29	1	0.50	4	0.35
Local	15	0.28	21	0.41	36	0.36

Source: Survey data, 2001

Total respondents exceeds total sampled farmers, indicating that some respondents grew more than one variety

The survey results in Table 5.6 revealed that farmers grew one improved and a number of local tef varieties. Of all tef varieties, white tef (local) was the most widely planted in the 2000 cropping year (50.76%), followed by the improved variety, DZ-01-354 (34.52%). The average farmer had 0.44 ha of white tef or 0.42 ha of DZ-01-354.

Table 5.6 Average area (ha) sown to tef varieties in the Moretna-Jirru district, 2000/2001

Land area	Small (n=102)		Large (n=95)		Total (n=197)	
	N	Area	N	Area	N	Area
DZ-01-354	31	0.34	37	0.50	68	0.42
Bunign	1	0.13	13	0.26	14	0.25
Red tef	6	0.27	5	0.43	11	0.34
White tef	54	0.38	46	0.51	100	0.44
Mixed tef	12	0.30	11	0.48	23	0.39

Total respondents exceed total sampled farmers, indicating respondents grew more than one variety

5.2.3.2 Productivity of crops

The survey revealed that almost all farmers (99%) grew wheat and tef during 2000. Of all the crops reported by farmers in the study area, wheat was the highest yielding (2932.72 kg/ha). This may be attributed to the favourable agro-ecological conditions in the district. Most farmers reported that pulses had been planted on their fields, but they were completely damaged by disease and pest (aphids). Only a few farmers reported that they got reasonable yields (Table 5.7).

Crop yields showed marked variations between farm groups. Large farms reported the highest wheat yield (3160.34 kg/ha) compared to small farms (2685.10 kg/ha). The lowest yield was reported on one of the small farms (2000 kg/ha).

Table 5.7 Average yields (kg/ha) of main crops, Moretna-Jirru district, 2000/2001 cropping year

Crop	Small (n=103)		Large (n=96)		Total (n =199)	
	N	Yield	N	Yield	N	Yield
Wheat	103	2685.10	96	3160.34	199	2932.72
Tef	102	1463.27	95	1501.81	198	1485.54
Chick pea	9	1644.44	10	1552.00	19	1595.80
Lentil	4	2096.00	6	1420.00	10	1692.00
Grass pea	9	1026.68	4	1285.00	13	1106.16
Faba bean	5	936.00	7	1334.28	12	1168.32

Source: Survey data, 2001

5.2.3.3 Productivity of wheat and tef varieties

The highest reported wheat yield (Table 5.8) was for ET-13 on both small (2832.64 kg/ha) and large farms (3402.72 kg/ha), followed by Kilinto (2979.52 kg/ha) and HAR-710 (2824.20 kg/ha).

Table 5.8 Average wheat yields (kg/ha) by variety, Moretna-Jirru district, 2000/2001

Variety	Small (n=103)		Large (n=96)		Total	
	N	Yield	N	Yield	N	Yield
ET-13	96	2832.60	90	3402.72	186	3118.40
HAR-710	7	2636.00	15	2912.00	22	2824.20
Kenya	1	2420.00	2	3228.00	3	2824.00
Pavon	1	2200.00	6	2912.00	7	2810.28
Kilinto	4	2799.00	4	3160.00	8	2979.52
Dashen	3	2733.32	1	3000.00	4	2800.00
Local	15	2028.00	21	2189.52	36	2122.24

Source: Survey data, 2001

Total respondents exceeds total sampled farmers, indicating respondents grew more than one variety

Farmers reported (Table 5.9) that white tef (local) gave the highest mean yield (1557.64 kg/ha), followed by the improved tef variety, DZ-01-354 (1441.48). Farmers also reported high adoption rates for DZ-01-354 (34.52%).

Table 5.9 Average tef yields (kg/ha) by variety, Moretna-Jirru district, 2000/2001

Variety	Small (n=102)		Large (n=95)		Total (n=197)	
	N	Yield	N	Yield	N	Yield
DZ-01-354	31	1422.60	37	1443.88	68	1441.48
Bunign	1	800.00	13	1332.32	14	1294.28
Red tef	6	1233.32	5	1212.00	11	1223.64
White tef	54	1516.76	46	1605.64	100	1557.64
Mixed tef	12	1448.32	11	1420.00	23	1435.64

Total respondents exceeds total sampled farmers, indicating respondents grew more than one variety

5.2.4 Livestock ownership

Moretna-Jirru district is characterized by mixed farming systems in which both crop and livestock production provides income to peasant households. Virtually all farmers reported ownership of livestock. Poultry and sheep in small numbers are common for small and large farms. In general, livestock in the study area fulfill several purposes: An output function (subsistence, income and nutrition), an input function (crop inputs and farm integration is an asset and security function), and a social and cultural function.

Many of the farms have small numbers of animals such as oxen, donkeys and cows. The most common is poultry, usually ranging birds, and only fed on weevil or waste wheat from fluff processing (wheat chaffs). Some farms keep a few sheep, which are tethered (tended in principle by children on crop residues and small grazing land). Farmers keep sheep, mostly for sale and home consumption during ceremonies. The surveyed farms reported that traditionally livestock production constitutes an important source of household income in the study area. Furthermore, consumption and special celebrations are other reasons for keeping animals.

Crop residues, which result from the cultivation of cereals and pulses, are also other important feed sources. Farmers in the study area indicated that crop residues account for up to 90% of livestock feed since they cover most of the dry season feed supply.

The contribution of cereal crop residue as livestock feed is very high compared to the pulse residues, because farmers allocated a limited area to pulse crops. But pulse residues have a high crude protein content, improving the nutritional quality of the overall residue as feed. Sale of crop residues in the area is also common. Farmers who do not have livestock give crop residues to other farmers free of charge so that they can borrow oxen for ploughing.

Large farms are in a better position to raise animals because livestock feeds produced from larger farmland are normally sufficient, while feed produced from small farms are insufficient. The surveyed farmers reported that the animals also serve them as security assets. If the revenues from crop production do not secure the needs of the household or in case of an urgent need of money, such as medical care, farmers can sell their animals.

Table 5.10 Types of important livestock owned in the Moretna-Jirru district, 2000/2001 cropping year

Types of livestock	Small farm (n =103)		Large farm (n = 96)		Group total	
	N	Mean	N	Mean	N	Mean
Oxen	91	1.14	96	1.55	187	1.35
Cows	39	1.03	67	1.04	106	1.04
Heifers	21	1.00	23	1.09	44	1.05
Calves	26	1.04	40	1.08	66	1.06
Donkeys	87	1.13	96	1.51	183	1.33
Horses	29	1.00	51	1.00	80	1.00
Sheep	55	2.16	72	2.99	127	2.63
Poultry	79	3.05	81	4.27	160	3.67

Source: Survey data, 2001

According to Table 5.10, the larger farmers have on average more animals in each category than smaller farmers except for horses. Apparently, small farmers owned fewer numbers of livestock than large farmers due to shortage of grazing and crop residues.

5.2.5 Asset ownership

Farmers seldom reveal their wealth status to outsiders; however, asset ownership could serve as a proxy indicator of the socio-economic status of the surveyed farmers. The survey showed that the peasant farmers in the district do not have a significant asset base (Table 5.11).

Agricultural production technology in the study area is based on manual labor. "*Mofer and Kenber*", hoes, sickles, axes, "*Mensh* and *Lyida*" are the most important agricultural tools. The number of farm implements owned by the households varied with farm size. All households used "*Mofer and Kenber*" for cultivation and sickles for harvesting. For winnowing, they used the "*Mensh and Lyida*". The average number of farm implements owned by large farmers was significantly higher than that owned by small farmers (Table 5.11). Only two small farmers and six large farmers owned carts. Only three large farmers owned wheelbarrows to transport farm products from the threshing place to the store.

Table 5.11 Number of farm implements owned by small and large farmers in Moretna-Jirru district, 2000/2001 cropping year

Implements	Small farms (n=103)		Large farms (n=96)		t-value
	N	Mean	N	Mean	
Mofer[1]	103	1.79	96	2.72	6.80*
Kenber[1]	103	1.61	96	2.37	7.35*
Sickle	103	2.68	96	3.90	8.70*
Hoe	98	1.32	96	2.09	9.11*
Shovel	74	1.01	88	1.30	5.56*
Ax	103	1.19	96	2.08	10.84*
Mensh[2]	103	2.49	96	3.98	11.47*
Lyida[2]	103	1.28	96	2.46	15.03*
Cart	2	1.00	6	1.00	[a]
Wheelbarrow	0	00	3	1.00	[b]

** Indicates statistically significant difference between groups at 1% test level*

[a] t-value cannot be computed because the standard deviations of both groups are zero

[b] t-value cannot be computed because at least one of the groups is empty

[1] Amharic words for implements that farmers use for ploughing

[2] Amharic words for implements that farmers use for winnowing their produce while threshing

5.2.6 Changes in farm size

The high level of population concentration in the study area has resulted in periodic changes in farm size. During the last five years, on average, 1,483 new households per year were formed in the study district. Thus periodic adjustments of land holdings were made by PAs in response to demand for land by newly formed families.

In the past, there were many options for providing land to newly formed families. One option was to supply them with communal grazing land or reserved land. Another was to bring new land under cultivation. A third one was to take part of an existing farmer's land and to allocate it to new farmers. All these options were used in land redistribution, but the first and the second options have become exhausted. At present, the only possible option is the third.

Farmers were asked how to state their farm sizes had changed during the last five years. According to Table 5.12, 21.4% and 10.4% of the small farmers reported that their farm size had increased (gained some land) and decreased (lost some land), respectively, while 68% of the respondents indicated no change during 1996-2000. Similarly 7.3% and 14.7% of the large farmers indicated that their farm sizes had increased and decreased respectively while 78.1% indicated no change.

Table 5.12 Change in farm size (ha), the Moretna-Jirru district, 1996-2000

	Small (n =103)		Large (n = 96)		Total (n =199)	
Types of change	N	%	N	%	N	%
Increased	22	21.4	7	7.3	29	16.5
Decreased	11	10.7	14	14.7	25	12.6
No change	70	68.0	75	78.1	145	72.9
Total	103	100	96	100	199	100

Source: Survey data, 2001

5.2.7 Land fragmentation

Various factors are responsible for land fragmentation in the study area. Among the main factors which caused land fragmentation are: (a) provision of land for newly married couples; (b) the variation in topography, the types and fertility status of soils; and (c) the traditional system of land inheritance.

There are different arguments against and in favour of land fragmentation. The most often heard arguments against it are: (a) the involvement of long distances and hence the time and effort required for moving animals, farm inputs and harvested crops, (b) the difficulty of supervising fields, and (c) the loss of land when making boundaries.

The limited reserved land under the jurisdiction of PAs has been distributed continuously to accommodate newly married couples and landless farmers in the study area.

The survey attempted to determine the attitude and perception of sample farmers towards land fragmentation. The farmers in the study area perceived land fragmentation to be both a problem and an advantage. Out of the total number of respondents, about 33% of farm households perceived land fragmentation as a problem whereas the rest 67% perceived it as an advantage.

In general, farms are not already very small but these farms are continuously fragmented further into diminutive fields or parcels. The average field or parcel size for small and large farms was 0.40 and 0.52 hectares, respectively. Number of land parcels and distance between parcels are important factors in the utilization of farm inputs. The number of parcels or plots of land cultivated by all sample farmers ranged from 2 to 13 with an overall average of 5.02 parcels. For small farms, the number of land parcels ranged between 2 and 8 with an average of 4.04 (Table 5.13), whereas for large farms the number of land parcels ranged between 3 and 13 with average of 6.06. This implies that there are more land fragmentations and more time wasted in walking between parcels on large farms. Comparatively speaking, land scarcity is more serious on the small than on large farms because small farms cannot afford money to rent in land and to buy modern inputs for sharecropping.

Table 5.13 Average number of land parcels and distance between parcels in the Moretna-Jirru district, 2000/2001 cropping year

Description		Small (n = 103)	Large (n = 96)
Farm size	Ha	1.50	2.81
Parcel size	Ha	0.40	0.52
Number of parcels per household	Minimum	2.00	3.00
	Maximum	8.00	11.00
	Average	4.04	6.06
Distance between parcels (walking in minutes)	Minimum	5.00	5.00
	Maximum	45.00	60.00
	Average	19.69	22.38
Average time taken to walk all parcels	Minute	79.55	135.62

Source: Survey data, 2001

5.3 Demographic characteristics

5.3.1 Household structure

The production unit that has been used as a basis for analysis in this study is the farm household. A household is defined as all the persons who live permanently within a farm compound. A permanent resident is considered to be a person of the nuclear family who spends more than 50% of his/her time at the household. Other studies consider a permanent resident to be a person who returns home regularly, i.e. on weekends, for vacations or special ceremonies. .

The two related sub-units, household and farm, and to some extent also the family, make joint decisions regarding the use of resources, production, output, distribution, and consumption. In the study area, farm households are typically centered on a nuclear family unit, consisting of the male head of the household, his wife and their children. Members of the extended family, such as the widowed wives of the household head's father, or grandchildren, can also be found in the household. The household size is an indicator of the social standing and a measure of prestige in the community.

The main difference in household structure between farm sizes is the number of members per household. Small farms have fewer members than large farms. The typical family has, on average, six members, including 3 children younger than 15 years. The survey revealed that about three members attend school.

Household size differs in accordance with the farm sizes. The size of households of all sample farmers ranges between 2 and 12 persons. In terms of farm size, an average of 5.35 persons live permanently in a household of the small farms, and 6.75 persons in the household of the large farms (Table 5.14).

Age is one of the demographic characteristics assumed to influence farm productivity and technical efficiency. The age of the household head and the date of founding of the household also differ between farm size groups. There could be a causal linkage between the age of the head of the household and the founding of the household.

The head of the household is usually a man; rarely is a woman the head of a household. The distribution of the ages shows that 17.5% of the farmers are older than 50 years. The mean age of heads for small farms and large farms was 40.17 and 41.41 years, respectively.

The average number of years of farming experience of small farmers was 16.63, whereas that of large farmers was 18.54 years. The magnitude of the standard deviation (SD) of farm experience indicates a considerable variability (i.e., some farmers of small farms have little experience while others have many years of farming experience). In this analysis, it was hypothesized that more farming experience makes a farmer more efficient in using resources and adopting new technology. The study showed no significant difference, however, between years of farming experience of small and large farm size groups.

In general, in the study area, young farmers have smaller farms. This is mainly due to the fact that little is available for distribution to them. Furthermore, inheritance or transfer of a farm from one generation to the next is usually only feasible upon the death of the head of the household. This has a negative impact on agricultural development due to the fact that youngsters do not have free access to land to participate actively.

Table 5.14 Age of household heads and family composition in the Moretna-Jirru district, 2000/2001 cropping year.

Description	Small (n = 103)		Large (n = 96)		T-value
	Mean	SD	Mean	SD	
Age of household head, years	40.17	13.62	41.41	10.71	0.711
Farming experience, years	16.63	12.49	18.54	10.51	1.164
Household size (persons)	5.35	1.84	6.75	2.00	5.152*
Adults between 15-60 years	2.52	0.94	3.07	1.29	3.45*
Children less than 15 years	2.82	1.42	3.44	1.59	2.74**

*, ** *Indicates statistically significant difference between groups at 1% and 5% test level, respectively*

Source: Survey data, 2001

Level of education of the household head is assumed to influence farm productivity and adoption of new technologies, since literate farmers would have a greater ability to obtain, process, and use information about farm efficiency and improved technologies. The level of education of the sample farmers is as follows: 30.2 % of the sample farmers were illiterate and 69.8% were literate, of whom 30.7% can read and write after participating in a literacy campaign, and 17.6% and 21.6% reached junior and senior high school, respectively (Table 5.15).

Table 5.15 Education level of household heads in the Moretna-Jirru district, 2000/2001 cropping year

Education level	Small (n = 103)		Large (n = 96)		Total (n =199)	
	N	%	N	%	N	%
Illiterate	37	35.9	23	24.0	60	30.2
Read & write	27	26.2	34	35.4	61	30.7
Elementary	19	18.4	16	16.7	35	17.6
Secondary	20	19.4	23	24.0	43	21.6
Total	103	100	96	100	199	100

Source: Survey data, 2001

5.3.2 Household labour use

Total household labour use is defined as the sum of labour inputs of all family members for crop and livestock production. The household agricultural labour use does not include food processing of crops, marketing, or other household activities, e.g. collection of firewood. In general, husbands and wives have only three to four days per week for working on their farms as dictated by religious and cultural holidays.

Most of the labour is provided by household members with the occasional assistance of community labour arrangements, locally called *Debo* and *Wonfel* (developed systems of labour exchange). Community labour (*Debo and Wonfel)* is often practiced when labour peaks exist on farms.

Three main labour peak seasons exist in the study area during the survey period:

1. Planting (July and August)
2. First weeding (September and October), and
3. Harvesting of crops (December and January).

The agricultural roles within the traditional household are generally differentiated according to gender. Tasks of the males are all those associated with planting, fertilizing, crop disease and control, harvesting, crop processing and marketing of food and cash crops as well as livestock. The women are responsible for planting, weeding, ridging, harvesting, processing and marketing of food crops only. Off-farm work is mainly a task for men. Children in the household participate in most of these tasks but are not available much because of school obligations.

Of the total surveyed farmers (199), 55.28% used traditional community labour exchange (*Debo and Wonfel*) for different farm operations. The highest labour exchange was for harvesting, followed by sowing and threshing (Table 5.16).

Table 5.16 Community labour exchange for different farm operations in the Moretna-Jirru district, 2000/2001 cropping year

Farm operations	Small (n =103)		Large (n =96)		Total (n =199)	
	N	%	N	%	N	%
Ploughing	8	13.8	6	11.5	14	12.7
Sowing	26	44.8	23	44.2	49	44.5
Weeding	16	27.6	8	15.4	24	21.8
Harvesting	38	65.5	20	38.5	58	52.7
Threshing	25	43.1	23	44.2	48	43.6
Transporting	17	29.3	18	34.6	35	31.8
Total	58	100	52	100	110	100

Source: Survey data, 2001

5.3.3 Hired labour

The large size of households helps ensure adequate labour for various agricultural activities. However, the large family size also creates a heavy demand for food and natural resources, despite the generally low level of agricultural productivity, making food security at the household level precarious or unstable.

Farmers in the study area hire labour for specific tasks such as weeding and harvesting crops, but rarely for the preparation of food crop plots. Almost 61% (63 farmers) of the small and 77% (74 farmers) of the large farms hired workers during peak seasons (Table 5.17). Wages are paid as a daily salary. The mean salary paid for hired labour during the season 2000/2001 was 136 Birr per hectare. The hired labour that is available locally comes mostly from farms with very limited land size and landless people.

Table 5.17 Labour hired for different farm operations in the Morrtna-Jirru district, 2000/2001 cropping year

Farm operations	Small (n =103)		Large (n = 96)		Total (n =199)	
	N	%	N	%	N	%
Ploughing	1	1.6	6	8.1	7	5.1
Sowing	9	14.3	16	21.6	25	18.2
Weeding	16	25.4	25	33.8	41	29.9
Harvesting	62	98.4	68	91.9	130	94.9
Threshing	10	15.9	8	10.8	18	13.1
Transporting	0	0	1	1.0	1.0	0.7
Total	63	100	74	100	137	100

Source: Survey data, 2001

5.3.4 Off-farm activities

Off-farm employment is practiced by nearly all farmers. As a source of income it can balance the weekly and monthly revenues and increase wealth and thus their living standard. In densely populated areas, Fadani (1999) assumes that off-farm employment is so attractive because of the locked situation of the traditional division of labour, where men are responsible for the production and selling of the cash crop and women are permanently responsible for household food processing and subsistence production. During prosperous crop production times, farmers invest the profits not in agriculture but mainly in off-farm activities e.g. a small shop. Thus, investment in off-farm activities has a profit-oriented character. Many farmers are of the opinion that agricultural activities are not as profitable as off-farm activities. In the survey area, farmers gave various reasons for off-farm employment: to increase income, to obtain a regular income, to substitute for land (more limiting production factor) and to minimize the risk of shortage of liquidity. On the other hand, farmers had several reasons not to leave the agricultural sector; the relatively cheap supply of food, the family relations, the cheap housing cost and the difficulty in finding adequate work for all household members.

Family size, it was hypothesized, influences farmers' efficiency and adoption behaviour because farmers with large families were expected to be more efficient and faster to adopt improved technologies in order to increase productivity and efficiency.

With regard to involvement in off-farm jobs, it was hypothesized that such employment influences farm productivity and promotes the decision to adopt improved technologies, as households involved in off-farm jobs may be able to afford to invest in improved technologies.

Working as civil servants, guards and teachers were the major off-farm jobs for small and large farmers. However, few households have family members working as guards, civil servants or teachers. The total number of family members engaged in off-farm activities was 1.94% for small farmers and 6.25% for large farmers (Table 5.18).

Table 5.18 Households engaged in non-farm and off-farm activities in the Moretna-Jirru district, 2000/2001 cropping year

Description	Activities	Small (n =103)		Large (n =96)		Total (n =199)	
		N	%	N	%	N	%
Non-farm	Fattening livestock	31	86.1	42	97.7	73	92.4
	Petty trading	4	11.1	1	2.3	5	6.3
	Handicraft	1	2.8	0	2.3	2	2.5
Total		36	100	43	100	79	100
Off-farm	Guard	1	50.0	2	33.3	3	37.5
	Civil servant	1	50.0	3	50.0	4	50.0
	Teaching	0	0	1	16.7	1	12.5
Total		2	100	6	100	8	100

Source: Survey data, 2001

The main non-farm activities were fattening livestock, petty trading and handicrafts. About 35% of owners of the small and 45% of owners of large farms were involved in non-farm activities during the survey period (Table 4.18). The average annual income earned by small and large farms from non-farm activities was estimated to be 1,336.77 and 2,033.69 Birr per household, respectively (Table 5.19).

Table 5.19 Average income (Birr[a]/household) from off and non-farm income in the Moretna-Jirru district, 200/2001 cropping year

Types of income	Small (n =103)		Large (n =96)		Total (n =199)	
	N	Mean	N	Mean	N	Mean
Off-farm income	2	452.00	6	1300.00	8	1338.00
Non-farm income	31	1336.77	42	2033.69	73	1737.74

Source: Survey data, 2001

[a] *Exchange rate, 1USD=8.30 Birr*

The survey revealed that farmers who were not involved in non-farm activities reported various constraints/reasons (Table 5.20), among which were shortage of capital (73%), location of residence (23%) and shortage of knowledge or know-how (10%).

Table 5.20 Constraints to non-farm activities as reported by farmers in the Moretna-Jirru district, 2000/2001 cropping year

Description	Small (n=103)		Large (n=96)		Total (n=199)	
	N	%	N	%	N	%
Shortage of capital	49	73.1	39	73.6	88	73.3
Shortage of knowledge	8	11.9	4	7.5	12	10.0
Location of residence	15	22.4	13	24.5	28	23.3
Time constraints	4	6.0	2	3.8	6	5.0
Labour shortage	4	6.0	5	9.4	9	7.5
Feed shortage	2	3.0	0	0	2	1.7
Total	67	100	63	100	120	100

Source: Survey data, 2001

5.4 Access to institutional support services

5.4.1 Extension services

Access to extension services is one of the institutional supports hypothesized to influence a farmer's decision to increase farm productivity and efficiency. The extension approach being implemented in the study area is known as the Participatory Demonstration and Training Extension System (PADETES) practiced since 1996. It is believed that this approach facilitates access to agricultural technologies, to improved inputs by providing credit and practical training to extension staff and farmers. Furthermore, the mobility of the extension workers is improved through the provision of vehicles, motorcycles, bicycles and pack animals to facilitate the implementation of the program. The other strength of the program is the effort made to build strong linkages between researchers, extension officers and input distributors a key issue for successful agricultural technology transfer. The extension program uses demonstration plots, usually 0.25 to 0.50 ha, to demonstrate improved farming practices. Regular visits to demonstration plots provide ample opportunities to discuss problems encountered in the process with farmers. In this strategy, the most important recommendations for crop production include improved varieties of seed, seedbed preparation, optimum seed rate, methods of fertilizer application, fertilizer type and rate.

The PADETES program includes farm households on the basis of accessibility, population density, and settlement pattern. At present, the Development Agent (DA) to farmer ratio is 1:800 in the study area. The major tasks of the DAs include organizing demonstration trails, assisting farmers in obtaining agricultural inputs, and channeling farmers' problems to the relevant organizations, particularly to the District Department of Agriculture.

Farmers can gain access to services about new technologies through various means, such as access to extension, credit, fertilizer, improved seeds and veterinary services. Of these, the main source of information for crop production practices is the extension service of the Bureau of Agriculture at the regional, zonal and district levels.

About 70.9% of small farms and 83.3% of large farms in the study area had access to extension services (Table 5.21). The types of contacts made with farmers by extension agents were identified as individual, group, and both individual and group: 85.4% and 15% of farmers were visited individually and as part of a group, respectively, during the survey year.

Distance to a development centre was hypothesized to influence the adoption of new technologies. Compared to households further away, households near a development centre are considered more likely to have access to development agents, new technologies and information. The average time taken to reach the nearest development centre was about 20 minutes and a farmer walks on average about 40 minutes to reach the nearest market centre. However, no significant difference was observed in the distance to a development centre from the residences of farmers.

5.4.2 Credit service

Access to credit was hypothesized to be one of the major institutional factors influencing the decision of a farmer to increase farm efficiency by adopting new technologies. In the study, it was found that 95.1% of the small farms and 95.8% of the large farms reported obtaining credit from the state (Table 5.21). The main purposes for which both categories of farmers take credit are to purchase chemical fertilizer and improved seeds. The most important credit problems cited in the study area were bureaucratic procedures involved, unfavourable loan repayment terms and fear of prosecution in case of default. Some farmers reported that they obtained credit from informal sources such as credit associations and local moneylenders. The reasons given were easily accessible loans and flexible repayment terms. However, compared to the state credit, informal moneylenders charged high interest rates because of lack of competition in the study area.

5.4.3 Veterinary services

There are ten veterinary service centres in the districts. The main task of these centres is to safeguard livestock against common diseases such as foot and mouth, anthrax, tuberculosis and brucellosis. Regular animal health monitoring is carried out among the households to treat sick animals and to give advice about livestock health care. Accordingly, 75.7% of the small farms and 86.5% of the large farms had access to veterinary services during the survey period.

Table 5.21 Farmers' access to different services in the Moretna-Jirru district, 2000/2001 cropping year

Descriptions	Response	Small Farms		Large farms		Total	
		N	%	N	%	N	%
Farmers' access to credit services	Yes	98	95.1	92	95.8	190	95.5
	No	5	4.9	4	4.2	9	4.5
Total		103	100.0	96	100.0	199	100.0
Farmers' access to extension services	Yes	73	70.9	80	83.3	153	76.9
	No	30	29.1	16	16.7	46	23.1
Total		103	100.0	96	100.0	199	100.0
Farmers' access to veterinary services	Yes	78	75.7	83	86.5	161	80.9
	No	25	24.3	13	13.5	38	19.1
Total		103	100.0	96	100.0	199	100.0

Source: Survey data, 2001

5.5 Farm management practices and use of farm inputs

5.5.1 Land preparation

Land is commonly prepared with *Maresha,* the local ox plough. The frequency of ploughing varies among crops. Wheat, chickpea, lentil and grass pea fields are ploughed twice on average, while tef fields are ploughed about three times, clearly showing that tef requires more labour for land preparation than other cereals. About 9% of the sampled farmers in the study area ploughed their wheat fields three times.

5.5.2 Use of farm inputs

Agricultural inputs are divided into so-called modern inputs such as chemical fertilizer, improved seeds, pesticides, purchased animals, and feed for animals, and inputs coming from the farm itself, such as seeds, plants and organic manure.

Modern inputs are mainly used for cereal crop production while the inputs from the farm are mainly used for legume food crops and traditional livestock production. Livestock feed is rarely purchased. This section deals with the use of chemical fertilizer and improved seeds, which are important yield enhancing technologies.

5.5.2.1 Use of chemical fertilizer

Before the introduction of chemical fertilizer in the district around 1974/75, farmers had been using rotation of cereals with legumes, green manure and fallowing to maintain and improve soil fertility. As land becomes scarcer, these traditional methods of maintaining soil fertility are gradually diminishing.

The abolishment of government subsidies in 1989 has increased fertilizer prices. However, farmers did not stop using fertilizer since then, as farmers believe that it is impossible to achieve high yields without fertilizer and they know that the use of fertilizer is essential to realize the full genetic potential of high-yielding crop varieties. Thus, the majority of farmers wish to continue using chemical fertilizer even if prices continue to rise. Alternatives they have identified were: (1) using rotation of cereals with legumes if pest and disease problems with the legumes are solved; (2) considering other ways of obtaining cash through non and/or off-farm activities; (3) planting a small portion of their areas with traditional wheat and tef without or with small amounts of fertilizer; (4) designing better use of manure and compost to replace some of the chemical fertilizers; and (5) obtaining government subsidy on fertilizer.

Chemical fertilizer in the study area was mainly used in wheat and tef production for priority crops in the households. The surveyed farmers clearly perceived that crops respond differentially to fertilizer depending on the rate, type of fertilizer, soil type, and time of application. Nearly all farmers reported that they observed yield differences due to changes in the rate of fertilizer applied.

Most farmers in the study area have 13-15 years of experience of using fertilizer. During the survey period, the mean rates of fertilizer application for wheat were calculated to be 122 kg/ha DAP and 146 kg/ha urea for small farms and 140kg/ha DAP and 151 kg/ha urea for large farms. The mean rates for tef were 113 kg/ha DAP and 137 kg/ha urea for small farms and 150 kg/ha DAP and 160 kg/ha urea for large farms (Table 5.22). The rates applied by the farmers were above the blanket recommended fertilizer rate to the study area. Farmers were asked whether they were aware of the recommended fertilizer rate and the extent of its use. Almost 52% of the sample farmers reported being aware of recommended fertilizer rates for wheat and tef, but only 16% of the farmers who were aware of the recommended rates actually used those rates for wheat and tef production. Farmers not using the recommended rates gave several reasons. About 84% of the interviewed farmers cited that they considered their fields to be too low in fertility and they felt that the recommended rate could not give an acceptable yield to cover their loans by selling the additional yield obtained from the application of fertilizer.

Table 5.22 Use of chemical fertilizer in the Moretna - Jirru district, 2000/2001 cropping season

Indicators	Small farms (n=103)		Large farms (n=96)		t-value
	N	Mean	N	Mean	
Use of fertilizer, years	103	13.10	96	15.30	2.13
Fertilizer applied on wheat, kg/ha					
DAP	103	121.79	96	140.08	4.95*
Urea	103	146.16	96	151.01	1.37
Fertilizer applied on tef, kg/ha					
DAP	102	113.20	95	149.52	12.32*
Urea	102	137. 56	95	160.20	7.14*

Indicates statistically significant difference between groups at 1% test level

Source: Survey data, 2001

Many of the farmers in the area have used chemical fertilizer for the last 15 years and they recognize its potential for enhancing crop productivity. In this period, the use of fertilizer has been increasing at farm level. The most common reasons cited for the increasing trend were to increase or maintain yield per hectare (64.8%), decline in soil fertility (84.9%) and decrease in farm size (3%) (Table 5.23). Almost all farmers (97%) in the study area reported that they planned to continue using chemical fertilizer on wheat and tef in the future.

Table 5.23 Farmers' reasons for increasing fertilizer rate per hectare, Moretna-Jirru district, 2000/2001 cropping year

Description	Small (n =103)		Large (n =96)		Total (n =199)	
	N	%	N	%	N	%
Increase/maintain yield/ha	71	68.93	58	60.42	129	64.82
Decline in soil fertility	91	88.35	78	81.25	169	84.92
Decrease in farm size	-	-	3	3.13	3	1.51
Total	103	100	96	100	199	100

Total of percentages exceeds 100, indicating respondents gave multiple responses

Source: Survey data, 2001

There also seems to be a trend in the preference of package size of fertilizer. DAP and urea fertilizers are sold in 50 kg bags. Consequently, buyers must purchase 50 kg even if they require less.

Farmers were asked to state their preferences if provided with a choice between fertilizer sizes of 25 kg and 50 kg bags. Their preferences were different for DAP and urea. Close to 96% of the respondents preferred the 50 kg bag for DAP and only 4% opted for the 25 kg bag. Farmers preferred the 50 kg bag for DAP because the package size is sufficient for their plots or because it is a quantity of fertilizer they can afford. For urea 60% of the farmers preferred the 50 kg bag, while 40% preferred 25 kg of bag. Farmers who preferred the 50 kg bag indicated that the package size is needed for their farm size, whereas the latter said that the package size is sufficient for top dressing.

5.5.2.2 Improved varieties

One of the most significant changes in Ethiopian agriculture in recent years has been the widespread adoption of high-yielding crop varieties. This has been considered a major engine of growth in agricultural production and factor productivity. In 1989, the area under high-yielding varieties as a share of the total cropped area was still low in the study area. These shares have since grown significantly and currently farmers use a wide range of improved seed varieties developed by DZARC and IAR; both have been responsible for the introduction, development and release of improved varieties. The major actors in the dissemination of information on improved varieties were extension agents (96%) and friends, researchers and neighbours (4%). Over the past 12 years, a number of improved crop varieties have been released and disseminated in the study area. As a result, farmers grow an array of improved wheat, tef and other crops.

In particular, the adoption rate of improved wheat varieties has increased dramatically during the last six years. The reason cited by farmers for adopting these improved wheat varieties were many, but the most important reasons were that improved varieties yield better with fertilizer (78%) and assisted farmers to overcome their shortage of land by increasing unit productivity.

Due to short supply of improved seed, farmers are forced to recycle the same varieties for 3 to 4 subsequent years. The reasons given for recycling the same varieties were that insufficient quantities were supplied by the government or that the seeds were not available at local markets. As a result, wheat and tef seeds of the previous harvests were used for the following cropping seasons.

The main constraints on the use of improved seeds were: difficulty of obtaining the amount of seeds farmers required and the ever-increasing price. In spite of these limitations 32% of the small farms and 28% of the large farms still had access to improved seeds during the survey period (Table 5.24).

Table 5.24 Farmers who used improved seed varieties and their constraints to use, Moretna-Jirru district, 2000/20001 cropping year

Description	Small farms (n=103)		Large Farms (n=96)	
	Respondents	%	Respondents	%
Farmers' access to improved seeds				
Yes	33	32.04	27	28.13
No	70	67.96	69	71.88
Farmers who adopted improved varieties				
Wheat	98	95.15	94	97.92
Tef	31	30.39	37	38.95
Constraints to use improved seeds				
Shortage of supply	60	58.25	63	65.63
High price	49	47.57	43	44.79
Lack of awareness	4	3.88	3	3.13
Low quality	4	3.88	4	4.17

Source: Survey data, 2001

5.5.2.3 Herbicides

Among the sampled farmers, 2% of the tef growers reported adopting herbicides for weed control in the study area. The majority of farmers control weeds mostly by hand weeding so that they can retain the weeds for livestock feed. About 92% of the wheat growers hand-weeded their wheat fields at least once, while 12% weeded twice. Few farmers purchased pesticides to control aphids on lentil and grass pea.

5.5.2.4 Manure and crop residues

Manure use for crop production is considered as a supplement to chemical fertilizer. But owing to limited number of livestock, farmers do not have a sufficient quantity of manure to use for crop production. Farmers prepared dung-cake from cattle dung, which is the only source of fuel in the study area. However, extension agents advised farmers to use left-over manure from dung-cake preparation. Despite the advice only eight farmers out of 199 applied manure on their crop during the survey period. These farmers also reported application of left-over manure applied to horticultural crops (onion, garlic, etc) around the homestead.

In the study area there is very limited grazing land due to population increase. Thus farmers collect the whole straw biomass for animal feeds and animals also graze the left- over crop residues. In the absence of grazing land and alternative resources of fuel, the return of biomass to the soil is questioned. Out of 199 sampled farmers, 191 (95.98%) and 183 (91.96%) farmers did not use manure and crop residues to maintain soil fertility for the reasons mentioned in Table 5.25.

Table 5.25 Farmers' reasons for not using manure and crop residues to maintain soil fertility, Moretna-Jirru district, 2000/2001 cropping season

Descriptions	Reasons	Small farms (n=103)		Large farms (n =96)		Total (n =199)	
		N	%	N	%	N	%
Use of manure	Shortage of manure	87	87.0	80	87.9	167	87.4
	No tradition	30	30.0	20	22.0	50	26.2
	Transportation problem	7	7.0	5	5.5	12	6.3
	Weed infestation	1	1.0	5	5.5	6	3.1
Total		100	100	91	100	191	100
Use of crop residues	Shortage of feed	97	98.0	84	100	181	98.9
	Weed infestation	2	2.0	0	0	2	1.1
	No tradition	1	1.0	1	1.2	2	1.1
	Difficult for making BBF	1	1.0	1	1.2	2	1.1
Total		99	100	84	100	183	100

Note: BBF = Broadbed and furrow

Total of percentages exceeds 100, indicating respondents gave multiple responses

Source: Survey data, 2001

5.5.2.5 Fallowing and crop rotation

Population increases very rapidly in the study area (3.1% per annum). As population increases, the intensity of cropping also increases. Thus farmers reported that fallowing is not practiced in the study area due to shortage of land. It was still practiced 20 years ago when farmers had enough land area for cultivation.

However, farmers practice more crop rotation for maintaining soil fertility. Farmers cultivated a specific plot or field with pulses, usually after having planted the field with tef or wheat for at least two consecutive years. However, the proportion of pulses in the crop rotation system is minimal. For instance, only 35% of the large farms and 10% of the small farms planted wheat on fields that had been sown with pulses in rotation in 2000/2001. The cereal-dominated crop rotation system has an important implication for soil fertility management. Cereals are heavy users of soil nutrients, particular nitrogen, emphasizing the importance of applying optimal levels of mineral fertilizer to minimize soil fertility decline. Farmers plant some fields or portions of fields to pulses when they cannot afford to buy fertilizer.

Although farmers express awareness of the advantage of crop rotation, some technical and socio-economic considerations hinder their use of rotations. The widespread land shortages, along with the perceived low yields of pulse crops, force farmers to practice continuous production of higher yielding cereal crops. Moreover, pulses are relatively more susceptible to insects and disease than cereals. The main reasons cited for not applying crop rotation were land shortages, insects and diseases, and low yield of the alternative crops (Table 5.26).

Table 5.26 Farmers' reasons for not using crop rotation, Moretna-Jirru district, 2000/2001 cropping season

Reasons	Small farms (n=103)		Large farms (n = 96)		Total (n = 199)	
	N	%	N	%	N	%
Shortage of land	85	82.52	40	41.67	125	62.81
Susceptibility of pulses to insects	80	77.67	73	76.04	153	77.88
Low yield of alternate crops	35	33.98	28	29.17	63	31.66
Shortage of improved pulse seed	22	21.35	12	12.50	34	17.09

Total of percentages exceeds 100, indicating respondents gave multiple responses
Source: Survey data, 2001

Despite the constraints mentioned in Table 5.26, farmers often attach a high value to cropland that has been planted with leguminous crops. This is closely related to the perceived fertility of the soil. According to Table 5.27, 73.39% of the farmers reported that they used a lower rate of fertilizer on fields that had previously grown legumes. The most common reason given for using less fertilizer after leguminous break crops (leguminous rotation) was adequate soil fertility (92.85%). A non-significant yield response prompted some farmers (29.35%) to reduce the rate of fertilizer applied on wheat and tef following legumes (Table 5.27). Certain socio-economic factors were also reported: about 28% of the farmers applied less fertilizer because they could not afford the fertilizer, while 3% did so because fertilizer was not available.

Table 5.27 Farmers' experience and reasons for reducing fertilizer rates after legume break crops, Moretna-Jirru district, 2000/2001 cropping year

Description	Small farms (n=103)		Large farms (n = 96)		Total (n = 199)	
	N	%	N	%	N	%
Farmers' experience						
No reduction in rate	28	27.19	25	26.04	53	26.61
Reduction in rate	75	72.83	71	73.96	146	73.39
Reasons for reduction						
Adequate soil fertility	94	91.26	90	93.75	184	92.85
No significant yield difference	31	30.10	27	28.13	58	29.35
Cannot afford fertilizer	35	33.98	20	20.83	55	27.65
Fertilizer not available	5	4.85	1	1.04	5	2.97

Total of percentages exceeds 100, indicating respondents gave multiple responses

Source: Survey data, 2001

5.5.2 6 Waterlogging and crop production

Poor internal drainage is a major problem associated with vertisols (heavy black clay soils) in high rainfall areas of the Ethiopian highland. As a result of this, the yield of crops planted without manually constructed broadbed and furrow (BBF) give low yields due to the fact that the roots of the crops are poorly aerated and nutrient uptake for growth and development is impaired (Berhanu, 1985).

The highest percentage of farmers in the study area cultivates vertisols. All crops, except tef, are planted on local handmade broadbed and furrow. Since tef tolerates waterlogging, furrows only 2 to 3 meters apart are made across the field to drain off the excess surface water.

Farmers were asked for how long the local broadbed and furrow has been used in the study area. The respondents claimed that the method has been practiced for many generations. In addition, farmers indicated that manually constructed broadbed and furrow is also used on light soils, but it has double tasks: to drain off the excess water and to control cutworms or soil-born diseases. However, using BBF on light soils needs conventional wisdom, meaning that the nature of the soil and topography of the land must be considered. Despite the above facts, vertisols are of crucial importance for improving and sustaining food production in the study area.

5.5.2.7 Harvesting and threshing

Farmers in the study area use traditional methods of harvesting and threshing, which depend heavily on manual labour. All crops are harvested entirely by hand using sickles and are threshed using mostly pack animals. In the local grain-threshing system, the harvested crops are spread on a threshing floor and animals then tramp on it.

In the current survey, farmers reported that they would have rented harvesting machinery like combine harvesters for harvesting wheat if available, but since harvesting machinery has not been introduced to the study district, it was not possible.

5.6 Farm performance indicators

Growth in output per unit of area and per worker in agriculture are generally recognized as necessary conditions for economic development. The great differences in the productivity of farms are caused by the supply of land, labour and technical inputs (improved seeds and fertilizer). Small and large farms are characterized by the difference in relative endowments of land and labour. Substantial differences in land and labour productivity are closely associated with changes in land area and labour supply.

Performance indicators of farm resources in the surveyed farms vary according to the farm size and dominant farm activity. Highest labour and land productivity is found on the large farms. This can be partly explained by the fact that large farms can afford to purchase land augmentation inputs (improved seeds, fertilizer), which small farms cannot. Lower labour productivity is found on small farms because of low output per unit area.

The analysis confirmed that there are marked differences between small and large farms (Table 4.28). The results suggest that performance indictors increase as farm size increases except for tef return per unit of urea. There was a substantial relative difference in farm size between small and large farms. Wheat yield (kg/ha), tef return per unit of DAP and labour productivity for wheat were the most important performance indicators between small and large farms (Table 5.28).

Table 5.28 Mean differences in land use and performance indicators between small and large-scale farms, Morrtna-Jirru district, 2000/2001 cropping year

Land use	Small	Large	T-value
Farm size, hectare	1.50	2.81	16.38*
Area under wheat, hectare	0.61	1.22	11.75*
Area under wheat to farm size (%)	40.44	43.21	1.67
Area under tef, hectare	0.36	0.56	7.87*
Area under tef to farm size (%)	24.34	20.20	3.67*

Table 5.28 Continued

Performance indictors			
Wheat yield, kg/ha	2685.10	3160.34	10.57*
Tef yield, kg/ha	1403	1502	0.75
Wheat return per unit of DAP, kg	22.76	23.51	1.06
Wheat return per unit of Urea, kg	18.87	21.60	4.55*
Tef return per unit of DAP, kg	12.39	10.03	7.91*
Tef return per unit of urea, kg	10.20	9.38	4.56*
Labor productivity in wheat, kg/man-hour	5.44	6.27	5.11*
Labor productivity in tef, kg/man-hour	1.28	1.40	1.24
Wheat output, kg/oxen-hour	44.27	49.94	4.38*
Tef output, kg/oxen-hour	16.03	16.58	1.11
Total income per household, Birr	1283.19	2126.75	4.84*

* *Indicates statistical significant difference at 1% test level between groups*

Source: Survey data, 2001

5.7 Fertilizer price and distribution

A number of development initiatives aimed at attaining food self-sufficiency have promoted the consumption of fertilizer in the peasant-farming sector in Ethiopia. The policy measures have included price (i.e., price control and input subsidies) and non-price mechanisms (i.e., research, extension, and credit).

The price of fertilizer has varied markedly since the subsidy program was abolished in 1989. The price of DAP increased from Birr 1.78/kg in 1995 to Birr 2.89/kg in 2000; the price of urea rose from Birr 1.68/kg in 1995 to Birr 2.50/kg in 2000. In contrast, the wheat price received by farmers declined from Birr 1.80/kg in 1998 to Birr 0.90 in 2000 due to a surplus during the survey year. The price drop for produce together with a price increase for fertilizer in the study area, as in other regions of the country, has affected the purchasing power and the production capacity of all farms.

Price variations are attributed primarily to three factors: the devaluation of the local currency, market liberalization, and international fertilizer prices. Before 1997, the government subsidized fertilizer to facilitate consumption in the smallholder sector. The government budgeted Birr 50 million annually for fertilizer subsidies from 1994 to 1996 (Mulat, 1996). In 1996, there was a 22% subsidy on the price of DAP and a 23% subsidy on urea. The subsidy program was abolished in 1997, and the fertilizer market was liberalized to promote the participation of the private sector in fertilizer trading. As a result, a few private and semi-autonomous enterprises, such as Ethiopian Amalgamated Limited, Ambassel, Dinsho and Fertiline are currently engaged in the procurement and distribution of fertilizer. The networks of these enterprises undertake both wholesale and retail functions. In 1996, the private sector accounted for 35% of the total fertilizer imports (Mulat, 1996). At present, the Agricultural Input Supply Corporation (AISCO) and Ethiopian Amalgamated are the dominant agents in the fertilizer market.

Almost all farmers reported that they obtain fertilizer from Ambassel through the Ministry of Agriculture (MOA) offices in their areas. Ambassel is the sole distributor in the study area. Some farmers bought fertilizer from retailers in the local market, but solely on a cash basis.

The distribution and timing of fertilizer sales in Ethiopia are closely related to the cropping calendar. This is due mainly to the predominantly single cropping season and the subsistence nature of farming. Fertilizer purchases are thus not evenly spread over the year. Farmers in the Moretna-Jirru district purchase fertilizer primarily between May and July. Fertilizer distribution centres are often located near the development centres of the MOA and service co-operatives (where these are functional). The location of distribution centres has an impact on farm resources in terms of more time spent and more transport cost involved. Fortunately, in the Moretna-Jirru district, farms are relatively near the fertilizer distribution centres at 5 km on average.

5.8 Crop production, consumption and sales

Although farmers are often reluctant to disclose how they dispose of their harvested produce, an overview of their priorities for specific crops is presented in Table 5.29. Food crops are mainly produced to assure household consumption needs. Because the selected district is an area which produces more food than it can consume the surplus is sold on small rural markets. The main commercialized crops of the observed farms are lentil, fenugreek and tef. Typically, farms with a dominant off-farm activity do not sell food crops. They produce food only for household consumption. The small farms normally produce food only for household consumption and can generate little surplus for the market.

Food consumption varies among households because of differences in family size per household. The main common observation from the survey is that wheat and tef have high importance in the consumption patterns of the study area. Lentil, chickpea and grass pea are the main sources of protein. Unfortunately, this study does not provide data on different consumption patterns within farm groups, but only presents averages per household. However, consumption patterns can vary significantly between households.

Farmers reported that wheat is the most important crop for satisfying both the cash and food needs of the family. This fact is also apparent from the large proportion of the cropped land area allocated to wheat.

The surplus calculated from the sampled farmers for 2000/2001 revealed that large farms have more wheat surplus (2,420.35 kg/household) than small farms (604.90 kg/household). This indicated that small farmers are vulnerable to famine whenever there is shortage of rainfall or drought.

Table 5.29 Average crop production, consumption, sales and surplus by farm size, Moretna-Jirru, 2000/2001 cropping year (kg/household)

Crops	Small farm (n = 103)				Large farm (n = 96)			
	Prod.	Consum.	Sales	Surplus	Prod.	Consum.	Sales	Surplus
Wheat	1629.99	712.63	312.46	604.90	3769.62	820.83	528.44	2420.35
Tef	532.86	222.65	203.51	106.70	832.17	273.46	233.61	325.10
Chick pea	275.56	161.84	180.00	-66.28	300.63	192.93	88.33	20.11
Lentil	967.50	48.80	00	918.70	695.00	61.99	100.00	533.01
Faba bean	159.00	63.45	200.00	95.55	570.00	78.39	300.00	191.61
Field pea	00	35.06	00	-35.06	125.00	46.27	00	78.73
Grass pea	208.89	70.47	155.00	-17.00	286.25	68.58	00	217.67

Source: Survey data, 2001

The negative figures indicate that some quantities of the crops were purchased

5.9 Farm income, credits and savings

The surveyed farmers reported that finance for agricultural production comes from four different sources: farm savings, loans, off-farm income and gifts. Farmers mentioned that the main constraint on the development of the agricultural sector in the study area is the lack of external finance capacity. According to farmers, boosting agricultural production, especially food production, requires external resources, which implies an active role by the government.

It was found that almost all farmers derived their capital from money saved from selling their crops, livestock and off-farm activities. Most farmers save their money in informal saving groups, which are not very strong in the study area. Government loans are mostly used for buying fertilizer and improved seeds (95%) and for obtaining farm equipment (5%). Household needs such as school fees, farm operating costs, funeral and medical expenditures are covered by informal loans, farm gross sales and off-farm income. Moreover, the sharp decline of crop prices reduced the auto-financing capacities of the households and led to a reduction of expenditure especially on agricultural inputs.

The cash income from different sources is used mainly to pay school fees for the children, invest in house construction, purchase clothes, salts, fuel and oil. Due to the decline in crop prices and thus decline in the total cash income, farmers are no longer able to supply financial means to the household. Furthermore, earning an off-farm income is rare, except if it involves buying food crops from the producers and selling to consumers on local markets.

Since 1999, cash income from crop sales has declined for all farm categories. The crop price decline changed the income structure of farm households. The surveyed farmers were not diversifying their production activities due to the drop in output price, decline in farm size and pest infestation in pulses.

The structure of farm revenues, including the value of food and livestock production for household consumption, point to the importance of subsistence food production within farm households. The share of subsistence food production in the total gross farm revenue varies from 60 to 74%. Large farms generate more cash income and they also secure their household consumption better than small farms. The small farms' main responsibility is food production and not generating a cash income like the large farms. Some small farms produce only a portion of the food required to satisfy household needs.

The types of crops produced do not vary between farm groups. Crop production is the major cash income source for both small farms (90.3%) and large farms (92.7%). One can conclude that it is the essential activity for the overall functioning of the farming system (Table 5.30). About 30.1% of the small farmers and 43.8% of the large farmers were engaged in fattening livestock and earning higher income in comparison to other activities.

The total income per household varies between farm groups. Large farms generate higher food production and cash income from both crops and livestock than small farms. Total income per household was Birr 1,293.97 for small farms, whereas large farms earned Birr 2,126.75.

Table 5.30 Average income of the sample farms in the Moretna-Jirru district, 2000/2001 cropping season (Birr)

Source of income	Small farms (n =103)			Large farms (n =96)			t-value
	N	Mean	SD	N	Mean	SD	
Crop sales	93	569.03	313.41	89	864.14	522.69	4.59*
Livestock sales	52	531.93	531.59	60	397.74	431.18	1.45
Fattening livestock	31	1452.26	544.43	42	2245.12	1434.61	3.28*
Off-farm	2	1452.00	1035.20	6	1300.00	716.82	0.19
Other income	8	705.63	638.48	3	433.33	321.46	0.93
Total income/hh	103	1293.97	782.78	96	2126.75	1545.89	4.73*
Income/family mem.	103	266.02	203.22	96	348.84	275.81	2.40*

* *Indicates statistically significant difference between groups at 1% test level*

Source: Survey data, 2001

5.10 Farmers' choice of crops

Both small and large farms grew wheat and tef. Farmers reported that their choice of crops depends on their use as food and their profitability. Some farmers cited that lentil, chickpea and grass pea were grown for food and profitability and as a rotation crop for soil fertility restoration. This survey however made an attempt to determine farmers' choice of crops. According to Table 5.31 small farms gave highest priority to wheat because it produced higher yield per unit area to meet family food requirements whereas large farms ranked tef first for profitability and food.

Table 5.31 Farmers' choice of crops, Moretna-Jirru district, 2000/2001 cropping year

Crops	Small farms (n=103)		Large farms (n=96)		Total (n=199)	
	N	%	N	%	N	%
Wheat	102	99.0	92	95.8	194	97.5
Tef	90	87.4	95	99.0	185	93.0
Lentil	71	68.9	86	73.0	157	78.9
Chickpea	62	60.2	55	57.3	117	58.8
Grass pea	33	32.0	47	49.0	80	40.2
Faba bean	3	2.9	2	2.1	5	2.5
Total	103	100.0	96	100.0	199	100.0

Total of percentages exceeds 100, indicating respondents gave multiple response
Source: Survey data, 2001

5.11 Farm problems in the surveyed area

Farmers were asked to rank the major production constraints in the study area. Almost 94% of the sampled farmers reported that the rising price of fertilizer was the most important production constraint during the 2000/2001 cropping year (Table 5.32). Both the devaluation of the local currency and the abolition of fertilizer subsidies have caused the fertilizer price to increase. Almost 90% of the farmers indicated that disease and insect problems for legume crops were the second most important constraint to crop rotation for renewing the soil and thus replacing the use of fertilizer. Crop production in the study area was heavily affected by producer prices. A price cut in 1999 led to a drop in production. As a result, the use of fertilizer, improved seeds, pesticides and hired labour were reduced and probably farmers cannot afford to pay. The survey confirmed that 64% of farmers felt badly affected by lower producer prices relative to the input prices.

Shortage of land was the third constraint. In particular, the availability of land and its quality has become a problem for all farmers due to population expansion. Shortage of improved seed was a limiting factor for only 16.7% of interviewed farmers. To a very limited extent crop production in the study area was handicapped by yield decline.

Table 5.32 Types of farm problems as listed by farmers in the study area, 2000/2001 cropping season

Types of problems	Small farms (n=103)		Large farms (n=96)		Total (n=199)	
	N	%	N	%	N	%
High price of fertilizer & seed	88	94.6	81	93.1	169	93.9
Low price for output	57	63.1	58	66.7	115	63.9
Shortage of land	37	39.8	38	43.7	75	41.7
Disease/insect problems	81	87.1	81	93.1	162	90.0
Lack of improved seed	20	21.5	10	11.5	30	16.7
Yield decline	11	11.8	7	8.0	18	10.0
Frost occurrence	9	9.7	11	12.6	20	11.1
Labour shortage	4	4.3	2	2.3	6	3.3
Lack of money	4	4.3	6	6.9	10	5.6
Feed shortage	2	2.2	5	5.7	7	3.9
Waterlogging	1	1.1	1	1.1	2	1.1
Total	93	100	87	100	180	100

Total of percentages exceeds 100, indicating respondents gave multiple responses

Source: Survey data, 2001

5.12 Summary and conclusions

Analysis of the data revealed that nearly all surveyed farmers are producing wheat and tef in consecutive cropping seasons. This shows that the two crops are important to the farm households as food and cash crops.

Farmers in the study area have benefited substantially from the use of fertilizer and improved seeds, but they still complain that the improved varieties released to date are in short supply. Therefore, the seed production system must be further strengthened to supply sufficient quantity of improved seeds to farmers at reasonable prices.

The surveyed farmers clearly perceived that crops respond differentially to chemical fertilizer depending on the rate of application, type of fertilizer and timing of application. Nearly all farmers reported that there is a considerable yield increment of wheat and tef after fertilizer application and changes in the rate of application.

The study found that all farmers in the study area used fertilizer and improved seeds to replace or compensate for the diminishing farm size. The adoption rate has increased markedly over the last six years due to a decreasing land-man ratio in the study area. However, the surveyed farmers reported various natural factors (e.g. insect pest, disease) and socio-economic factors (e.g. high input prices, low produce prices, land scarcity) that limit the yield of their crops. Most farmers (93.9%) reported that the rising price of fertilizer is the most important factor limiting yields in the study area. About 90% of farmers identified disease and pest problems as contributing factors for yield reduction (Table 5.32).

The survey confirmed that marked variations were observed in the rates of input use and productivity (performance) between small and large farms within the study area, and that the fertilizer rates adopted by both small and large farms do not reflect the research recommendations.

The most important credit problems cited in the study area were the unavailability of loans from formal and informal sources, high interest rates, and unfavourable loan repayment terms. This is also a clear indication of the shortage of support services in the area. It has been noted that due to rising input prices, improved access to credit for peasant farmers has become indispensable or vital. The formal credit system needs to address the credit constraints faced by all farmers and increase awareness about the types of credit available for agricultural production. In addition, the government should encourage farmers to form service co-operatives or farmers' groups to reduce transaction costs and improve loan recovery rates.

Chapter 6

EFFICIENCY ANALYSIS OF WHEAT AND TEF PRODUCTION

6.1 Introduction

In this chapter, the stochastic frontier production function model is first specified. The model is then applied, focusing on wheat and tef, which are the two main crops grown by both small and large farms. Wheat is the main cash crop and tef the main staple food and cash crop for small-scale farmers in Ethiopia. Besides a comparative technical efficiency analysis between wheat and tef production, the emphasis is on drawing a policy recommendation regarding small and large-scale farmers.

6.2 The stochastic frontier model

The main purpose of this section is to specify the stochastic frontier model for selected variables and to investigate their effect on productivity and efficiency.

The stochastic frontier model for farmers who produce wheat and tef is defined by:

$$\ln(Y_i) = \beta_0 + \beta_1 \ln(Area_i) + \beta_2 \ln(Seed_i) + \beta_3 \ln(DAP_i) + \beta_4 \ln(Urea_i) + \beta_5 \ln(Labour_i) + \beta_6 \ln(Traction_i) + V_i - U_i \quad (1)$$

Where the subscript i indicates the i-th farmer in the sample (i =1, 2,......, N);

ln represents the natural logarithm;

Y_i is the yield of wheat or tef (kg/ha);

Wheat or tef area, seed, diammonium phosphate (DAP), urea, labor and traction are as defined in Table 6.1.

The βs are unknown parameters to be estimated;

The V_is are assumed to be independent and identically distributed random errors having a normal (0, σ_v^2) distribution; and

The U_is are non-negative random variables, called technical inefficiency effects, which are assumed to be independently distributed such that U_i is defined as α by the truncation (at zero) of the normal distribution with mean, μ_i, and variance, σ^2, where μ_i is defined by (Ali and Chaudhry, 1990)

$$\mu_i = \alpha_0 + \alpha_1(Age_i) + \alpha_2(Experience_i) + \alpha_3(Education_i) + \alpha_4(Parcel_i) + \alpha_5(Distance_i) + \alpha_6(Oxen_i) + \alpha_7(Family\ size_i) + \alpha_8(Income_i) \quad (2)$$

Where α-coefficients are unknown parameters to be estimated, together with the variance parameters, which are expressed in terms of age, experience, education, parcels, distance, oxen, family size and income as defined in Table 6.1.

Table 6.1 Variable definitions for stochastic frontier and inefficiency effects for wheat and tef production in the Moretna - Jirru district, 2000/2001 cropping season

Variables	Descriptions
Yield	Yield of wheat/tef, kg/ha
Input categories	
Area	The size of wheat/tef area, ha
Seed	Wheat/tef seed rate, kg/ha
DAP	The amount of DAP applied to wheat/tef, kg/ha
Urea	The amount of urea applied to wheat/tef, kg/ha
Labour	Labour input used in wheat/tef production, man-hours/ha
Traction	Oxen input used in wheat/tef production, oxen-hours/ha
Inefficiency effects	
Age	Age of the household head, years
Experience	Farming experience of the household head, years
Education	Dummy variable[+] (1= if educated and 0= otherwise)
Parcel	No. of parcels or plots of land the household possesses
Distance	Average walking distance between parcels, in minutes
Oxen	No. of oxen owned by household
Family size	Family size of a household
Income	Income of the household, Birr

[+] *For definition, refer to Table 5.15 on page 125.*

The stochastic frontier model for merged farms (small and large) of wheat producers is defined by equations (1) and (2). The production function, defined by equation (1), specifies that the two groups may have different mean levels of wheat output.

The model for the technical effects, defined by equation (2), specifies that the technical inefficiency effects in the stochastic frontier (1) are a function of age, farming experience, education, parcels of land, distance between parcels, number of oxen owned by household, family size and total income per household. More years of formal education and farming experience with larger family size, higher income per household, and more oxen are expected to result in smaller values of the technical inefficiency effects, whereas the older farmers, more parcels of land and larger distance between land parcels are expected to have greater inefficiencies.

The maximum- likelihood estimates for the parameters of the stochastic frontier were obtained by using the program FRONTIER Version 4.1 (Coelli, 1996). Estimates of the variance parameters are as follows:

$$\sigma_s^2 = \sigma_v^2 + \sigma^2 \qquad (3)$$

$$\gamma = \sigma^2 / \sigma_s^2$$

The γ-parameters indicated above have a value between zero and one. The discrepancy parameter, γ, is an indicator of the relative variability of the two error components. If γ approaches zero, this implies that the random effect dominates the variation between the frontier output level and the actually obtained output level. Conversely, as γ approaches one, it can be assumed that the variations in output are determined by technical inefficiency. The technical efficiency of a farmer is defined as the ratio of the observed output to the frontier output that could be obtained by a farm operating at 100% efficiency.

The technical efficiency of production of the i-th farmer (TE_i) in the appropriate data set, given the level of inputs, is defined by:

$$TE_i = \frac{Y_i}{F(X_i;\beta)\exp(V_i)} = \exp(-U_i) \qquad (4)$$

Where Y_i is the estimated value of the frontier output;

X_i is input quantity used by the i-th farm;

Other variables as defined on page 155

The technical efficiency of the farmer is between zero and one and is inversely related to the level of the technical inefficiency effect. The technical efficiencies can also be predicted using the Frontier Program, which calculates the maximum likelihood estimator of the predictor for equation (4) that is based on its conditional expectation (Battese and Coelli, 1995).

The stochastic frontier outputs, which include the effects of the random errors in the production but not the technical inefficiencies of production, are important for comparing the productivity of small and large farms. Given the specifications of the stochastic frontier models (1) and (2), the stochastic frontier output for the i-th farmer, $Y_{i,}*$, is the observed output divided by the technical efficiency (TE_i).

$$Y_i = Y_i / TE_i \qquad (5)$$

The mean frontier outputs are estimated for the average input values for small and large farms in order to compare the overall technical efficiency of the two groups of farmers.

6.3 Empirical results and discussion

6.3.1 Technical efficiency of wheat production

A summary of the values of the variables for the wheat frontier analysis is presented in Table 6.2. It is observed from the summary that, on average, large farm households tend to perform better than small farm households in terms of output produced, cultivated land operated, total fertilizer applied (DAP and urea) and labour and traction inputs. The average wheat yields on large and small farms were 3,186.34 kg/ha and 2,685.10 kg/ha, respectively. The overall t-value indicated that there is a statistically significant difference in yield at the 1%test level between the groups.

Table 6.2 Summary statistics of variables for small and large farm size households in wheat production in the Moretna-Jirru district, 2000/2001 cropping season

	Small farm (n =103)				Large farm (n =95)			
Variables	Mean	Std Dev	Min value	Max value	Mean	Std Dev	Min value	Max value
Yield	2685.10	341.33	2000.00	3000.00	3186.34	286.54	2050.00	3640.00
Area	0.61	0.24	0.25	1.13	1.22	0.45	0.38	2.50
Seed	139.26	23.39	76.69	180.00	127.39	27.94	80.00	220.00
DAP	121.07	25.42	95.32	150.00	140.08	26.64	100.00	165.00
Urea	146.17	25.13	98.00	197.04	151.02	24.48	100.00	175.00
Labour	502.97	69.63	352.00	668.00	519.54	86.55	368.00	744.00
Traction	62.41	12.49	44.00	88.00	65.35	13.76	48.00	128.00
Age	38.10	10.69	23.00	65.00	41.41	10.71	25.00	80.00
Experience	13.76	7.83	3.00	35.00	18.54	10.51	3.00	44.00
Education	0.65	0.48	0.00	1.00	0.76	0.43	0.00	1.00
Parcel	3.99	1.16	2.00	7.00	6.06	1.93	3.00	10.00
Distance	18.88	7.25	5.00	35.00	22.38	9.67	5.00	60.00
Oxen	0.99	0.47	.00	2.00	1.55	0.52	.00	2.00
Family size	5.36	1.83	2.00	9.00	6.75	2.00	2.00	11.00
Income	1281.21	762.61	120.00	3269.00	2126.75	1545.89	192.50	5980.20

Note: n = number of wheat growers selected for frontier function

Source: Survey data, 2001

6.3.2 Maximum likelihood estimation

One can use either a farm group or a merged analysis to determine the maximum likelihood estimation. The question is which approach will be best to estimate the parameters. The merged farm analysis approach is more appropriate when the farms considered are located in the same region, have the same production sets and share the same support structures. When farms do not have the same production function, the analysis for the two groups should be done separately (Assefa and Heidhues, 1996).

Moreover, the efficiency scores in the stochastic frontier model are determined relative to the best farms in the sample (Coelli et al., 1998). Accordingly, the mean efficiency scores from one sample group only reflect the dispersion of efficiencies within that group, but indicate nothing about the efficiency of that sample relative to the other group. Since it was necessary for this study to determine the efficiency of the small farms group relative to that of the large farm group, it can be concluded that the merged farm analysis would provide a better result.

The maximum likelihood (ML) results of the estimation of the parameters of the stochastic frontier production function are presented in Table 6.3. The values of the likelihood ratio (LR) sigma-square (σ^2) and gamma (γ) are statistically significant. This indicates that the frontier model is an adequate representation for the farms considered in the study.

The estimated coefficients of all the input variables in the production function have positive signs, as expected, except for the labour input. An increase in wheat area by 10%, *ceteris paribus,* will increase wheat output by about 2.33%. A similar increase in seed is expected to result in an increase in wheat output by 2.53%. Application of DAP and urea also led to significant increases in wheat yield. The results indicate that area and seed contributed the most to growth in wheat output. Labour and traction were not significant because sample farmers used too much of these inputs.

Causes of inefficiency on farms were determined with the stochastic frontier model in single-stage maximum likelihood estimation. From the estimated coefficients of the inefficiency variables, land parcels, distance between parcels, number of oxen, family size and family income were significantly different from zero.

Owning more oxen, increased family size and higher income per household reduce technical inefficiency as farming activities can be done timely, whereas increase in land parcels and distance between parcels reduce the technical efficiency of farmers because farmers have to spend more time moving from place to place. The coefficients of age, experience and education are positive but they were found to have no statistically significant influence on the technical efficiency of farmers. A possible reason is that, given the static conditions of traditional agriculture, farming experience and education will do little to improve productivity, since peasant producers are already relatively efficient in production. Farming experience and education may be advantageous to help farmers learn to adjust resource use to changing conditions so as to maintain high levels of efficiency (Norton and Alwang, 1993). This result is consistent with the finding of Chilot *et al.* (1996), that level of education of farmers has no impact on the adoption decision of modern wheat varieties in the Addis Alem district of Ethiopia.

The sum of the output elasticities is calculated to be less than one (0.73), which indicates that farms are operating in the rational zone of production (decreasing returns to scale). This result is confirmed by applying the data envelopment analysis program Version 2.1 which specifically indicates the increasing or decreasing returns to scale for individual farms. By conducting both a constant return to scale (CRS) and a variable return scale (VRS) in DEA, one may obtain a return to scale measure for each farm. Stated otherwise, DEA helps to identify farms operating or not operating at optimal scale.

Table 6.3 Maximum-likelihood estimates for parameters of the stochastic frontier wheat production and inefficiency models for merged households in the Moretna-Jirru district, 2000/2001 cropping season

Variable	Merged sample (n = 198)		
	Parameter	Coefficients	Standard error
Stochastic Frontier			
Constant	β_0	5.5552***	0.3898
ℓn (Area)	β_1	0.2325***	0.0225
ℓn (Seed)	β_2	0.2530***	0.0467
ℓn (DAP)	β_3	0.0716**	0.0383
ℓn (Urea)	β_4	0.1251***	0.0449
ℓn (Labour)	β_5	- 0.0019	0.0443
ℓn (Traction)	β_6	0.0507	0.0397
Returns to scale		0.7310[1]	
Inefficiency Model			
Constant	α_0	0.3211***	0.0434
Age	α_1	0.0001	0.0011
Experience	α_2	0.0005	0.0013
Education	α_3	0.0069	0.0146
Parcel	α_4	0.0124***	0.0037
Distance	α_5	0.0019***	0.0008
Oxen	α_6	- 0.0423***	0.0159
Family Size	α_7	- 0.0104***	0.0041
Income	α_8	- 0.0002**	0.0001
Variance parameters	σ^2	0.0225***	0.0148
	γ	0.9697***	0.0251
Log-Likelihood Function		88.55	
Average Technical Efficiency		0.8085	

****, ** and * indicate statistically significant differences from zero at 1%, 5% and 10% test level*

[1] *The result is confirmed by DEA*

6.3.3 Frequency distribution of technical efficiency

The frequency distribution of the predicted technical efficiency and the summary statistics for small and large farmers are presented in Table 6.4. The predicted technical efficiencies for the large farms vary between 0.68 and 0.98, with the mean calculated to be 0.83. Small farms, on the other hand, are operating at mean technical efficiency of 0.79, which ranges between 0.65 to 0.97 (see Appendix D).

Comparatively speaking, about 46.6% of the small farms are clustered between 0.70 to 0.80 whereas 47.4% of the large farms are clustered between 0.75 to 0.85. Thirteen farms from the small size group and nine farms from large farm size group operated between the 0.65 and 0.70 efficiency level. Stated otherwise, eight farms operated at frontier level (0.95-1.00), with six farms (6.3%) from the large size group and two (1.9%) from the small size group. The overall t-value indicated that there is a statistically significant difference in the efficiency index at 1% test level between the groups.

Table 6.4 Frequency distribution of technical efficiency in the stochastic wheat production frontiers for small and large farm size households in the Moretna–Jirru district, 2000/2001

Efficiency intervals	Small farm size		Large farms		Total sample	
	N	%	N	%	N	%
0.650 - 0.700	13	12.6	9	9.5	22	11.1
0.701 - 0.750	24	23.3	9	9.5	33	16.7
0.751 - 0.800	24	23.3	23	24.2	47	23.7
0.801 - 0.850	16	15.5	22	23.2	38	19.2
0.851 - 0.900	16	15.5	12	12.6	28	14.1
0.901 - 0.950	8	7.8	14	14.7	22	11.1
0.951 - 1.000	2	1.9	6	6.3	8	4.0

Table 6.4 Continued

Number of observations	103	95	198
Mean	0.791	0.833	0.809
Minimum	0.652	0.675	0.652
Maximum	0.972	0.984	0.984
Std.Dev	0.075	0.080	0.079
CV (%)	9.48	9.60	9.79
T-value	2.905***		

*** *indicates significant difference of efficiency index at 1% test level between groups*

6.3.4 Technical efficiency of tef production

A summary of the values of the variables, which were used in the tef frontier analysis, is presented in Table 6.5. It is observed from the summary that there is no major yield difference between the two farm groups. Large farms allocated on average more land to tef, used more oxen and labour and applied more fertilizer (DAP and urea) per hectare than small farms. The average age of farmers, farming experience and education level were 41.46, 18.69 and 0.76 years for large farms and 40.17, 16.40 and 0.65 years for small farms, respectively. The average number of land parcels on large and small farms was 6.06 and 4.04, respectively. The average time required to walk between parcels on large farms was 22.38 minutes, whereas on small farms it was 18.88 minutes. Large farms have bigger family sizes and higher household incomes (2,077.44 Birr) than small farms (1,288.71 Birr).

Table 6.5 Summary statistics of variables for small and large farm size households in tef production in the Moretna-Jirru district, 2000/2001 cropping season

Variables	Small farm (n =102)				Large farm (n =95)			
	Mean	Std Dev	Min value	Max value	Mean	Std Dev	Min value	Max value
Yield	1403.27	368.92	800.00	2160.00	1501.81	352.69	800.00	2240.00
Area	0.36	0.13	0.13	0.75	0.56	0.21	0.25	1.50
Seed	34.80	5.04	24.00	44.00	34.44	5.78	20.00	60.00
DAP	113.20	20.27	95.32	150.00	149.53	21.07	100.00	165.00
Urea	137.56	22.32	98.00	197.04	160.22	22.20	100.00	175.00
Labour	1094.63	164.34	768.00	1416.00	1073.44	44.40	152.00	374.00
Traction	83.88	13.86	56.00	136.00	90.57	15.35	64.00	128.00
Age	40.17	13.69	23.00	79.00	41.46	10.76	25.00	80.00
Experience	16.40	12.02	3.00	50.00	18.69	10.46	3.00	44.00
Education	0.65	0.48	0.00	1.00	0.76	0.43	0.00	1.00
Parcel	4.04	1.22	2.00	8.00	6.07	1.94	3.00	13.00
Distance	19.74	8.50	5.00	45.00	22.40	9.71	5.00	60.00
Oxen	1.02	0.51	0.00	3.00	1.56	0.52	0.00	2.00
Family size	5.31	1.81	2.00	9.00	6.79	1.97	2.00	11.00
Income	1288.71	761.94	120.00	3269.00	2077.44	1360.20	192.50	5910.00

n = Number of tef growers selected for frontier function

Source: Survey data, 2001

6.3.5 Maximum likelihood and inefficiency estimation

The estimated statistics and parameters of the model are shown in Table 6.6. The values of the likelihood ratio (LR) sigma-square (σ^2) and gamma (γ) indicate that the model has a good fit and that inefficiency effects of a stochastic nature exist.

Table 6.6 Maximum-likelihood estimates for parameters of the stochastic frontier of tef for combined households, the Moretna-Jirru district, 2000/2001 cropping year

Variable	Merged farm (n = 197)		
	Parameter	Coefficients	Standard error
Stochastic Frontier			
Constant	β_0	3.3389***	0.9423
ℓn (Area)	β_1	0.2873***	0.1002
ℓn (Seed)	β_2	0.0869*	0.0861
ℓn (DAP)	β_3	0.1654**	0.1308
ℓn (Urea)	β_4	0.4638***	0.1148
ℓn (Labour)	β_5	0.1611**	0.0427
ℓn (Traction)	β_6	0.0668	0.0736
Returns to scale		1.231	
Inefficiency Model			
Constant	α_0	0.7771***	0.1834
Age	α_1	0.0089	0.0044
Experience	α_2	- 0.0051*	0.0049
Education	α_3	0.0233	0.0455
Parcel	α_4	0.0004*	0.0161
Distance	α_5	0.0058**	0.0027
Oxen	α_6	-0.0433**	0.0546
Family Size	α_7	-0.0089*	0.0113
Income	α_8	-0.0003***	0.0001
Variance parameters	σ^2	0.0535***	0.0088
	γ	0.9762***	0.2766
Log-Likelihood Function		49.15	
Average Technical Efficiency		0.7072	

****, ** and * indicate statistically significant differences from zero at 1%, 5% and 10% test level*

The estimated coefficients of all the input variables in the production function have positive signs as expected (Table 6.6). Increasing the tef area by 10% will increase tef yield by about 2.87%. Similar increases in DAP and urea application could increase tef output by 1.65 and 4.64%, respectively. From the estimated coefficients it is evident that land, urea and DAP are by far the most important variables explaining differentiation in output. Access to land and application of urea fertilizer led to statistically significant increases in tef yield. An increase in the application of DAP also led to a significant increase in tef yield for the sampled farms.

Causes of inefficiency in tef production on farms were also determined with the Stochastic Frontier in a single-stage maximum likelihood estimate. From the estimated coefficients of the inefficiency variables, income, oxen, distance between parcels, family size and land parcels were statistically different from zero.

Higher family income and owning more oxen and increased family size per household reduce inefficiency as farming activities can be done timely, whereas increase in land parcels and distance between parcels in the inefficiency model reduce the technical efficiency of farmers because farmers have to spend more time moving from place to place. The estimated coefficient for farming experience in the inefficiency models is negative. This indicates that as farming experience increases, inefficiency drops, the coefficient is statistically significant at 10% test level. Similarly, the coefficients of age and education are positive but the values are statistically insignificant.

The sum of tef output elasticities is more than one (1.231), which indicates that farms are operating at increasing returns to scale. Although this implies that it will be efficient to use more resources/inputs for tef production, this must be evaluated in context because wheat for food and tef for cash income compete for the same resources.

When comparing the rates of return of wheat and tef, one is tempted to conclude that the production technology applied in the case of wheat is more optimal than in the case of tef. The reason for this conclusion is that farmers in the study area gave more emphasis to the production of wheat than tef because of food security and suitability of land. This is inter alia reflected by farmers using more improved seed varieties for wheat (recycling them for a number of years) than for tef.

Analysis of the regression coefficients of specific inputs for wheat and tef, however, shows certain inconsistencies, indicating that inefficiencies still exist in the production technology of wheat. For instance, with regard to seed, the regression coefficient, which also reflects the impact of improved varieties, is much higher for wheat than for tef, showing that more attention is given to developing improved wheat varieties (than tef). Over time, the potential for productivity gains is still higher for wheat than for tef.

In the case of fertilizer (DAP and urea) the regression coefficients are considerably higher for tef than for wheat. Despite this, the conclusion should not be that there is less scope for productivity improvement for wheat than for tef.

The rate at which farmers use fertilizer is a blanket recommendation. Presumably the amount added annually in the form of DAP is not enough to increase wheat yield and to have any cumulative effect because wheat is more responsive to phosphorous than tef. Thus, change in fertilizer application rate over time is important in order to enhance wheat yield and accumulate soil phosphorous capital (Setotaw *et al.*, 2000). Fertilizer recommendations must be dynamic, reflecting changing economic scenarios. There is an urgent need to study and refine location, crop and soil-specific fertilizer recommendations for the study area.

6.3.6 Frequency distribution of technical efficiency

The frequency distribution of the predicted technical efficiency and the summary statistics for both groups of farmers are presented in Table 6.7. The distribution of the predicted technical efficiency for large farms ranges between 0.45 to 1.0, whereas the distribution of technical efficiency for small farms has a much wider spread of values, ranging from 0.35 to 1.00. By the same token, about 55% of large farms and only 41% of small farms are clustered in the interval of 0.60 to 0.75 ((see Appendix D). This implies that the majority of large farms achieved higher technical efficiencies than small farms. One farm from the large farm group and 17 farms from the small farm group were found to be poorly performing farms (less than 50% efficiency). Similarly, six top performing farms were in the large size group, whereas four farms from the small size group were top performing farms (more than 95% efficiency).

Considering the standard deviation and coefficient of variation of the data distribution, it can be concluded that the technical efficiency of large farms is more stable than that of small farms. The large farms exhibit a variability of 15.95% compared to 25.00% for small farms. There is an overall significant difference in the efficiency index (P=.001) test level between the groups.

Table 6.7 Frequency distribution predicted technical efficiency in the stochastic tef production frontiers and summary statistics for different size households in the Moretna-Jirru district, 2000/2001 cropping season

Efficiency intervals	Large farms		Small farms		Total	
	N	%	N	%	N	%
0.351 – 0.400	0	0	4	3.9	4	2.0
0.401 – 0.450	0	0	3	2.9	3	1.5
0.451 - 0.500	1	1.1	10	9.8	11	5.6
0.501 - 0.550	0	0	6	5.9	6	3.0
0.551 - 0.600	7	7.4	12	11.8	19	9.6
0.601 - 0.650	24	25.3	10	9.8	34	17.3
0.651 - 0.700	18	18.9	10	9.8	28	14.2
0.701 - 0.750	10	10.5	9	8.8	19	9.6
0.751 - 0.800	6	6.3	8	7.8	14	7.1
0.801 - 0.850	11	11.6	7	6.9	18	9.1
0.851 - 0.900	6	6.3	7	6.9	13	6.6

Table 6.7 Continued

0.901 - 0.950	6	6.3	12	11.8	18	9.1
0.951 - 1.000	6	6.3	4	3.9	10	5.1
Number of observations	95		102		197	
Mean	0.741		0.683		0.707	
Minimum	0.44		0.35		0.35	
Maximum	0.98		0.97		0.98	
Std Dev	0.118		0.170		0.148	
C.V. (%)	15.95		25.00		20.85	
t-value	2.95***					

*** *indicates significant difference of efficiency index at 1% between both groups*

6.4 Summary and conclusions

This study uses a stochastic frontier model to obtain technical efficiency measures for a sample of peasant farmers located in the central highlands of Ethiopia. The analysis is performed separately for two crops, namely wheat and tef.

Wheat: The results revealed that large farmers are on average technically more efficient than the small farmers. The technical efficiencies of large farms range from 0.67 to 0.98, with the mean technical efficiency estimated to be 0.83. For small farms, the technical efficiencies range from 0.65 to 0.97, with the mean technical efficiency calculated to be 0.79. It is important to note that on average, the potential exists for large and small farms to reduce the use of all inputs by 17.0% and 21.0% respectively without reducing output.

Tef: The mean technical efficiency of tef is calculated to be 0.74 for large farms and 0.68 for small farms. This means that average efficiency levels of large and small farms were below the frontier by 25.9% and 31.7%, respectively. Stated otherwise, the total output can be increased by up to 25.9% for large farms and 31.7% for small farms above the actual output levels attained in the study area during the cropping year.

Gains in output resulting from improvements in productivity and efficiency are important to Ethiopian agriculture considering that the opportunities for increasing farm production by bringing additional virgin lands into cultivation have significantly diminished in recent years while, at the same time, population pressure has been on the rise. In the analysis, land size remains a key variable explaining differentiation in output, especially in keeping farmers near to or on the production frontier. Reduction in farm size and land fragmentation have contributed to technical inefficiencies. Therefore, a number of policy interventions need to be made by government if small-scale farmers are to improve technical efficiency. These include increasing minimum land size for these farmers so that they operate viably, and avoiding frequent redistribution of land.

Based on the results of the stochastic frontier production function estimated in this study, significant technical inefficiencies of production exist between small and large farm groups. This suggests that there is at least some room or scope for raising agricultural output through improvements in technical efficiency, without resorting to new improved technologies. The results found that the mean technical efficiency of the large farm group differs from that of the small farm group on a statistically significant level. The main reasons for differences in technical efficiency was that large farms allocated more area to newly released wheat varieties, and that the amount of fertilizer and traction used per hectare were higher than that of small farms.

Chapter 7

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter presents a statement of the problem, a summary of the methodology, results and conclusions consistent with the objectives of the study.

7.2 Statement of the problem

Population pressure causes land fragmentation and this leads to ever-decreasing size of landholdings and intensification, e.g. monocropping or monoculture, more frequent annual cropping and shorter total absence of fallow periods.

In Ethiopia, policy reforms have strengthened the position of individual farms by allocating land to millions of farm households, but for all practical purposes this has created a "small farm" agriculture. These small units are often too small to support and feed farm households, consequently inhibiting use of highly productive technology.

Although smallholders of the area are known to contribute to the greater food supply, they have very limited cultivated land area to further increase production. Thus, to improve the life of farmers in the study area, there is a need to study the effect of landholding on productivity and adoption of technologies. It is with this intention that this study investigated the differences in farm performance and efficiency between farm groups (small and large).

7.3 Objectives of the study

The main objective of the study is to analyze the effect of farm size on farm efficiency at household level in cereal-based farming systems and to suggest policy recommendations. The specific objectives of the study are:

1. To determine the effect of farm size on technical efficiencies of small-scale householders in the selected district;
2. To investigate whether the mean technical efficiency differs between small and large farm sizes;
3. To suggest policy recommendations on resource use options to raise farm efficiency of the least efficient farms.

7.4 Study area

The survey was conducted in the Moretna-Jirru district of Ethiopia during the 2000/2001 cropping season. The district was selected for this study on the basis of the relatively longer experience of farmers in the use of new technology, the number of crop growers and the high potential for crop production. The area is well-endowed with better soils, longer growing seasons and higher rainfall than other districts in the Semien Shewa Zone. Moreover, according to the last census in 1994, Moretna-Jirru is the second most populous district in the Semien Shewa Zone.

7.5 Methodology applied

7.5.1 Organization of the research

The research was carried out in a sandwich form; partly in Ethiopia and partly in South Africa. The study was planned/scheduled in three phases. During the first phase, course work was undertaken in the Department of Agricultural Economics at the University of the Free State. At the same time, the research proposal and questionnaire were developed. An intensive literature study was also executed during this phase to identify analytical models and relevant factors to be included in the models.

In the second phase, the fieldwork was conducted in Ethiopia. The main activities during this phase were conducting the survey, and coding, cleaning and entry of data into the computer and preliminary analysis of data. Both the promoter and co-promoter of the researcher/student visited the study area with the student and held group discussions with farmers.

The third phase comprised data analysis by applying different models. The write-up of the thesis was undertaken at the University of the Free State in South Africa. These activities started during May 2002 and were concluded in June 2003.

7.5.2 Questionnaire development

A questionnaire was developed to collect primary farm-level data during August to November 2000. The questionnaire was supported by a literature review. Finally, to facilitate the communication between farmers and enumerators, the structured questionnaire was developed in two versions: English and Amharic (local language).

7.5.3 Survey design and sampling

The study is based on farm-level data of 199 sampled farm households in the Moretna-Jirru district, which is one of the major wheat and tef producing districts in the central highlands of Ethiopia. The survey was conducted between January and September 2001. The sample farmers were selected randomly from the smallholder farmers in the study area. A two-stage selection technique was employed, where the first stage involved the random selection of peasant associations (villages) and the second the random selection of sample farmers who were registered as members of a peasant association and who had official access to at least 0.5 hectare of arable land through the peasant association. A census carried out in March 1994 provided a sampling framework to randomly select the households who had official access to state land. The total sample of farmers was then classified into two groups based on farm size. Farm size is designated as the size of total cultivated land operated by the farm household. Based on the farm size, those whose farm size was larger than two hectares were classified as large farm size households while those whose farm size was equal or less than two hectares were classified as small farm size households. Out of the total 198 sampled farmers, 95 were classified as large farm size (group) and 103 as small farm size (group).

For the purpose of efficiency analysis, information was collected on wheat and tef outputs as dependent variables in the analysis. Six input categories and eight inefficiency effects that might explain efficiency differentials among farm households were defined and used in the production function model.

7.5.4 Conducting fieldwork

The actual fieldwork was organized in three phases. In the first phase, the local development agents who knew the culture and language of the local people interviewed 300 randomly sampled farmers from six PAs on their farms. The enumerators were trained how to complete the questionnaires.

In the second phase, group discussions were carried out with farmers' leaders. The main issues of the research were discussed with six groups of seven farmers' leaders from each of the six PAs involved in the survey. A researcher led the discussions and two experienced extension staff were present to keep the minutes. These discussions made it possible to interpret the data and explore topics raised by farmers, which had not been dealt with in the individual interviews, because farmers complement each other during group discussions.

The third phase was an in-depth group discussion with stakeholders (experts in the MOA, development agents and researchers). The main aim of this group discussion was to obtain a more complete picture of the farming situation in the district.

7.5.5 Analyzing and summarizing data

Following data collection, the data were coded and entered into the SPSS Version 10.1 computer software package for analysis. Data were initially analyzed using descriptive statistics such as percentages, means, frequencies and standard deviations. Frequencies and means were computed for different variables. The t-test was run to detect statistically significant differences in the continuous variables between small and large farm groups, while contingency tests were conducted for discrete variables.

The coefficients of inputs, inefficiency effects and technical efficiencies of sampled farms were then determined by applying the Stochastic Frontier Model using the computer program FRONTIER version 4.1 (Coelli, 1996).

7.6 Findings/results

The main findings of the study are based on the literature study, questionnaire survey, group discussions with farmers' leaders and stakeholders, and the stochastic frontier model analysis.

7.6.1 Literature study

Various evidences from the literature indicated that under the present Ethiopian constitution, land is the property of the state, and it cannot be sold or mortgaged. The right of peasants of free access to land is guaranteed, but given the scarcity of land, it is not clear for how long peasants' rights of free access to land can be assured in practice, and what effect this may have on tenure security of those currently possessing the land; nor is it clear how much land peasants are entitled to have in future. These issues have been left unresolved. For instance, in the Amhara region, general land distribution was completed five years ago and no policy has been established regarding future distributions. Given these circumstances, tenure insecurity has become a major constraint to land improving investment and soil conservation. Moreover, the present land policy contributes to the following:

- Increased sub-division and land fragmentation;
- Limiting farmers' ability to obtain sufficient income from farming;
- Limiting incentives to invest in land improvement;
- Constraining farmers' ability to take advantage of better economic opportunities outside farming or in other locations; and
- Inhibiting land mortgaging, thus reduce farmers' collateral and access to collateral-based credit.

7.6.2 Questionnaire survey

The survey results revealed that almost 30.2% of the sample farmers were illiterate, whereas 69.8% were literate, of whom 30.7% can read and write after participating in a literacy campaign, and 17.6% and 21.6% reached junior and senior high school, respectively.

Wheat and tef are the dominant crops and covered 75% of the total cultivated land area during the survey period. Different wheat varieties were introduced in the study during the last five years. The varieties that farmers adopted widely were ET-13 (96%), HAR-710 (15%) and Kilinto (10%).

Most farmers in the study area have 13-15 years of experience of fertilizer use. All farmers reported that they have never discontinued using fertilizer since they started using it. About 85% of the farmers were aware of the recommended rates but do not actually use the recommended rates. Farmers indicate that the yield increment is substantially higher as fertilizer application increases more than recommended rate.

The survey confirmed that marked variations were observed in the rate of input use and in productivity (performance) between small and large farms within the study area. The estimated yield difference of wheat between small and large farms was significant (P=.001) whereas there was no significant yield difference of tef between the two farm groups.

The use of modern inputs increases productivity per unit area and neutralizes the effect of land scarcity. However, almost 94% of the total sampled farmers reported that the rising price of fertilizer was the most important production constraint during the survey period. The survey also confirmed that 64% of the sampled farmers felt heavily affected by lower output prices relative to fertilizer prices. Therefore, either market stabilization or a fertilizer price subsidy may be necessary to alleviate present farm problems.

The results revealed that the mean farm size of the sample farmers included in the study was 1.50 ha for small and 2.81 ha for large farms. About 22.1% of the farmers rented in land, on average 0.74 ha for crop production. Sharecropping was also common in the study area. About 40.7% of the farmers shared in land, an average of 0.75 ha.

Mean oxen owned was 1.55 for large farms and 1.14 for small farms and there is a significant difference between the groups (P=.001) in the number of oxen owned.

7.6.3 Group discussions with farmers' leaders and stakeholders

Group discussions were held with farmers' leaders and stakeholders to collect data that were not obtained by the structured questionnaire and to check part of the data collected by the questionnaire. Confirmation on the following issues was obtained.

Frequent redistribution and allocation of land has resulted in fragmentation, tenure insecurity, and in farms too small to support the livelihood. Although most of the farmers use the land they have been allocated by the peasant association, four different transactions among farmers were identified in the study area, namely:

1. Leasing land for oxen
2. Leasing land for labour
3. Sharecropping
4. Renting land for cash

These practices created an informal land market in the study district.

An attempt has been made to determine the number of landless households in the group discussions. By the time of the survey, 2,500 households were landless because all land for redistribution available within the respective peasant associations' jurisdiction areas has already been allocated. The number of landless households is expected to increase in the years to come.

7.6.4. Model results

In the stochastic frontier analysis six input factors (land, seed, DAP, urea, labour and traction) were considered. Of these four factors (area, quantity of seed, DAP and urea) had a statistically significant and positive influence on wheat yield at the 1% and 5% probability levels. Similarly, area, labour, quantity of DAP and urea used had a statistically significant positive influence on tef yield at the 1% and 5% probability levels.

Among the eight inefficiency factors postulated to influence technical efficiency of wheat and tef, five of them have been found to be statistical significant at 1% and 5% test level. These were land parcels, distance between parcels, number of oxen owned, family size and income per household.

The stochastic frontier model results revealed that land size and seed application rate contributed the most to growth in wheat yield whereas increase in land size and application of urea led to statistically significant increases in tef yield.

Based on the findings of the stochastic frontier production function estimated, significant technical inefficiencies of production exist between small and large farm groups. In the analysis, land size remains a key variable for explaining differentiation either in wheat and tef outputs, especially in keeping farms near to or on the production frontier. Reduction in farm size and land fragmentation have contributed to technical inefficiencies.

7.7 Conclusions

In view of the research objectives the major results/findings of the research are:

- The stochastic frontier model analysis revealed that large farms are technically more efficient than small farms regarding both wheat and tef production (Objective 1).
- The mean technical efficiency of wheat is calculated to be 0.83 for large farms and 0.79 for small farms (P=.001). The mean technical efficiency of tef for large and small farms is calculated to be 0.74 and 0.68, respectively (P=.001) (Objective 2).
- The average technical efficiencies of wheat and tef were calculated to be 80.85% and 70.72%, respectively. Under the current technology, farmers can thus increase the actual output levels of wheat and tef by about 19.1% and 29.3%, respectively, to become 100% efficient. The challenge remains to decrease technical inefficiency factors and to raise the production level towards the frontier production level.

From the disaggregated data by size of holding, the conclusion is that larger size holdings perform better with regard to technical efficiency, food production and income generation than smaller size holdings irrespective of the extension program.

7.8 Recommendations

7.8.1 Policy recommendations

With regard to research recommendations (Objective 3), a number of policy interventions need to be made by government if small-scale farmers are to improve technical efficiency.

7.8.1.1 Land scarcity

The survey results revealed that the cause of land scarcity is high population pressure. Four possible ways of combating population congestion are out-migration, birth control, intensification and off-farm employment. The chance of birth control and out-migration being applied successfully is however small due to lack of awareness and ethnic-based regional separatism. This creates short-term and long-term negative impacts on the country's ability to combat congestion of the farming population. As a result, relaxing some of the policy options for creating off-farm employment within the district and improving the level of intensification remain the possible solutions for overcoming the problems of land scarcity.

7.8.1.2 Land size and distribution

The main reason for land distribution in the study area is to accommodate the young and landless farmers, but frequent redistribution and allocation of land has resulted in fragmentation, tenure insecurity, and in farms too small to support the livelihood. Ways and means of reducing/avoiding frequent redistribution of land should be of the highest priority to combat the decrease in farm productivity and efficiency. This requires further study to determine the minimum farm size required to support farm households.

7.8.1.3 Rural land markets

Based on the results of this study, a conducive environment must be created to encourage rural land markets in view of their role in improving resource allocation, productivity, efficiency and mobility. In this respect, the government needs to revisit its land policy in order to devise an appropriate policy framework that addresses the problem faced by the agricultural sector in this regard.

7.8.1.4 On-farm problems

With regard to on-farm problems, it was found that the rising price of fertilizer was the most important factor limiting crop yields in the study area. Famers were also affected by lower producer prices relative to the fertilizer prices. Therefore, either fertilizer price stabilization or a fertilizer price subsidy is necessary to alleviate the existing on-farm problems.

7.8.1.5 Access to credit

During the survey valuable information was collected on access to credit through group discussions held with farmers' leaders and stakeholders. The most important credit problems cited were the unavailability of loans from formal and informal sources, high interest rates, and unfavourable loan repayment terms. This is a clear indication of the shortage of support services in the area. Thus the formal credit system needs to be upgraded to effectively address the credit constraints faced by small-scale farmers and to increase awareness about the types of credit available for agricultural production.

7.8.1.6 Rural development activities

The study area is well endowed with natural resources and is blessed with a good climate for agriculture, except that the land area suitable for growing food is virtually fixed in supply. However, public investment to develop rural roads, market stabilization and soil and water conservation are not in place. Thus, applied research and rural development activities are of great importance for enhancing agricultural productivity.

7.8.2 Recommendations for future research

Decrease in farm size at household level often poses problems for economic and social analysis and this problem is receiving increased attention in discussions about rural poverty reduction. This research explored one facet of the farm problem as is manifested in the current debate about the small farm households, namely their efficiency as an agricultural enterprise, responsiveness to new technologies and constraints to raising farm productivity and efficiency. In this respect, the study results confirmed productivity and efficiency differences between small and large farms. Moreover, in a country like Ethiopia, where intensification of land use by way of increased use of chemical fertilizer is limited, change in land size constitutes the primary source of production increase. In this regard, this study was conducted at the right time.

The study results indicate that the incidence of poverty is greater among families on small farms than on large farms and small land size is a major impediment to the application of production technology to increase productivity and efficiency. These results are supported by the findings of Wolday (1998) and Mulat *et al.* (1998), that quantity of input used in Ethiopia is directly proportional to land holding. Therefore, the degree to which small farms should be scaled up to viable sizes/levels to enable intensification and applying mechanical power should be further researched.

It is important to note that small farms can make a difference in food self-sufficiency schemes, but they will never be providers of food and fiber for the fast-growing population. Small farm producers will fill niche consumer markets. Providing solutions for the root causes of rural poverty and changing the gloomy situation of Ethiopian farmers requires multiple strategies. Therefore, future work in this area should begin by posing questions differently. For example, *What is the best path to sustainable agricultural development? What characteristics must a farm possess for it to be sustainable, socially responsible, environmentally sound and economically viable? What is the optimal farm size and how could size be measured in the sustainable era?* Such questions do not have easy answers. They do, however, reveal some of the shortcomings of this analysis and can guide further work in this area.

Finally, the results that emerged from the technical efficiency differentials between small and large farm groups in the Moretna-Jirru district of central Ethiopia have policy implications. However, in order to obtain a more meaningful and accurate estimate of the technical efficiency of the small-scale farmers, the following aspects should receive further attention in future research:

- This study used cross-sectional data which do not reflect multi-periodic optimization, and
- Panel data of a sufficiently large random sample of farmers from wider area coverage should be used to further refine this study.

In conclusion, the micro-level results of this study provide guidelines to areas in the Semien Shewa Zone and other areas in Ethiopia with similar socio-economic and agro-ecological conditions.

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APPENDIX A: FORMAL SURVEY QUESTIONNAIRE

Objective: This questionnaire is intended to obtain primary information concerning farm size, productivity/efficiency, use of new technology and current farm problems in the study area during 1992/1993[1] cropping year (Ethiopian Calendar).

Date of interview: ___________________________
Enumerator's name: ___________________________
Study area: Moretna-Jirru Woreda in Northern Shewa Administrative Zone

A. Farmer's identification

A1: Farmer's name: ____________________________
A2: Peasant Association (PA): ____________________
A3: Farmer's number: ___________________________
A4: Village: __________________________________

B. Household demographic characteristics

1.Head of Household: 1. Male 2. Female
2. Age of household head: ________ years
3. When did you start your own farming? In the year 19_______
4. Education level of household head (mark the correct one)

1.Illiterate		4.Secondary education (7-12)	
2.Read and write		5.Higher education (above 12)	
3.Elementary education (1-6)		6.Other (specify)	

5. Religion: 1.Christian 2.Muslim

C. Use of labour resource

6.Household size

Description	Male	Female
1.Members between 15 and 60 years old		
2.Members less 15 years old		
3.Members more than 60 years old		
4.Dependents in the household		
5.Full-time farm workers in the household		
6.Part-time worker in the household		
Total household size		

[1] *1992/93 Ethiopian Calendar = 2000/2001 European Calendar*

7. Have you hired casual labor for any of your farm operations during the last harvest (last year)?

1. Yes 2. No

If YES, for which type of farm operation?

No.	Farm operation	No.	Farm operation
1	Ploughing	3	Weeding
2	Sowing	4	Harvesting

8.Did you use labor exchange (like Debo, Wonfel, etc.)

1.Yes 2.No

If YES, for which farm operation?

1.Ploughing 4.Harvesting
2.Planting 5.Threshing
3.Weeding 6.Others (specify)

9. Have you or your family members been engaged in off-farm work since last harvest (last year)?

1.Yes 2. No

If YES, indicate the type of engagement ________

10.Have you or your family engaged in some non-farming activities during slack period?

1.Yes 2. No

If YES, indicate the type of non-farming activity and amount of income

No.	Type	Amount (Birr)	No.	Type	Amount (Birr)
1	Fattening		3	Sewing clothes	
2	Petty trading		4	Handicraf	

If NO, what is (are) the limitation(s) not to do non-farming activities?

1	Lack of capital	3	Location/residence
2	Lack of knowledge	4	Other (specify)

D. Use of land resources

11. Area of crops grown in this cropping season (1992/93 E.C[2])

Crops	Area (Gemed)	Crops	Area (Gemed)
1. Tef		7.Gras pea (Guya)	
2. Wheat		8. Fenugreek(Abish)	
3. Chickpea(Shibra)		9. Linseed (Teleba)	
4. Lentils(Misir)		10.Oats (Aja)	
5. Horse beans(Bakela)		11. Other (specify)	
6.Field peas(Ater)			

[2] *E.C. = Ethiopian calendar*

12. Land owned by the farmer (by soil types)

No.	Soil type	Area (Gemed[3])	No.	Soil type	Area (Gemed)
1	Heavy black soil (merere)		3	Areda (near the house)	
2	Light soil (Bushola)		4	Other (specify)	

13. Land used in different tenure forms

No.	Forms of tenure	Area (Gemed)	No.	Forms of tenure	Area (Gemed)
1	Own land		5	Share out land	
2	Land rented in		6	Family land	
3	Land rented out		7	Relatives land	
4	Shared-in land		8	Other (specify)	

14. Land allocation to different uses (1992/93 Production Year)

No.	Land uses	Area (Gemed)	No.	Land uses	Area (Gemed)
1	Cultivated land		4	Fallow land	
2	Grazing land		5	Other (specify)	

15.Total farm size __________Gemed[2]

16.When land was distributed or first given to you? In 19______

17.The main criteria used to distribute land during that time

1.Soil type 3. Distance from the household

2. Soil productivity 4. Other (specify)

18.Indicate the type of change in your farm size during the last five years (1988-1992)

1.Increased 3.Both increase and decrease

2.Decreased 4.No change

19.How many distinct parcels of land do you have? ______________

20.What is the average walking distance between parcels? ______minutes

21.Is land fragmentation or fragmented holding a problem?

1.Yes 2.No

22.Is your land holding enough to produce for your family consumption?

1.Yes 2.No

If NO, how many Gemed do suggest to produce enough for your family consumption? ________Gemed.

23.Do you grow legumes, in rotation with other crops, to maintain soil fertility? Yes 2. No

If NO, what are the reasons not to grow legumes?

1. Shortage of land 3.Low yield of alternative crops

2. Disease-pest problem 4. Other(specify)

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[3] *Gemed = 0.25 hectare*

If Yes, what is the fertilizer rate/application after legume rotation/legume break?

1. Reduction in fertilizer rate
2. No reduction in fertilizer rate
3. Same rate of fertilizer

If the farmer reduces the fertilizer rate after legume rotation, what are the reasons for reduction?

1. Adequate soil fertility
2. No significant yield difference
3. Cannot afford fertilizer
4. Fertilizer is not available

24.Can more organic manure is returned to the soil?

1.Yes 2. No

If NO, what are the reasons?

1	Shortage of manure	3	Transportation problem
2	There is no tradition	4	Other (specify)

25. Can more crop residues and stubble be returned to the soil?

1.Yes 2. No

If NO, what are the limitations?

1.Shortage of feed 2. Weed problem 3. Other (specify)

E. Use of production technology

E1. Use of new varieties of crops

26.When did you first use-improved seeds on your farm? In the year 19____.

27. Did you use improved varieties of wheat in 1992/93-production year?

1. Yes 2. No

If YES, what is the area covered and yield of improved varieties?

Crop	Name of variety	Area covered (Gemed)	Yield Kg/Gemed
Wheat	1.		
	2.		
	3.		
	4.		
	5.		

28.Did you use improved varieties of tef in 1992/93-production year?

1. Yes 2. No

If YES, what is the area covered and yield of improved varieties?

Crop	Name of variety	Area covered (Gemed)	Yield Kg/Gemed
Tef	1.		
	2.		
	3.		
	4.		
	5.		

29. Is enough quantity and preferred type of improved seeds available at any time you want to buy?
    1.Yes 2. No
    If NO, what are the reasons for it, not to be available when you want to buy?
    1. ____________________________
    2. ____________________________

E2. Use of fertilizer

30.When did you first use fertilizer on your farm? In the year 19______.

31.Since then, indicate the rate of fertilizer you used per Gemed?
1.Increased 3.Maintained
2.Reduced 4.Ceased application

32.What are the reasons for your decision?
1. ______________________ 3. ______________________
2. ______________________ 4 ______________________

33.Have you applied fertilizer on wheat and tef in 1992/93 cropping season?
1.Yes 2. No
If YES, what is the rate of DAP and Urea application per Gemed? (in kg)

Crop	Improved variety		Local variety	
	DAP	Urea	DAP	Urea
Tef:				
Planting				
Top dressing				
Wheat:				
Planting				
Top dressing				

If NO, what are the reasons for not applying fertilizer?

1	Lack of Knowledge	4	Lack of availability
2	Lack of cash	5	Fertility of land
3	High fertilizer price	6	Other (specify)

34.Do you know the recommended fertilizer rate for the improved varieties wheat and tef per Gemed?

1.Yes 2. No

If YES, what is the recommended rate? (kg/Gemed)

Crop	Improved variety		Local variety	
	DAP	Urea	DAP	Urea
Tef:				
Planting				
Top dressing				
Wheat:				
Planting				
Top dressing				

35.Do you use the recommended rate per Gemed? 1.Yes 2.No

If NO, what are your reasons for not applying the recommended rate on the improved varieties of wheat and tef?

No.	Reasons	No.	Reasons
1	Lodging	5	Does not pay
2	Lack of cash to purchase more	6	Disease-pest problem
3	Use more than recommended rate	7	Adequate soil fertility
4	Unavailability of fertilizer	8	Other (specify)

36.Is enough quantity and preferred type of fertilizer available at any time you want to buy?

1.Yes 2. No

37.The fertilizer package size the farmer prefers to buy (mark what farmer prefers)

Type of fertilizer	Fertilizer package size	
DAP	25 kg bag ( )	50 kg bag ( )
Urea	25 kg bag ( )	50 kg bag ( )

38. Source of information about recommended rate: __________

39. Do you use improved and local varieties without fertilizer?

1.Yes 2.No

F. Farm input and output data on main crops

40.Estimate of farm inputs quantity use on major crops (for one Gemed) in 1992/93 cropping season

No.	Items	Wheat	Tef	Chickpea	lentil
1	Seed used, kg				
2	Fertilizer at Sowing, kg				
	DAP, kg				
	Urea, kg				
	Top dressing				
	Urea, kg				
3	Oxen-days for				
	1st ploughing, hour				
	2nd ploughing, hour				
	Sowing, hour				
4	Labor & oxen hours for:				
	1st Ploughing: Oxen- hour				
	Man-hour				
	2nd ploughing: Oxen-hour				
	Man-hour				
	Planting: Oxen-hour				
	Man-hour				
	Threshing: Oxen-hour				
	Man-hour				
	Labor for:				
	1st weeding: Man-hour				
	2nd weeding: Man-hour				
	Harvesting : Man-hour				
5	Other(specify)				
	Total				

41.Estimate of crop yield in 1992/93 cropping season

Crops	Yield/Gemed (kg)	Total output sold (kg)	Price/Kg (Birr)
1.Tef			
2.Wheat			
3.Chickpea			
4.Lentils			
5.Horse beans			
6.Field pea			
7.Grass pea			
8.Others(Specify)			

42.Do you know your family consumption of farm produce per year?
1. Yes   2. No

If YES, what quantity is retained on the farm for family consumption purposes (in Kilogram)

Crop	Quantity retained for the family	Crop	Quantity retained for the family
1. Tef		5.Horse beans	
2. Wheat		6.Field peas	
3. Chickpea		7.Grass pea	
4. Lentil		8.Other (specify)	

If NO, can you estimate your family consumption per month or year? (kg)

Crop	Family consumption		
	Per month	Per year	Duration
1. Tef			
2. Wheat			
3. Chickpea			
4. Lentil			
5. Horse beans			
6. Field peas			
7.Grass pea			
8.Other (specify)			

43.Number of farm implements owned by household during 1992/93 cropping year

Type of implements	No.	Type of implements	No
Mofer		Mensh	
Kenber		Layida	
Sickle		Cart	
Hoe		Bicycle	
Shovel		Wheelbarrow	
Ax		Others	

44. What is your livestock number since last year and for what purpose do you keep them?

Livestock type	Number	Livestock type	Number
1. Oxen		7. Donkeys	
2. Cows		8. Mules	
3. Horses		9.Sheep	
4. Heifers		10.Goats	
5. Calves		11.Poultry	
6. Bulls		12.Others (Specify)	

45.Did you sell livestock and livestock products in 1992/93 cropping season?
1.Yes   2.No

If YES, estimate the sales of livestock and livestock products

Livestock type	Number	Average price/head (Birr)
1.Oxen		
2.Cows		
3.Heifers		
4.Caves		
5.Sheep		
6.Goats		
7.Poultry		
8.Other (specify)		

46.Are your oxen enough for farm operations?
1.Yes 2.No
If NO, how do you get additional oxen to plough you farm?
1.Meknajo 3. Borrow from friend
2.hire from other persons 4.Others(specify)

47. What is the estimated farm income since last year?

Type	Amount (Birr)	Type	Amount (Birr)
1.Agricultural income		3.Other income	
a) Crop sales		a) Capital sales	
b) Livestock sales		b) Land rents	
c)Livestock product sales		c) Old plough sales	
2.Non-agricultural income		d)Sales of implements	
a) Income from Petty trade		e) sales of hand craft	
b) Off-farm income		4.Other (specify)	
c) Income from rents			

48. Do you save some money income till the next harvest?
1.Yes 2. No
If YES, for what purpose do you save money? _________

49. Estimate of farm expenditure in 1992/93 cropping season

No.	Expenditure item	Quantity	Wage rate/day Or price/unit	Total cash (Birr)
1	Hired labor for			
	Land preparation			
	Sowing			
	Weeding			
	Harvesting			
	Threshing			
2	Fertilizer			
	DAP			
	Urea			

3	Seed expenses			
	Improved (wheat and tef)			
	Local (all crops)			
4	Herbicide expenses			
5	Insecticide expenses			
6	Other cash expenses			
	1. Oxen rent			
	2. Land rent			
	3. Interest on loan			
	4. Vet. Service cost			
	5 Cash paid for transport			
	6 Others (specify)			
	Total expenditure			

G. Access to services

Type	Farmers' responses	
1.Access to credit services	Yes	No
2.Access to Agri. Extension services	Yes	No
3.Acess to vet services	Yes	No
4.Access to improved seeds	Yes	No
5.Access to fertilizer	Yes	No

50. Have you taken credit for fertilizer in 1992/93 production year?
1.yes   2.No

If YES, what was the amount of money expect to be paid in 1992/93 production year?

Type of payment	Amount in Birr
Advance	
Final	
Total	

H. Production constraints

51. Do you have constraints in achieving your production goals according to your priorities?   1.Yes   2. No

If YES, rank or prioritize them according to their seriousness (gravity)

No.	Constraints	No.	Constraints
1	Shortage of land	6	Water logging problem
2	Shortage of labor	7	Yield decline
3	Shortage of capital/money	8	Lack of improved seed
4	High fertilizer and seed price	9	Disease and insect problem
5	Low price for output/product	10	Others (specify)

52. Main constraints to use of improved seeds (rank or prioritize them)

No.	Constraints	No.	Constraints
1	Not available	6	Lack of knowledge
2	High price of improved seed	7	High price of fertilizer
3	Lack of credit	8	Land shortage
4	Weather not good	9	Poor straw quality
5	Low price of output	10	Late input delivery

53. Main constraints to use of fertilizer (rank or prioritize them)

No.	Constraints	No.	Constraints
1	Not available	6	Lack of knowledge
2	High price of fertilizers	7	High price of improved seed
3	Lack of credit	8	Land shortage
4	Low price of output	9	Late input delivery

54. Rank (prioritize) the crops according to your needs (their importance) for research attention

No.	Crops	No.	Crops
	Wheat		Chick pea
	Tef		Grass pea
	Lentil		Other (specify)

55. Time of the year cash and food is very scarce (months)

Months at which food is very scarce	Months at which cash is very scarce
1	1.
2	2.
3	3.

56. Do you have any general remark to pass about farm problems and farming?

1. Yes 2. No

If YES, what are the main problems?

1.____________________ 3.____________________

2.____________________ 4.____________________

Thank you for your cooperation!

APPENDIX B: FRAMEWORK FOR GROUP DISCUSSIONS WITH FARMERS' LEADERS AND STACKEHOLDERS

1. ***Farm Size***

- Population growth
- Effect of periodic land redistribution
- Excessive division and land fragmentation
- Reduction of cultivated land per household
- Mini–farms

2. ***Use of Fertilizer***

- Impacts on yields
- Impacts on land scarcity
- Availability and distribution
- Problems with its use

3. ***Use of Improved Seeds***

- Impact on yield
- Availability and distribution
- Problems with its use

4. ***Integration of Crop and Livestock Production***

- Livestock raised for multiple purposes (draft, manure, cash, etc.)
- Use of crop by-products
- Problems associated with crop and livestock production

5. ***Non-Farm/Off-Farm Activities***

- Types of non-farm and/or off-farm work available to farm families
- Limitations to run non-farm and/or off-farm activities

6. ***Use of Improved/ Local Wheat/Tef Varieties Without Fertilizers***

- Are there farmers who produce wheat/tef without fertilizer
- If yes, what are the reasons
- Is it possible to get reasonable yields

7. ***Credit Availability***

- Absorbing capacity of farmers for credit
- Credit repayment capacity of farmers
- Number of defaulters

- Buying capacity of farmers in cash

8. *Land Redistribution*

- How often done in the PA
- Number of youngsters denied access to land ownership
- Floor and ceiling for land holding

9. *Production Problems*

- Major production problems
- Minor production problems

10. ***Measures taken to solve the existing problems*** (by government and by you as farmers' leaders)

APPENDIX C: CHECKLIST FOR SECONDARY DATA COLLECTION

Table 1. Population of the study district/Woreda (1996 -2000)

Year	Total population	Farming population
1996		
1997		
1998		
1999		
2000		

Table 2. Population and household size of the study district/Woreda (1996-2000)

Year	Population		Household number	Children below 15 years of age
	Male	Female		
1996				
1997				
1998				
1999				
2000				

Table 3. Number of households and cultivated area of the study district/Woreda (1996-2000)

Year	Number of household	Cultivated area (ha)	Average cultivated area per household (ha)
1996			
1997			
1998			
1999			
2000			

Table 4. Area covered (ha) by main crops in the study district/Woreda (1996-2000)

Year	Area covered by main crops						Total
	Wheat	Tef	Chick pea	Lentil	Grass pea	Others	
1996							
1997							
1998							
1999							
2000							

Table 5. Production (kg) of main crops in the study district (Woreda) (1996-2000)

	Wheat	Tef	Chick pea	Lentil	Grass pea
1996					
1997					
1998					
1999					
2000					

Table 6. Approximate average yields (kg/ha) of main crops at research station, demonstration and farm level in the district (1996-2000)

Crops	Research station	Demonstration plot	Farm level
Wheat			
Tef			
Chick pea			
Lentil			
Grass pea			
Horse bean			
Other (specify)			

Table 7. Livestock population of the study district/Woreda (1996-2000)

Year	Oxen/Bulls	Cows	Heifers	Sheep & goats	Horses & mules	Donkeys
1996						
1997						
1998						
1999						
2000						

Table 8. Institutional services currently available to farmers in the study district/Woreda

Institutional services available to farmers	Total number
Main roads	
Telephone center	
Electricity	
Government extension networks	
Service cooperatives	
Agricultural research	
Input suppliers (fertilizer, seed etc.)	
Output markets (main)	
Banking service	
Local markets	

APPENDIX D: TECHNICAL EFFICIENCY

Table 1. Technical efficiency of wheat production of sampled farms in the Moretna-Jirrru district based on the stochastic frontier model, 2000/2001 cropping season

Farm No.	Technical efficiency		Farm No	Technical efficiency	
	Small farms	Large farms		Small farms	Large farms
1	0.82	0.89	53	0.75	0.92
2	0.70	0.87	54	0.76	0.81
3	0.79	0.79	55	0.86	0.92
4	0.70	0.81	56	0.91	0.78
5	0.74	1.00	57	0.84	0.96
6	0.76	0.88	58	0.86	0.74
7	0.66	0.94	59	0.78	0.70
8	0.81	0.84	60	0.90	0.72
9	0.72	0.97	61	0.72	0.86
10	0.74	0.94	62	0.83	0.98
11	0.67	0.84	63	0.91	0.69
12	0.67	0.93	64	0.81	0.98
13	0.86	0.79	65	0.84	0.73
14	0.82	0.95	66	0.74	0.78
15	0.72	0.83	67	0.85	0.93
16	0.76	0.70	68	0.70	0.77
17	0.77	0.78	69	0.89	0.91
18	0.67	0.92	70	0.71	0.83
19	0.73	0.80	71	0.87	0.88
20	0.76	0.78	72	0.88	0.75
21	0.90	0.73	73	0.73	0.84
22	0.71	0.84	74	0.79	0.80
23	0.74	0.68	75	0.97	0.93
24	0.75	0.77	76	0.76	0.84
25	0.75	0.81	77	0.84	0.79

26	0.84	0.85	78	0.84	0.81
27	0.92	0.74	79	0.70	0.75
28	0.82	0.88	80	0.86	0.73
29	0.87	0.67	81	0.71	0.89
30	0.77	0.90	82	0.75	0.83
31	0.73	0.99	83	0.86	0.69
32	0.79	0.78	84	0.70	0.85
33	0.76	0.79	85	0.72	0.78
34	0.92	0.91	86	0.76	0.77
35	0.65	0.85	87	0.76	0.70
36	0.73	0.85	88	0.80	0.78
37	0.81	0.76	89	0.82	0.77
38	0.86	0.76	90	0.86	0.79
39	0.72	0.78	91	0.79	0.87
40	0.74	0.92	92	0.81	0.77
41	0.85	0.83	93	0.94	0.81
42	0.82	0.91	94	0.72	0.75
43	0.79	0.93	95	0.96	0.65
44	0.87	0.83	96	0.86	
45	0.79	0.81	97	0.79	
46	0.69	0.89	98	0.96	
47	0.75	0.69	99	0.68	
48	0.97	0.95	100	0.70	
49	0.80	0.70	101	0.92	
50	0.77	0.92	102	0.85	
51	0.77	0.84	103	0.77	
52	0.86	0.80			
Mean				0.79	0.83

Table 2. Technical efficiency of tef production of sampled farms in the Moretna-Jirrru district based on the stochastic frontier model, 2000/2001 cropping season

Farm No.	Technical efficiency		Farm No	Technical efficiency	
	Small farms	Large farms		Small farms	Large farms
1	0.77	0.44	52	0.40	0.68
2	0.59	0.65	53	0.72	0.78
3	0.92	0.61	54	0.46	0.72
4	0.79	0.69	55	0.96	0.74
5	0.88	0.64	56	0.62	0.75
6	0.79	0.63	57	0.80	0.74
7	0.54	0.64	58	0.55	0.75
8	0.66	0.64	59	0.84	0.72
9	0.76	0.69	60	0.92	0.69
10	0.91	0.64	61	0.90	0.72
11	0.84	0.69	62	0.48	0.78
12	0.70	0.63	63	0.96	0.72
13	0.96	0.65	64	0.68	0.77
14	0.80	0.62	65	0.47	0.72
15	0.89	0.59	66	0.74	0.84
16	0.75	0.64	67	0.77	0.79
17	0.70	0.63	68	0.93	0.85
18	0.66	0.59	69	0.43	0.83
19	0.53	0.56	70	0.84	0.91
20	0.94	0.58	71	0.45	0.92
21	0.85	0.66	72	0.61	0.64
22	0.72	0.63	73	0.35	0.88
23	0.92	0.57	74	0.90	0.88
24	0.55	0.61	75	0.47	0.85
25	0.42	0.64	76	0.86	0.83
26	0.61	0.62	77	0.79	0.88
27	0.41	0.65	78	0.47	0.93
28	0.72	0.59	79	0.56	0.84

29	0.38	0.76	80	0.72	0.96
30	0.68	0.67	81	0.83	0.84
31	0.58	0.69	82	0.46	0.84
32	0.84	0.64	83	0.42	0.88
33	0.92	0.69	84	0.55	0.95
34	0.88	0.62	85	0.75	0.82
35	0.60	0.70	86	0.95	0.95
36	0.57	0.70	87	0.61	0.85
37	0.65	0.65	88	0.58	0.82
38	0.64	0.64	89	0.45	0.93
39	0.68	0.68	90	0.53	0.91
40	0.63	0.61	91	0.72	0.90
41	0.57	0.63	92	0.65	0.95
42	0.93	0.66	93	0.70	0.98
43	0.86	0.68	94	0.50	0.83
44	0.90	0.62	95	0.56	0.98
45	0.90	0.69	96	0.77	
46	0.65	0.61	97	0.71	
47	0.63	0.75	98	0.37	
48	0.65	0.69	99	0.83	
49	0.72	0.72	100	0.64	
50	0.56	0.74	101	0.51	
51	0.53	0.68	102	0.59	
Mean				0.68	0.74

APPENDIX F: THE COMPUTER SOFTWARE USED IN THE STUDY

Two computer programs are used in this study, namely:

1. Frontier Version 4.1: A Computer Program for Stochastic Frontier Estimation

The FRONTIER computer program was written by Coelli (1996) to provide maximum- likelihood estimates of the parameters of a number of stochastic frontier production and cost functions. The program can accommodate cross-sectional and panel data; time varying and time-invariant inefficiency effects: cost and production functions; half-normal and truncated normal distributions; and functional forms which have a dependent variable in logged or original units.

The execution of FRONTIER Version 4.1 on an IBM PC generally involves five files:

1) The executable file FRONT41.EXE
2) The start-up file FRONT41.000
3) A data file (for example, called TEST.DTA)
4) An instruction file (for example, called TEST.INS)
5) An output file (for example, called TEST.OUT).

The start-up file, FRONT41.000, contains values for a number of key variables such as the convergence criterion, printing flags and so on. The text file may be edited if the user wishes to alter any values. The data and instruction files must be created by the user prior to execution. The output file is created by FRONTIER during execution[1].

The program requires that the data be listed in a text file and is quite particular about the format. The data must be listed by observation. There must be 3+k[1+p] columns presented in the following order:

1) Firm number (an integer in the range 1 to N)
2) Period number (an integer in the range 1 to T)
3) Dependent variable
4) Regressor variables; and
5) Variables influencing the inefficiency effects (if applicable)

The observations can be listed in any order but the columns must be in the stated order. There must be at least one observation on each of the N firms and there must be at least one observation in time period 1 and in time period T. If you are using a single cross-section of data, then

[1]Note that a model can be estimated without an instruction file if the program is used interactively.

column 2 (the time period column) should contain the value "1" throughout. Note that the data must be suitably transformed if a functional form other than a linear function is required.

The program can receive instructions either from a file or from a terminal. After typing "FRONT41" to begin execution, the user is asked whether instructions will come from a file or the terminal. The structure of the instruction file is listed in the next section. If the interactive (terminal) option is selected, questions will be asked in the same order as they appear in the instruction file.

1.1 The Three-Step Estimation Method

The program will follow a three-step procedure in estimating the maximum likelihood estimates of the parameters of a stochastic frontier production function.[2] The three steps are:

1) Ordinary Least Squares (OLS) estimates of the function are obtained. All β estimators with the exception of the intercept will be unbiased.

2) A two-phase grid search of γ is conducted, with the β parameters (excepting β_0) set to the OLS values and the β_0 and σ^2 parameters adjusted according to the corrected ordinary least squares formula presented in Coelli (1995). Any other parameters (μ, η or δ's) are set to zero in this grid search.

3) The values selected in the grid search are used as starting values in an iterative procedure (using the Davidon-Fletcher-Powell Quasi-Newton method) to obtain the final maximum likelihood estimates.

1.2 Program Output

The ordinary least-squares estimates, the estimates after the grid search and the final maximum likelihood estimates are all presented in the output file. Approximate standard errors are taken from the direction matrix used in the final iteration of the Davidon-Fletcher-Powell procedure. This estimate of the covariance matrix is also listed in the output.

Estimates of individual technical or cost efficiencies are calculated using the expressions presented in Battese and Coelli (1995). When any estimates of mean efficiencies are reported, these are simply the arithmetic averages of the individual efficiencies.

2. DEAP Version 2.1: A Data Envelopment Analysis Program

The DEAP computer program is very similar in construction to the FRONTIER computer program. This computer program has been written to conduct data envelopment analyses (DEA). The computer program can consider a variety of models. The three principal options are:

[2]If starting values are specified in the instruction file, the program will skip the first two steps of the procedure.

1. Standard CRS and VRS DEA models that involve the calculation of technical and scale efficiencies. These methods are applied in Chapter 6.
2. The extension of the above models to account for cost and allocative efficiencies.
3. The application of Malmquist DEA method to panel data to calculate indices total factor productivity (TFP) change; technological change; technical efficiency change and scale efficiency change.

All methods are available in either input or an output orientation (with the exception of the cost efficiency option). The output from the program includes, where applicable, technical, scale, allocative and cost efficiency estimates; slacks; peers; targets; TFP and technical change indices.

The DEAP computer program is written in Fortran (Lahey F77LEM/32) for IBM compatible PCs. It is a DOS program but can easily run from windows using FILE MANAGER. The program involves a simple batch files system where the user creates a data file and a small file containing instructions. The user then starts the program by typing "DEAP" at the DOS Prompt[3] and is then prompted for the name of the instruction file. The program then executes these instructions and produces an output file which can be read using text editor, such as NOTEPAD or EDIT, or using a word processor, such as WORD or WORD PERFECT.

The execution of DEAP Version 2.1 on an IBM generally involves five files

1) The executable file DEAP.EXE

2) The start-up file DEAP.000

3) A data file (for example, called TEST.DTA)

4) An instruction file (for example, called TEST.INS)

5) An output file (for example, called TEST.OUT

The executable file and the start-up file are supplied on the disk. The start-up file, DEAP.000 is a file which stores the parameter values which the user may or may not need to alter. The data and instruction files must be created by the user prior to execution. The output file is created by DEAP during execution.

2.1 Data File

The program requires that the data be listed in a text[4] and expects the data to appear in a particular order. The data must be listed by observations (i.e., one row for each farm). There must be a column for each output and each input, with all outputs listed first and then all inputs

[3] The program can also be run by double clicking on the DEAP.EXE file in FILE MANGER in WINDOWS.
[4] All data, instruction and output files are (ASCII) text file

listed (from left to right across the file). For example, for 40 observations on two outputs and two inputs there would be four columns of data (each of length listed in the order: y1, y2, x1, x2. Note that the data file should only contain numbers separated by spaces or tabs and should not contain any column headings.

2.2 Instruction file

The instruction file is a text file which is usually constructed using a text editor or a word processor. The easiest way to create an instruction file is to make a copy of the DBLANK.INS file, which is supplied with the program (by using the FILE/COPY menus in FILE MANAGER in WINDOWS or by using the COPY command at the DOS prompt) this file is edited (using a text editor or word processor) by typing in the relevant information. The best way to describe the structure of the instruction file is via examples.

2.3 Output file

The output file is a text file which is produced by DEAP when an instruction file is executed. The output file can be read using a text editor, such as NOTEPAD or EDIT, or using a word processor, such as WORD or WORD PERFECT. The output may also be imported into a spreadsheet program, such as EXCEL/LOTUS or SPSS to allow further manipulation into tables and graphs for subsequent inclusion into report documents

SUMMARY

The main objective of the study is to analyze the effect of farm size on farm efficiency at household level in cereal based farming systems and to suggest policy recommendations. The survey was conducted in the Moretna-Jirru district of Ethiopia during the 2000/2001 cropping season. The district was selected for this study on the basis of the relatively longer experience of farmers to use new technology, the number of crop growers and the high potential for crop production.

As part of the methodology, a structured questionnaire was developed and used during personal interviews with farmers. The collected data was analyzed using statistical package SPSS Version 10.1. The empirical model used for the estimation of technical efficiency of smallholders in this study was the stochastic production function.

The stochastic frontier model results revealed that land area and seed application rate contributed the most to growth in wheat yield whereas increase in land size and application of urea led to statistically significant increases in tef yield.

In view of the research objectives the major results/findings of the study were:

- The stochastic frontier model analysis revealed that large farms were technically more efficient than small farms regarding both wheat and tef production;
- The mean technical efficiency of wheat was calculated to be 0.83 for large farms and 0.79 for small farms (P=.001). The mean technical efficiency of tef for large and small farms was calculated to be 0.74 and 0.68, respectively (P=.001);
- The average technical efficiencies of wheat and tef were calculated to be 80.85% and 70.72%, respectively. Under the current technology, farmers can thus increase the actual output levels of wheat and tef by about 19.1% and 29.3%, respectively, to become 100% efficient. The challenge remains to decrease technical inefficiency factors and to raise the production level towards the frontier production level.

According to the model analysis, land size remains a key variable explaining differentiation in output, especially in keeping farmers near to or on the production frontier. Reduction in farm size and land fragmentation have contributed to technical inefficiencies.

From the disaggregated data by size of holding, the conclusion is that larger size holdings perform better with regard to technical efficiency, food production and income generation than smaller size holdings, irrespective of the extension program.

The results that emerged from the technical efficiency differentials between small and large farm groups in the Moretna-Jirru district of central Ethiopia have policy implications. A number of policy interventions need to be made by government if small-scale farmers are to improve technical efficiency. These include, among others, that policies on land size and land distribution must be revisited and that further studies are needed to determine the minimum farm size to support farm households. Frequent redistribution and allocation of land has resulted in fragmentation, tenure insecurity, and in too small farms to support livelihood. This in turn contributed to decrease in farm productivity and efficiency.

It is important to note that small farms can make a difference in food self-sufficiency schemes, but they will never be big providers of food and fiber for the fast growing population. Small farm producers will fill niche consumer markets. Providing solutions for the root causes of rural poverty and changing the gloomy situation of Ethiopian farmers requires multiple strategies. Therefore, future work in this area should begin by posing questions differently. For example, *What is the best path to sustainable agricultural development? What characteristics must a farm possess for it to be sustainable, socially responsible, environmentally sound and economically viable? What is the optimal farm size and how could size be measured in the sustainable era?* Such questions do not have easy answers. They do, however, reveal some of the shortcomings of this analysis and can guide further work in this area.

OPSOMMING

Die hoofdoel van die studie is om die uitwerking van plaasgrootte op doeltreffendheid op die huishoudingvlak in graangebaseerde boerderystelsels te ontleed en om beleidsvoorstelle te maak.

Die opname is gedurende die 2000/2001 oesjaar in die Moretna-Jirru distrik van Etiopië gedoen. Dié distrik is vir hierdie studie gekies omdat die boere hier relatief meer ervaring het van die aanwending van nuwe tegnologie, weens die aantal gewasboere en die hoë potensiaal van gewasproduksie in hierdie gebied.

As deel van die metodologie is 'n gestruktureerde vraelys ontwikkel en gedurende persoonlike onderhoude met boere voltooi. Die versamelde data is deur middel van die statistiese pakket, SPSS Version 10.1, ontleed. Die empiriese model wat vir die beraming van tegniese doeltreffendheid van kleinboere gebruik is, is die stogastiese produksiefunksie.

Die resultate van die stogastiese front model het bevind dat die grootte van die grond en die hoeveelheid saad wat gesaai word, die grootste bydrae gemaak het tot 'n toename in die koringoes, terwyl 'n toename in die hoeveelheid grond en die aanwending van ureum tot statisties beduidende toenames in tefopbrengste gelei het.

In die lig van die navorsingsdoelstellings was die belangrikste gevolge/bevindinge van die studie die volgende:

- Die analise met die stogastiese front model het getoon dat groot plase tegnies meer doeltreffend was as klein plase met betrekking tot sowel koring- as tefproduksie;
- Die gemiddelde tegniese doeltreffendheid van koring is bereken op 0.83 vir groot plase en 0.79 vir klein plase (P=.001). Die gemiddelde tegniese doeltreffendheid

van tef vir groot en klein plase was bereken op 0.74 en 0.68 onderskeidelik (P=.001);

- Die gemiddelde tegniese doeltreffendheid van koring en tef is op 80.85% en 70.72% onderskeidelik bereken. Met huidige tegnologie kan boere dus die ware uitsetvlak van koring en tef onderskeidelik met ongeveer 19.1% en 29.3% ondeskeidelik verhoog ten einde 100% doeltreffend te wees. Die uitdaging is om faktore wat tegniese ondoeltreffendheid veroorsaak, te verminder en die produksievlak tot die front produksievlak te verhoog.

Volgens die modelanalise, is die grootte van grond steeds 'n sleutelveranderlike om die variasie in uitset te verduidelik, veral om boere na of op die produksiefront te hou. Vermindering van die grootte van grond en die fragmentering van plase het bygedra tot tegniese ondoeltreffendhede.

Uit die data, ingedeel volgens grootte van plaas, word die gevolgtrekking gemaak dat groter plase beter presteer met betrekking tot tegniese doeltreffendheid, voedselproduksie en skepping van inkomste as kleiner plase, ongeag die voorligtingsprogram.

Die gevolge wat uit die tegniese doeltreffendheidsdifferensiale tussen groepe klein en groot plase in die Moretna-Jirru distrik van sentraal-Etiopië bereik is, het beleidsimplikasies. 'n Aantal beleidsingrypings deur die regering is nodig indien kleinskaalse boere hulle tegniese doeltreffendheid moet verhoog. Dit sluit onder meer in dat beleid oor plaasgrootte en grondverspreiding hersien moet word en dat verdere navorsing onderneem moet word oor die minimum plaasgrootte wat 'n plaasgesin kan onderhou. Gereelde herverspreiding en toewysing van grond het tot fragmentering, onsekerheid oor eiendomsreg en plase wat te klein is om lewensbestaan te onderhou, gelei. Dit het, op hulle beurt, gelei tot 'n afname in plaasproduktiwiteit en –doeltreffendheid.

Dit is belangrik om te noem dat klein plase wel 'n verskil kan maak in skemas vir voedselselfonderhoud, maar dat hulle nooit groot verskaffers van voedsel en vesel vir die vinnig groeiende bevolking sal wees nie. Kleinboere kan vir nis-verbruikersmarkte produseer. Veelvuldige strategieë is nodig om die oorsake van landelike armoede te voorsien en om die droewige situasie van Etiopiese boere te verander. Daarom behoort verdere werk in hierdie veld begin te word deur vrae op ander maniere te stel. Byvoorbeeld, *Wat is die beste plan vir volhoubare landbou-ontwikkeling? Watter eienskappe moet 'n plaas hê om volhoubaar, sosiaal verantwoordelik en ekonomies lewensvatbaar te wees? Wat is die optimum grootte en hoe moet grootte in die volhoubare era gemeet word?* Sulke vrae het nie maklike antwoorde nie. Hulle identifiseer egter van die tekortkominge van hierdie analise en kan verdere werk in hierdie veld rig.