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From: Mulat Demeke, A/Chairman
Department of Economics

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Thank you.

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

TECHNICAL EFFICIENCY AND DETERMINANTS OF FOOD PRODUCTION IN THE HIGHLANDS OF ETHIOPIA

WENDWOSEN FELEKE ABEBE

JUNE 1998

TECHNICAL EFFICIENCY AND DETERMINANTS OF FOOD PRODUCTION IN THE HIGHLANDS OF ETHIOPIA

A THESIS PRESENTED TO THE SCHOOL OF GRADUATE STUDIES

ADDIS ABABA UNIVERSITY

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ECONOMIC POLICY ANALYSIS

BY

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ADDIS ABABA UNIVERSITY

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Technical Efficiency and Determinants of Food Production in the Highlands of Ethiopia

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ABSTRACT

The main objective of this study is to identify major factors and constraints that determine crop production and estimate the technical efficiency of smallholders in the highlands of Ethiopia. Using cross-sectional data collected from 1660 households, this study has attempted to estimate the stochastic frontier Cobb-Douglas production function, and it examines the determinants of food production. Most of the coefficients of the variables included in the production function (except that of credit and rainfall) are statistically significant and have the correct sign as expected.

The result, suggests that the major determinants of food production in the Ethiopian highlands are the traditional inputs, namely oxen, land and labour (family and hired). Furthermore, education level and age of household heads that are expected to proxy management and experience have exhibited positive and significant relationship with output.

The findings of the study have also indicated that there is a significant amount of technical inefficiency among private farmers. The mean technical efficiency of the households covered in this study is estimated to be 0.45. This implies that, it is possible to attain a maximum of 55% increase in output by improving the efficiency of private farmers.

A comparison of technical efficiency of households, led by educated and uneducated, holders have disclosed that the impact of education on the productivity of farmers is stronger at a higher level of education than lower level.

Based on the findings of this study policy emphasis on education, extension service, land quality improvment and increasing the availability of oxen etc. are recommended.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND AND STATEMENT OF THE PROBLEM.

With a GNP per capita of US $100 (1995) and about 33.8% of its population living with a daily income of less than US $1 (1981-95)[1], Ethiopia remains one of the poorest countries in the world. Growing at annual rate of 2.9%, the Ethiopian population is estimated to be 56.4 million in 1995. Being predominantly an agrarian society the main sector in the economy is agriculture. In the early 60's about two thirds of GDP of the country is estimated to have originated from this sector. Though the relative share of the agricultural sector in the economy has been improving, since 1994, it had been declining persistently during 1970's, 1980's and early 1990's. The relative contribution of agricultural sector to GDP was estimated to be 65%, 51% 48% and 51% in 1960, 1965, 1980 and 1990 respectively.[2] World Bank (1982, 1986).

Currently agriculture accounts for about 57% of GDP, 80% of employment and 90% of the export earnings of the country. Besides its contribution to the economy in terms of GDP formation, employment generation, and export earning, the importance of the agricultural sector is often reflected by the dominant influence it exerts on most other sectors and the economy as a whole. This fact is manifested by fluctuations in the economy in line with the achievements or failure in the agricultural sector[3].

Despite some periodic fluctuations in output, the overall performance of the agricultural sector

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1 All macro figures are taken from The World Bank World Development Report 1995 unless the sourcess are quoted otherwise.

2 Diminishing role of agriculture is a natural development process if it is brought by simultaneous progress in agriculture and the remaining other sectors of the economy. However in the case of Ethiopia this phenomenon is mainly, if not totally, the result of poor performance in the agriculture sector itself.

3 In 1980's Ethiopia had two serious droughts, one in 1984 and another in the latter half of 1987. During the first drought real GDP fell by about 10% and value added in agriculture declined by 25%, while in the later drought GDP fell by 2%. On the other hand the relative recovery of agricultural production in 1985 and 1987 has occasioned a 6.7% increase in GDP in 1985 and 9% increase in 1987.

in the last few decades has been disappointing compared to the 2.9% growth rate of the population. The sector grew at the rate of only 2.2%, 0.7 % and 0.4% over the period of 1960-1970, 1970-1980 and 1980-1992 respectively (World Development Report 1982, 1986,1993). This has resulted in a continuous decline of per capita food production. Between 1979 and 1992, per capita food production has been declining on the average at a rate of 1.9% annually (World development report 1993). The rate of food self-sufficiency was about 58% in 1991/92 and per-capita availability of food declined below the recommended intake of 2100 calorie per day (World Food Programme cited at Mulat et al 1997).

Domestic food production, which failed to keep up with the growing demand for food, forced the government to import large amount of food and accept food aid from donors. The volume of cereals imported in 1974, 1984 and 1994 were 118,000 tons, 506,000 tons and 928,000 tons respectively. Between 1985 and 1996 annual cereal food aid ranged from 200,000 metric tons to about 1.2 million metric tons that is equivalent to 3.5% and 26% of domestic food production respectively (Clay, et al, 1997).

Agricultural production could be increased through expansion of cultivated land, increasing cropping intensity (i.e. expansion of harvested area through intensity of land use e.g. double cropping, inter cropping etc.) and improvements in productivity (per hectare yield). However, for the last two decades no significant change was observed , in yield, area of land cultivated and annual harvested area.(Tables AX7-1, AX7-2 and AX7-3).

According to the Central Statistics Authority (CSA 1980-1996) estimate, the area of land reported under major crops has not changed significantly during the 1980's. It has rather stagnated around 6 million hectares. The data book on Land use and Agriculture prepared by Land Use Planning and Regulatory Department (LUPRD) of the Ministry of Agriculture (MOA) / United Nations Food and Agricultural Organisation (FAO) (1984) indicate that since the 1960's the average area of land covered under major crops ranges between four and seven million hectares. (Table AX7--1)

Although considerable improvement in per hectare yield was observed, in research station's best operated sample farms, the national average yield is still around 11 quintals/hectare. (Table AX7--7 and AX7--3)

Several studies have suggested that the potential to increase agricultural production through expansion of arable land is substantial in Ethiopia. As proper inventory of land resource was not carried out, most of these studies have based their conclusion on the land use study conducted by the LUPRD of MOA and FAO in 1984[4]. According to this study out of the total land area of 124.8 million hectares (including Eritrea) only 18.5 million hectares or (14.8%) was covered by annual and perennial crops, while 63.7 million hectares (51%) was used for grazing and browsing. About 14.6 million hectares (11.7%) was covered by forest, woodland, bushland, and shrubs, while 4.7 million hectares (3.8%) was catagorized as unproductive, 23.3 million hectares (18.7%) catagorized as unutilizable.

According to the MOA/FAO study, the cultivated land was only around 18% of the potential area suitable for agriculture. The largest proportion of the unutlized potential agricultural land is located in the lowlands of the country (area below 1500 meters above sea level)[5]. However, except the lowlands in the western and south western parts of the country, the remaining lowlands do not have adequate rainfall to support rainfed agriculture. Even the lowlands with sufficient rainfall have problems due to the prevalence of the Tse Tse fly and malaria that prohibit settlement in the area. (Berhanu, 1989).

The arable land in the highlands seem to have already been exhausted due to severe population pressure. The highlands that occupy around 43% of the total land area account for about 95% of cultivated land and host 85% of the total population. The highlands also house about two-third of the livestock and account for more than 90% of the economic activity in the country. (Constable, 1984)

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4 The estimate on land resource data base was the result of interpreting the satellite imagery showing the land use situation during 1972-78. No proper inventory was carried out. Besides land use is dynamic and changes through time. However, no periodic adjustment mechanism is established in Ethiopia to update changes and generate time series data. Thus, it is this data which is often quoted.

5 The 1500 meters contour is estimated to be the boundary between the settled mixed agriculture of the highlands and the nomadic livestock area of the lowlands.

Estimates made by the Ethiopian Highlands Reclamation Study (EHRS 1986) suggests that total area with in the highlands which have a length of growing period grater than 180 days is about 19 million hectares. Of this area around 14 million hectares or 72% is estimated to have fertile land, but of this fertile land about 4 million hectares (29%) comprises valley bottoms currently out of cultivation due to drainage problems. The valley and plateaux are waterlogged particularly during the rainy seasons and are used mainly for livestock grazing as they are not suitable for farming. Daniel Gamachu (1988) has crudely estimated average size of rainfed arable land area that can theoretically (areas with mean total annual length of growing period of more than 120 days) be available to each rural household to be 7.2 hectares[6].

Nearly 70% of the highland areas have slope of over 30%. According to conservation guidelines, land whose slope is above 33%, should not be cultivated. Some conservation schemes are recommended on agricultural land with slopes of over 12%. However, in Ethiopia land with slopes of up to 55% are presently cultivated. This implies that, even from the area of land under cultivation at present, some areas must be withdrawn from agriculture for conservation purpose. (Daniel. G 1988, Berhanu. D 1989).

Increasing cropping intensity through reducing fallowing period is an exhausted potential as farmers have already reduced the fallowing period due to population pressure and scarcity of land. The fallow period fell from 9 years before 1974 to between 1 and 4 years (Yohannes cited in Croppenstedt and Mulat 1998) There may be enough growing period for double cropping opportunity in areas having annual growing period of 240 days and more. The prevailing high humidity and uninterrupted rainfall in this, contrary to the time interval required to dry and harvest additional crop, have constrained the utilization of this potential.

Though some areas in eastern and southern highlands have a bimodal rainfall and two harvests Meher and Belg, the production from the Belg season is not significant in terms of the national

[6] This estimate includes areas that cannot for various reasons be brought under cultivation (i.e. steep slopes, waterlogged areas, very low fertility area) and areas which should continue to be used for purpose other than cultivation eg. grazing, forest, residence etc (Table AX4-4)

food requirement and it can not be extended to other parts of the country. Besides there are high risks associated with crop failure. Crops may not mature on time and it may also be difficult to prepare land for the main season.

The estimated potential land area suitable for irrigation is 3.496 million hectares. Out of this potential only 4.6% is currently utilised (Abate. T 1991). The huge amount of resources required to construct the necessary infrastructure (dams, canals, pump stations e.t.c,) to run an irrigation scheme has contributed for the very low level of utilization of the existing potential[7]. Besides lack of perennial surface water flow and limited potential for ground water in areas where the landscape is suitable for irrigation are the other constraints. Thus increasing agricultural production through irrigation is costly and unaffordable in the short run.

The prevalence of sever land degradation has continuously been reducing the productivity of land and rapidly changing a one time fertile land in to waste land. According to EHRS estimate around 100,000 Km^2, or 18% of the area of the highlands will have less than 10cm soil depth by the year 2010 compared to the estimated 4% under this category during the time of the study 1985. If the current state of production and rate of population growth continues without change let alone increasing agricultural production through expansion of cultivated land maintaining the current level of output could be difficult.

Even though Ethiopia has the potential for increasing agricultural production through horizontal expansion, the utilisation of this potential is unrealisable at least under the present state of technology. The arable areas in the highlands that the existing technology and resource enable the farmers to cultivate more seem to have been exhausted. Therefore, expansion of cultivated land can not be a reliable source for increasing agricultural production unless major technological change, which will enable the utilisation of the lowlands and marginal lands, is achieved.

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7 At 1991 price the cost of Small scale irrigation is estimated to be a littel less than ETB 9000/hectar. The current cost and the cost for midium and large scale irrigation schemes are quite high. (MEDaC 1998)

In a situation where increasing agricultural production through expansion of land is difficult, improving per hectare yield is the only way to achieve increased production. Traditionally productivity of land had been maintained and increased through long fallowing period and application of organic fertlizer (dung and crop residues). However, the unbridled population growth that put more pressure on land had forced the farmers to reduce the fallowing period and turn forests, bushlands, marginal lands into farming plots. This has created the fuel wood crisis that turned animal dung and plant residues, which would have been used to maintain fertility of the land, in to major sources of household energy supply. As a result it has become extremely difficult to practice the traditional soil fertility restoring techniques.

The other opportunity for increasing agricultural production could be through intensification of farming by using chemical fertlizer, improved seeds and pesticides etc., The Ethiopian agriculture is characterised by low uses of these modern inputs[8], implying that the possibility to increase production by increasing the application of various inputs is still high and unexhausted[9].

At present the government is trying to exploit this potential through the new system of agricultural extension, Participatory Demonstration and Training Extension System (PADETES), which was launched in 1994/95. However, the cost involved and the prevailing resource scarcity are the major constraints limiting the utilisation of this potential . Out of the estimated 9 million rural households only 350,000 households (3.9%)are covered under this programme in 1995/96[10].

As the potential to increase agricultural production by bringing more resources into use becomes more difficult and unattainable, ways of improving production with the resource at hand must be looked into. Improvement in the efficiency of utilising available resources, is one of the

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[8] According to CSA estimates, out of the average area cultivated under major crops only 1.09% was covered by improved seeds, 7.1% was treated with pesticides, less than 1% was irrigated and about 33% was fertilised. These figures represent average for 1990/91, 1991/92, 1995/96, 1996/97, (Table AX4-5)

[9] Per hectar incremental yield by using 100Kg DAP/ha. is estmated to be 3.49qts, 6.13qts, 7.44qts, 6.75qts, 4.4qts, and 3.4qts for Teff,Wheat, Maize, Barley, Millet and Sorghum respectively.(Mulat et al 1997)

[10] The number of farmers included in the programme were only 35,000 in 1994/95 and the plan for 1996/97 was to include as much as 700,000

immediate feasible way through which additional production could be attained in the short run. Recent studies conducted in developing countries have exhibited that there exists a considerable amount of technical inefficiency among private farmers (Shapiro 1983, Bagi 1982, Ali and Chaudhru 1990) See annex 1 for details.

Appropriate policy recommendations in this regard need an empirical study and thorough understanding of the current production practice, constraint and determinants of output, factors governing the usage and productivity of inputs, the allocative and technical efficiency in resource use, etc. However, studies made in this area are very few in Ethiopia. Besides, most attempt to study the problem of the agricultural sector in the past was highly influenced by Schulthz's theory that peasants are poor but efficient[11]. Due to this bias, the poor performance of the agricultural sector is usually associated with inadequate supply of factor inputs and other exogenous factors. Thus, policy recommendations resulting from such studies emphasise on massive technical change and intensive application of modern inputs. Virtually no attempt was made to enquire about the proper utilisation of scarce inputs, socio-economic and market constraints of production etc.,.

Furthermore, the absence of farm household data at a national level and the high cost of conducting national household surveys associated with scarcity of funds had discouraged possible efforts to undertake studies in this area However, in the last couple of years few rural household surveys were conducted, which made possible the availability of some farm household data at a national level. It is the availability of this data, which partially initiated the inception of this study.

farmers (Croppenstedt and Mulat 1998).

[11] After the seminal work of G. Schultz there was(is) a conviction (for a long time) among scholars that farmers in less developed countries are poor but efficient. Since then studies regarding the problem of agricultural sector was highly influenced by this postulate of Schultz. Empirical studies conducted were mainly dominated by the analysis of elasticities, marginal and relative contribution of factor inputs. Therefore, poor performance of agricultural sector is usually associated with scarcity of factor inputs. Until recently nobody dare to refute Schultz's postulate and attempt to enquire on the efficiency of input uttilization.

1.2 OBJECTIVES OF THE STUDY

Given the technology agricultural production could be augmented either by increasing the application of factor inputs or by improving efficiency of their utilisation. However in a situation where increasing the supply of factor inputs is highly constrained, it is imperative to find ways of increasing efficiency of input utilisation. To this end the present study attempts to assess the potential of increasing agricultural production by improving input utilisation. The specific objectives of this study are:-

⇒ To identify major factors and constraints that determine and limit the production and yields of major crops in the peasant sector; and to sort out key factors that can stimulate rapid growth.

⇒ To asses the technical efficiency in the peasant sector and test the hypothesis that farmers are poor but efficient.

⇒ To determine factors that could be responsible for the variation in technical efficiency among farmers.

1.3. SIGNIFICANCE OF THE STUDY

In the last few decades Ethiopia has lost the lives of millions of its people due to the failure of the agricultural sector to perform well and feed its continuously growing population. In spite of the tremendous food problem Ethiopia has and the dependency of its economy on the agricultural sector, empirical studies of the structure , performance problem and prospects of agricultural production are very few. This study is hopefully thought to make certain contribution to fill this gap.

In accomplishing its objectives this study will attempt to give answers to important questions that could be raised by policy makers and planners in the Ethiopian context. How could agricultural production be increased with the resource at hand under the given level of technology?

The findings of this study could provide information for policy makers and planners on the magnitude, area and causes of technical inefficiencies among peasant farmers. This information will enable policy makers to identify both the area and the extent of policy interventions required. It guides planners in their planning activities by identifying potential area of resource reallocation.

1.4. LIMITATIONS OF THE STUDY

⇒ There may be a potential problem of omission of relevant variables (e.g. seed, farm implements etc.). Omission of relevant variables may occur due to lack of appropriate data or the variables may not be observable. If the omitted variables are positively correlated with the included ones the result will have a tendency to over estimate one or more of the coefficients of the included variables. The reverse is true in the case of negative correlation between included and omitted variables.

⇒ Since most of the desired variables can not be obtained directly from the survey we are forced to use proxies that may create bias due to mis-specification and measurement error. Ignoring qualitative difference within a factor is equivalent to omitting several variables plus including the imperfectly specified variable the consequences of omitting variable as already indicated will tend to bias the coefficient of the included variable. The inclusion of mis-specified variable may compliment or counteract the bias.

⇒ As aggregate production function is fitted into the data and no variable is specified to take care of crop specific variations, there may be potential problem resulting from undesired but inevitable aggregation. Furthermore, no different production function is estimated for fertlized and unfertlized farms.

⇒ As the data set which is used in this study is a cross-sectional of one year its scope is limited and it is very difficult to draw strong conclusion from the results of this study. Bearing this fact in mind, any use and interpretation of the result must be considered cautiously.

1.4. ORGANISATION OF THE STUDY

The remaining part of this study is organized under five chapters. In the second chapter a brief review of the role, performance, problems and constraints of the agricultural sector will be presented. It is believed that this chapter will help to understand the current situation in the sector.

Chapter three deals with theoretical and empirical review of literature associated with the study. In this chapter, the gradual development of frontier production functions, the theoretical justifications, the techniques and method used to calculate and measure efficiency will be briefly reviewed.

Chapter four will focus on the model to be used in this study, its limitations, weaknesses and strength. The functional form, specification of the variables and method of estimation will also be highlighted.

Chapter five presents the empirical findings of this study and critically discuss the results. Finally conclusions and recommendation of the study will be presented in chapter six.

CHAPTER TWO

AN OVERVIEW OF THE AGRICULTURAL SECTOR

2.1 STRUCTURE OF PRODUCTION

The annual rainfall in the highlands of Ethiopia ranges from 500 to 1500 millimetres. There are two seasons of production, Meher and Belg. The main season being Meher, it has a long rainy period between June and October covering most of the country and accounting for about 90% of crop production. The second season Belg, has short period of rainfall between March and May covering some part of the country.

The South and south western part of the highlands mostly produce (perennial)crops while the other parts of the highlands produce mainly cereals. The lowland part of the country is predominantly occupied by pastoralists who make their livelihood out of livestock rearing.

The main food crops in the country are cereals, pulses and oil seeds. Cereals being the basic staple crops in Ethiopia account on the average for about 84% of total cultivated land and 89% of total annual production of major crops. CSA 1996)

Among the cereals Teff, Maize, Wheat, Barley, Sorghum, and Millet constitute the major food crops in most parts of Ethiopia. In addition to their nutritional value the stalks, leaves and straw of these crops are used for construction of houses, as animal feeds, as fertlizer and serve as a source of household energy.

The unique feature of the Ethiopian food production is the dominance of Teff which is a staple crop recognised only in Ethiopia. Despite its low per hectare yield and high labour requirement compared to other crops, Teff accounts for about 30% of the total land area cultivated under cereals and about 25% of the total cereal production.[12]

Pulses are mainly used as supplementary food. They provide the basic material for stew and sauce preparation. In addition to their food value, pulses play an important role in fixing nitrogen into the soil. Oil seeds are cash crops and they contribute significantly to the export earnings of the country.

Even though they are not included in the present study, the contribution of root crops in Ethiopian agriculture is significant. Root crops like enset, potato, taro etc., constitute the major staple food in the southern and south western parts of the country.

Ethiopian agriculture is dominated by peasant farmers, who produce mainly for their own consumption. Private peasant farmers on the average account for about 95% of total area cultivated and 92% of total crop production for the 13 years between 1979/80 and 1991/92 (See table AX7-6). After the collapse of the socialist government the relative share of private small holders has increased due to the abolition of co-operatives and the shrinking of state farms. Out of 94.3 million quintals of production for the year 1995/96, about 92.8 million quintals (98.4%) had its origin from the peasant sector (Gebremeskel et al 1998).

There is an uneven distribution of food production among the regions of Ethiopia. The former three Administrative regions Shewa, Gojam and Arsi contain about 58% of total area under cereals and 45% of total cereal production. About 87% of Agricultural Marketing Corporation's (AMC i.e., the former name for Grain Trade Enterprise GTE) purchase of food grain originated from these three regions (ONCCP, 1987).

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12 FAO (1986) has estimated that if all area cultivated under teff were substituted with maize the country would have over a million more tons of cereals annually at its disposal (FAO cited in Seifu Ketmas 1989).

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2.2 PROBLEMS IN THE AGRICULTURAL SECTOR

As it was discussed in the introduction there is sever shortage of arable land in the highlands and much of the unused potential arable land area is not utliazable under the current state of technology. Furthermore, the continuous population pressure has plagued the use of traditional techniques for maintaining soil fertility. As a result the overall productivity of land remained low and no significant yield change was observed for most of the major crops.

Mulat et al (1998) have examined the trend of the yield of major crops during the fifteen years between 1980 and 1995, estimation of a simple regression of yield as a function of time showed that the coefficient of time variable was insignificant for all major crops but wheat.. This implies the stagnation of yield over this period. The change in the yield of the major crops during 1980-1995 is presented on table AX7-7.

What are the reasons behind this stagnation? Why have Ethiopian farmers failed to increase production? What are the constraints limiting and problems hindering vertical as well as horizontal expansion of agricultural production? The following section will review this and related issues briefly.

2.2.1 LAND DEGRADATION

Accelerated population growth with no change in the traditional land use practice has seriously degraded the highlands resulting in loss of productivity and the cultivation of ecologically fragile (steep slopes, water logged plateau and basins, etc.) land.

The EHRS estimated that the annual soil loss from crop land is about 40 metric ton per hectare. If erosion rate stays at its level during the time of the study (1986), it was projected that land covered by soil less than 10 Cm. depth will reach about 100,000 Km^2 (18% of the highland area) by the year 2010.The percentage of total land covered with shallow soil (that is soil depth less than 35 cm.) according to the former administrative regions of Ethiopia is presented on Table AX7-8.

FAO/ MOA (1986) have estimated that about 47 million hectares of Ethiopian highlands are significantly eroded and over 2 million hectares of farm lands have reached to a point of no return. Thus, it cannot sustain economic crop production in the future. Land degradation is still the major plague in Ethiopia which suppresses productivity of land as well as labour

2.2.2 TRADITIONAL FARMING PRACTICE

Ethiopian agriculture is characterised by the low usage of modern package inputs. Although the relative share of cultivated area covered by fertilizer application has increased to about 32% (Table AX7--5) of the total cultivated area, the amount of fertilizer applied is far below the optimum amount recommended by MOA. The average fertilizer application in Ethiopia is 13.5 kg/hectare in 1995 while the optimum amount recommended by MOA for Ethiopian agro-climatic condition is 50 KGs of urea and 100 KGs of Dap (Mulat 1994). Furthermore, the timely availability of fertilizer and other inputs is not reliable due to poor infrastructure and distribution network..

Although trials carried out in the country has shown that improved seed could increase yield by about 45-100%, the application of high yielding variety seeds is extremely low in Ethiopia. The average area covered by improved seeds during 1990/91-1996/97 is about 1% of the total cultivated area, (Table AX7--5).

The Ethiopian agriculture is largely dependent on the amount and variability of rainfall. That is why the high production years of 1979/80,1982/83 and 1995\96 coincide with years of comparatively high rainfall. According to CSA agricultural Sample survey, irrigated agricultural land accounts for less than 1% of cultivated area (Table AX7--5).
Another serious constraint in peasant agriculture is the shortage of oxen for ploughing. Even though Ethiopia is reported to have the largest number of cattle in the whole of Africa, about 37.7 % of all farmers are without oxen, 32% have only 1 ox, 24% have 2 oxen, 3.7% have 3 oxen and the remaining 2.1% possesses more than 4 oxen.(MOA 1986b)

Proven packages of higher yielding and disease resistant seed varieties, farm inputs and agricultural practices adopted to the needs of Ethiopia's varying agro- climatic zones have not been made available to peasant farmers in sufficient quantity. Even where these package inputs have been developed, their diffusion and adoption have been slow because of poor transport, inadequate agricultural input supplies and low purchasing power of the farmers.

2.3.3 UNDERDEVELOPED INFRASTRUCTURE.

If farmers have no easy access to transport and communication services, delivery of outputs and inputs on time is extremely difficult. The rural transport system is basically traditional in Ethiopia (i.e. both animal and human modes, portage). According to Agricultural Sample Survey conducted by MOA in 1984, animal transport and portage accounts for 51% and 49% respectively of the surplus produce hauled to market. The survey has also estimated average distant that a farmer has to travel to reach the nearest small and big market to be 8.2 Km and 15 Km respectively (MOA 1984). The average rural road density is estimated to be 8.03 meter/km^2 (rural road and transport strategy study 1993).

2.2.4 UNFAVOURABLE POLICY ENVIRONMENT

Although the current government is in the process of solving some of the policy problems in the past regieme, the political and economic policy that the previous government had been pursuing in the past played a considerable role in stagnating the development of Ethiopian agriculture.

Allocation of meagre resources in the past was biased towards the socialised sectors (state farms and producers' co-operatives). The previous government had attempted to promote agricultural expansion by directing disproportionately large amount of scarce resources to the inefficient socialised sectors at the cost of vast peasant agriculture.

The government has kept, the real price for agricultural products much lower than they would have been under open market without offsetting the differences through subsidies. Grain prices

Proven packages of higher yielding and disease resistant seed varieties, farm inputs and agricultural practices adopted to the needs of Ethiopia's varying agro- climatic zones have not been made available to peasant farmers in sufficient quantity. Even where these package inputs have been developed, their diffusion and adoption have been slow because of poor transport, inadequate agricultural input supplies and low purchasing power of the farmers.

2.3.3 UNDERDEVELOPED INFRASTRUCTURE.

If farmers have no easy access to transport and communication services, delivery of outputs and inputs on time is extremely difficult. The rural transport system is basically traditional in Ethiopia (i.e. both animal and human modes, portage). According to Agricultural Sample Survey conducted by MOA in 1984, animal transport and portage accounts for 51% and 49% respectively of the surplus produce hauled to market. The survey has also estimated average distant that a farmer has to travel to reach the nearest small and big market to be 8.2 Km and 15 Km respectively (MOA 1984). The average rural road density is estimated to be 8.03 meter/km^2 (rural road and transport strategy study 1993).

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The government has kept, the real price for agricultural products much lower than they would have been under open market without offsetting the differences through subsidies. Grain prices were controlled and free movement of agricultural production were restricted State monopoly of buying and distribution of agricultural products were established and wholesale grain traders were banned.

Although at present the problem of market distortion is being remedied its adverse impact on the development of agricultural production is enormous. There is no doubt that the aggressive surplus extraction imposed on the farmers by the distorted market system have significantly eroded farmers motive to produce beyond subsistence level[13].

Protracted civil war and political instability are also the other major factors that account for the stagnation of the agricultural sector. Ethiopia has experienced a civil war that lasted for 30 years. Besides, making the land, which could have been ploughed, a battle ground and insecure for farming; the war had costed the lives of nearly 1 million active labour force removed from Agricultural sector (Mesfin W/Mariam 1989)

After the collapse of the socialist regime in 1991 the new government, besides restoring relative peace in the country, has attempted to solve some of the policy problems in the agricultural sector. Since 1990 the agricultural marketing policy of the country has been changed towards a free market operation. Since then, quotas and fixed grain prices were abolished, check points were removed, private wholesale grain traders were permitted while AMC was scaled down in its size as well as its objectives. Other policy reforms include devaluation of the currency, elimination of export taxes, introduction of floor price for coffee, etc.

With a long term goal of achieving Agricultural Development-Led Industrialisation (ADLI), the current government has made agriculture the centre of its economic policy. The ADLI strategy concentrates on accelerating growth focusing on the supply of fertlizer, improved seeds and other inputs to small farmers, pastoralists and large scale commercial farmers.

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13 The World Bank (1986) notes that the post 1974 annual growth rate is 50% lower than the agricultural growth rate during the 1965-1973 (World Bank cited on Mesfin .M 1994).

Based on the work of SG-2000 a new system of agricultural extension, known as Participatory Demonstration and Training Extension System (PADETES), was launched in 1994/95. PADETES is an extension programme which is carried out on a 1/2 hectare of the farmers own plot. All operations are performed by the farmer himself under a close supervision of an extension agent. PADETES covered 10 regions and 350,000 farmers in 1995/96. Evaluation reports have indicated that there is a considerable productivity improvement on the plots covered under the new programme.

The contribution of the new economic policy in increasing agricultural production is enormous. However, one major unresolved policy issue is still at stake. The land tenure policy, which favours state ownership and usufruct (user-rights) for the farmers against private ownership, is believed to create tenure insecurity. The current land tenure policy retains land under the control of the people and government of Ethiopia. Thus, it prohibits the buying and selling of land. It ensures its usufructuary tenure rights and allows for leasing its usufructuary rights to or from others.(MNRDEP, 1994). The current policy is thought to deprive peasants the power of decision over their land and discourage investment on conservation and fertility improvement.

CHAPTER THREE

LITERATURE REVIEW

3.1. THEORETICAL BACKGROUND

One of the basic topics in microeconomics is the theory of optimization. Optimization deals with the task of searching for the optimum combinations of resource use to attain the maximum possible benefit. The maximum possible benefits targeted to achieve could be represented by production, cost, profit or other objective functions which set limit or frontier to the possible and attainable level.

In microeconomics, the production function is defined as the maximum (frontier) output that could be produced from a given set of inputs. Similarly profit function is defined as the maximum (frontier) profit that can be attained given the prices of outputs and inputs. Cost function is defined as the minimum(frontier) cost required to produce a given level of output. The extent and degree of attaining these objectives could be measured by efficiency parameters. The amount by which a firm lies below its production and profit frontier and above its cost frontier can be regarded as inefficiency.(Forsund et al 1980 and G.E.Battese 1992).

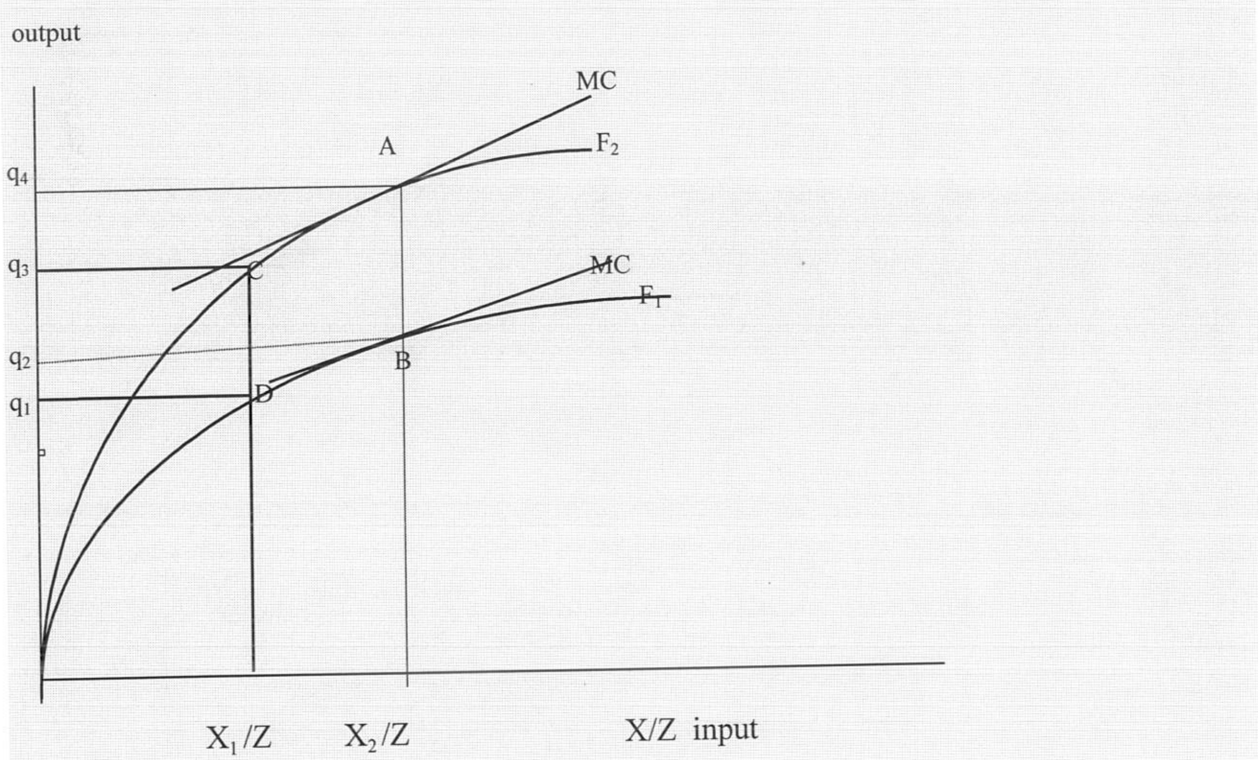
3.1.1 ALLOCATIVE EFFICIENCY

Allocative efficiency refers to the adjustment of inputs and outputs to reflect relative prices. Allocative efficiency measures the ability of farms to equate the marginal value product of an input to its marginal factor cost and the marginal value product per unit of an input across different outputs. If the marginal cost of an input is equal to its marginal revenue the firm is said to be allocatively efficient and if its marginal cost is grater than its marginal revenue the firm is said to be allocatively inefficient. An allocative efficient farm minimizes the total cost of producing a given quantity by selecting a combination of factor inputs where the slope of the production function is equal to the slope of the cost function.

3.1.2 TECHNICAL EFFICIENCY,

Given the technology and set of factor inputs, technical efficiency deals with searching the highest possible production function where maximum level of out put could be produced. Thus it is associated with the firms' ability to equate the level of its actual production from a given input to the maximum possible or frontier level of production that could be produced using the same level of inputs. The difference between the two types of efficiency could be illustrated by using a one factor product space.

Figure 1 Technical and allocative efficiency



Source: Frank.E (1988)

Assuming that a certain farm has a given amount of fixed input z and employs x variable inputs to produce only one output say q. Under a given technology F_1 and F_2 are two different production functions where F_2 represents the frontier production function and is greater than F_1 .

F_2 displays higher output for all positive levels of input use than F_1 . Therefore, F_2 is technically superior than F_1 . A farm operating at any point on F_2 is technically more efficient than a farm operating at any point on $F_{1,}$ because any point on F_2 represents a higher level of output for a given input.

A farm producing q_1 at point D on the production function $F_{1,}$ is technically inefficient compared to point C, where the maximum level of production q_3 is produced using the same amount of factor inputs (x_1/z) but on the higher production function F_2 and allocatively inefficient compared to a farm producing q_2 at point B on the same production function but at increased level of input (X_2/Z) use. The ratio q_1 / q_3 measures the technical efficiency (TE) of the farm producing at point D. The value of TE lies between zero and one and the closer the value of TE to one the more technically efficient the farm is.

At point B, the farm produces at a point where the marginal value product of the factor input is equal to its marginal cost thus, the farm is said to be allocatively efficient. The level of allocative efficiency AE of the farm producing at point D could be measured by using the output ratio q_1 / q_2. Note that at point D the farm is both technically and allocatively inefficient. At point B the farm is allocatively efficient but technically inefficient while at point C the farm is technically efficient while it is allocatively inefficient. It is at point A that the farm is both technically and allocatively efficient. At this point the farm is said to be economically efficient. Economic efficiency of a farm producing at point D, is measured by the ratio of q_1 / q_4 and it is the product of TE and AE

The calculation of allocative efficiency assumes that market prices are a true measure of scarcity of resources and that the farmer's only objective is profit maximisation. These assumptions require the existence of perfect market for all factors of production and the absence of risk (i.e. certainty of production) which are lacking in our country as in most other developing countries (Farell 1957, Pasour 1981, Assefa. A 1995)

The prevalence of these discrepancies between theoretical assumptions behind the measure of

Isoquants[14]. The deviation of observed input-per unit of output ratio from the unit isoquant was considered to be associated with technical inefficiency.

Farell suggested that the efficient unit isoquant be estimated by Linear programming method such that the convex function involved was never above any of the observed input per unit of output ratio.

Besides estimating the maximum limit of a production which can be derived from a given quantities of input, the principal advantage of non-parametric frontier production method is that no functional form is imposed on the data. However the non-parametric frontier production method has some shortcomings. As the frontier production is computed from a supporting subset of observations from the sample, it is susceptible to extreme observations and measurement errors. The non-parametric frontier production method measures technical efficiency relative to an isoquant rather than to an efficient subset. This may lead to identifying inefficient practice as efficient. In addition, the constant returns to scale, that the method assumes, is restrictive and relaxing this assumption is cumbersome (F.R Forsund et al 1980, Assefa 1995).

Since Farell first introduced the non-parametric method, estimation of frontier production function has been consistently improving. To solve shortcomings of non-parametric method, Farell himself has proposed the **deterministic parametric frontier production** function in which he computed a parametric convex hull of the observed input output ratios limiting his functional form to Cobb-Douglas production function. Farell's work was further improved by Aigner and Chu (1968), who specified a homogeneous Cobb-Douglas production frontier and required all the observations to lie on or beneath the frontier. The model they introduced can be written as:-

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[14]The unit isoquant is defined as the input per unit of output ratios associated with the most efficient uses of the inputs to produce the output involved.

$$\ln y = \ln f(x) - u$$
$$= \alpha_0 + \sum \alpha_i \ln X_i - U_i$$
$$U_i \geq 0$$

Where X is inputs, Y is output and α_I is parameters to be estimated.

The one sided error term ($U_i \geq 0$) restrict the observed Y_i to be less or equal to the frontier production function f(x). The elements of the parameters $\alpha_I = \alpha_0 \ldots \alpha_n$ could be estimated either by linear programming (i.e. minimising the sum of absolute value of the residual subject to the constraint that each residual be non positive) or quadratic programming technique (i.e. minimising the sum of squared residuals subject to the above constraint) (Forsund et al, 1980)

The principal advantage of the parametric approach compared to the non-parametric approach is its ability to characterise frontier production in mathematical form and its ability to accommodate non constant returns to scale (Forusnd et al 1980). The basic weaknesses of this method is that the parametric estimate does not have any specific statistical properties (i.e. mathematical programming produces parameter estimates without standard errors and T-ratios thus, it is difficult to test and make inference from the result. The deterministic parametric frontier method, imposes restrictions on the number of technically efficient observations. For example in the case of homogeneous Cobb-Douglas production function when linear programming algorithm is used there will in general be only as many technically efficient observations as there are parameters to be estimated. Furthermore the estimation of the parameters is highly influenced by extreme observations(F.R. Forsund et al 1980)

It is the method of **deterministic statistical frontier model** proposed by Afriat (1972) which solved some of the shortcomings of deterministic parametric frontier method. Unlike the deterministic parametric model which uses programming to estimate the parameters, the statistical frontier model is estimated basically using statistical techniques. The deterministic statistical frontier method makes some assumptions on the error term and the explanatory variables that makes statistical analysis possible.

The deterministic statistical frontier model can be written as -

$$Y = f(x)e^{-u}$$
$$\ln Y = \ln(f(x)) - u$$

Y and X represent output and input respectively.

Where $u \geq 0$ and thus $0 \leq e^{-u} \geq 1$

Since no established theory exists about the specific distribution of the error term, it is not known apriori. Therefore, assumptions must be made so that sound statistical interpretation could be realized. Afriat proposed a two parameter beta distribution for e^{-u} and the model to be estimated by maximum-likelihood, (this implies that a gamma distribution for u_i as it was proposed by Richmond (1974). Schimidt (1976) has shown that the maximu-liklihood estimates for the parameters could be obtained by linear programming method if u_i has exponential distribution or by quadratic programming techniques if u_i has half normal distribution.

One basic problem of maximum-liklihood estimates in the frontier setting is that the range of the dependent variable (output) depends on the parameters to be estimated[15]. This violates one of the regularity conditions invoked to prove the general theorem that maximum likelihood estimators are consistent and asymptotically efficient (F.R Forsund et al 1980). Green (1980) proved that if the U_i's were independent and identically distributed as gamma random variables with parameters $r>2$ and $\lambda>0$ then the required regularity conditions are satisfied (Green cited on George E. Batttese 1992).

The deterministic statistical frontier production function solves the shortcomings of deterministic parametric frontier as it provides statistical assumptions for the error term and makes possible the application of statistical inference on the estimated parameters.

One of the basic shortcomings of all deterministic frontier production functions is the failure to distinguish between inefficiency and other factors influencing farmer's efficiency beyond his

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15 because observed output must be less than the frontier output {y<f(x)and f(x) depends on the estimated parameters} which depends on the estimated parameters.

control. The actual output produced by a certain farm may lie below the frontier production function either due to farmer's inability to efficiently utilize the resources at hand. Or it could be due to other exogenous factors such as unfavourable weather conditions, the prevalence of diseases, natural calamities, hostile policy environments etc. All deterministic parametric frontier models lump these two sources of variation of observed output from the frontier production level into a one-sided error component (i.e. Ui ≥0) and considers it as inefficiency.

In deterministic frontier production function all firms share a common family of production frontier and all variations in firm performance is attributed to variations in firm's efficiency relative to common family of frontiers. This method ignores the real possibility that a firm's performance may be affected both by factors entirely outside its control (such as bad weather, diseases, bad luck etc.) as well as by factors under its control (inefficiency) (Assefa, 1995). Deterministic frontier production function thus lumps the effect of exogenous shocks, and measurement error with inefficiency in to a single one sided error term (Forsund et al, 1980).

The introduction of stochastic frontier production function in 1977[16] has solved the weakness of deterministic frontier method. The stochastic frontier production function, unlike the deterministic, differentiates the effect of random factors that cannot be controlled by firms from technical inefficiency which is controlled by firms. It is because of this superiority that stochastic frontier production function is employed in this study.

The stochastic frontier production function is defined as

$$Y_i = f\left(X_i : \beta\right) \exp^{(V_i - U_i)}$$

$$i = 1, 2, \ldots\ldots\ldots N$$

Where N is the number of observations

Y_i and X_i represent the output and input vector respectively

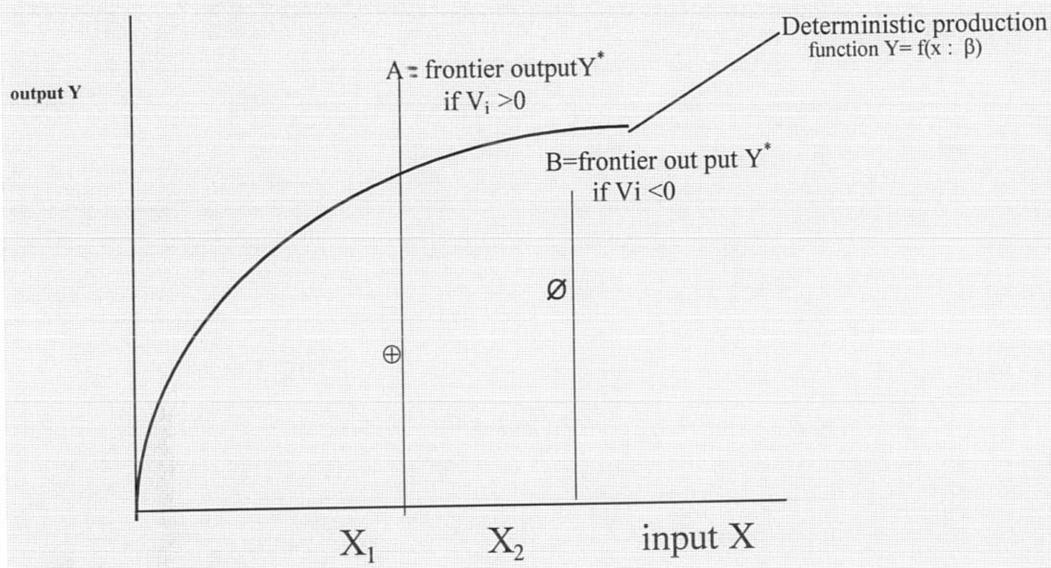
β is vector of parameters to be estimated.

[16] Stochastic frontier production function was first independently proposed by Aigner et al (1977) and Mee usen and van. D Brock (1977). The model was further improved by Jondrow et al (1982), (George E Battese 1992) and others. These extensions include the specification of more general distribution assumptions for the u_i such as truncated, half-normal or two parameter gamma distribution, the consideration of panel data, time varying technical efficiency and the extension of the method to cost functions etc.

U_i is the one-sided error term representing farmers inefficiency

V_i is the symmetric error term representing the stochastic disturbances.

Figure-2 Stochastic Frontier Production Function



Source: G.E Battese 1992

The basic structure of stochastic frontier production could be illustrated using figure 2. Where stochastic frontier production could be greater, less or equal to the deterministic frontier depending on the value of V_i. A positive value of V_i implies favourable influence of exogenous variables which allow the stochastic frontier production function to lie above the deterministic frontier, like point A in the diagram. Conversely negative value of V_i implies unfavourable influence of random variables and in this case stochastic frontier production function lies below the deterministic frontier production function as it is illustrated on the diagram at point B. It should be noted that if $V_i < 0$ the technical efficiency value calculated under stochastic frontier model is greater than the technical efficiency value measured under deterministic frontier model and if $V_i > 0$ the reverse is true.

3.2. EMPIRICAL REVIEW

The seminal work of Farell in 1957 has stimulated empirical studies on frontier production functions. Since then several attempt were made to empirically estimate frontier production and efficiency parameters for different economic sectors in both developing as well as developed countries.

A brief review of these empirical studies could be found from the works of Ali and Byerlee, 1991; Battese ,1992 and Assefa, 1995. In this study only a summary of the results of some empirical works are presented on a table in annex 1. As can be seen from this table the average technical efficiency found in the empirical studies ranges from a minimum of 0.17 to a maximum of 0.85[17] . This wide variation could be explained by the different methods and functional forms applied, the different types of production function estimated or time and area variation among the studies. Although it is very difficult to arrive at certain policy conclusion from the result, what is obvious is the existence of technical inefficiency and the potential to increase production through improvement of input utilization.

Despite the limitations of Cobb-Douglas production function most empirical studies have used it. The translog production function is also used in some cases. The corrected ordinary least square method of estimation is often used Maximum-likelihood and linear programming were also applied.

Empirical works done in the case of Ethiopia were very limited, and among which few of them are reviewed in this study. Giovanni A. Cornia (1985) has estimated a Cobb-Dogulas production function for Ethiopia agriculture and found that an output elasticity of 0.14, 0.35, 0.20 and 0.3 for land, labour capital and intermediate input respectively and the sum of elasticity's (0.99) shows constant returns to scale. This study has only considered factor inputs and ignored all other possible variables affecting the level of production.

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[17] This empirical studies are by no means exhousthive they are taken and tabulated from the studies cited on Bettese 1992

Shujie Yao (1996) using time series data (1981-87) estimated a Cobb-Dogulas production function for the peasant sector in Ethiopia. According to the result of this study about 90% of crop output is explained by the two major traditional inputs labour and land. Output elasticity of labour is between 0.56 and 0.76 while that of land is between 0.20 and 0.45. The study has also shown the significant and sizeable impact of rainfall. The elasticity of rainfall ranges from 0.35 to 0.9 and for all crops. The elasticity of returns to scale was almost equal to one. However shujie Yao has omitted some important variables such as crop damage, improved seeds, capital etc.

Using parametric Linear programming method Sisay Assefa (1983) has attempted to estimate the potential to increase productivity of small holders by improving their efficiency. His study, which is based on data collected from four sites in Chilli, suggests that a considerable gap exists between the actual and the optimal resource allocation for the farmers under the study. The results of the study show that compared to actual farm plan the optimal farm plan shows an increase of 21.5% to 40.7% in land productivity, 32.1% to 57.1% to labour productivity etc. (Sisay 1983)

Alemayehu Seyoum (1989) using Cobb-Dogulas type production function has attempted to estimate the allocative and technical efficiency of farmers in Ada and Holeta woreda. The results of his study show that in labour use low income group are allocatively efficient than high income groups while in land use both are inefficient.

Assefa Admassie (1995), using cross-sectional data collected from Baso and Worena (101 households) and Ada (99 households) and applying Cobb-Douglas stochastic frontier production function, has estimated the technical efficiency of small holders. Assefa has found that there is some sort of technical inefficiency and for the whole farmers included in the study output can be increased by about 10% at the aggregate level without incurring additional cost. The result has indicated that the most important factors of production considered in the study are human labour, animal power and fertlizer respectively in that order of importance. According to the result on the average Ada farms have been more than 93% technically efficient. The technical efficiency levels for unfertlized and fertlized farms in Baso and Worena sub district were found to be 87% and 91 % respectively, implying that fertlized farms are technically more efficient than unfertlized farms. In the study, the factors behind efficiency variation among different group of farmers were analysed using a multiple regression analysis and it was found that secondary school education, oxen, time of fertlizer delivery, extension contact, farming experience, credit availability, distance from the market centre, and family size are the most important factors influencing technical efficiency.

Using the data from the first round of the Ethiopian Rural household survey Croppenstedt and Mulat (1997) have estimated technical efficiency of private farmers using a mixed fixed random coefficient approach. According to their result land size is a major constraint in agricultural production followed by labour. The coefficient for land is 0.58 explaining relatively more of the variation in output. Their findings have also shown that there is a high degree of input specific technical inefficiencies especially for labour and fertilizer. The result also showed that farmers are 41% technically efficient. If the study has increased the sites to include some of the regions like Bale, Gondar, Wollega, Keffa, etc., the result could have better representation.

CHAPTER FOUR

METHODOLOGY

4.1 THE DATA SOURCE

Two rural household surveys are used as a source of data for this study. The 1995/96 CSA's Agricultural Sample Survey and the 1996 Rural Household Food Security Survey executed by CSA and Financed by MEDaC (Food Security Research project) The major source of data for the present study is obtained from the first survey and some missing information such as food aid, credit and other relevant information is obtained from the latter.

CSA has been conducting Agricultural Sample Surveys on annual basis since 1980/81[18]. The 1995/96 Agricultural sample survey, which is intended to be used in this study is part of this series. It covers nationally representative samples of 14800 randomly selected households based on CSA sampling frame.

The 1996 Rural Household Food Security Survey was designed to obtain some additional complementary information about how rural households decide on what to produce, consume and market. Out of the 14800 households visited previously by the Agricultural Sample Survey, 4218 randomly selected households were interviewed. The survey was performed in June 1996 and it covered the period from the beginning of 1995 Meher harvest to the beginning of 1996 Meher harvest. Important information on mean rainfall, elevation ,price etc. was obtained from GMRP collection of secondary data in a lookup files.

4.2 SAMPLE AREA AND SAMPLE SIZE

The prevalence of significant variation in soil fertility and other factors even between adjacent

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[18] CSA's agricultural sample survey was interrupted in 1992/93 and 1993/1994 because during these two years the authority was fully engaged in the preparatory activities for the 1994 population Census.

farming plots makes the task of fitting appropriate production function to the data very difficult[19]. In such conditions a production function estimated for the nation as a whole is meaningless and will not represent or proximate the actual input output relationship. A possible way of dealing with this problem is to reduce the sample to specific areas that have certain common features.

Covering about 56% of the total land area of the country, the lowland accounts only for about (5 to 10 %) of crop production. Furthermore, the lowlands are occupied predominantly by pastoralists who earn their livelihood mainly from livestock rearing. On this ground, excluding the lowlands from the study is believed to improve efficiency of estimated parameters and minimise the impact of regional and production system variations, without having a significant influence on the conclusion drawn from the study. Therefore, the sample households included in this study are only from the highlands. All sample woredas located below 1500 meter above sea level (masl) are excluded from the study and similarly woredas located above 3000 masl are also dropped from the study.

In order to avoid variation in production system, households who have reported to use hand hoe and no animal traction for ploughing are excluded from the study. The excluded households are very few compared to the large sample we have (they are only 27) to create the problem of selectivity bias..

The raw data has been cleaned. Observations having missing values for important variables such as production, land etc. are dropped. Households with unreliable and inconsistent responses are filtered off using criterion set for checking variables created based on major variables such as cultivated area of land and KGs of total production. Households reporting less than 50 KGs of total production and less than 0.1 hectares of cultivated land are dropped from the study.

Afar, Gambela and Diredawa are excluded from the study in the process of selection.

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19 Asmerom K. and D.J Alber have asserted that there could be as many production functions as there are farms, or even more if a farm uses different techniques on its mdifferent plots of land. (Asmerom K. and David G. Abler (1993).

Furthermore, Somali, Benishangul, Harrari, and Addis Ababa are dropped; because the remaining few households after the selection were insufficient to be considered as a representative of their regions. In some cases these households are not located in all the zones or they are very few in number (e.g. 5 in Harari, 11 in Benishanguel etc.). Somali region has a total of nine zones but only three zones have significant rural sedentary population. Afar region has a total of five zones but only two zones have significant rural sedentary population. Addiss Ababa has a total of six , however only two zones have rural settled population. In the remaining four zones the entire population is urban resident (CSA statistical Bulletin 163). Therefore, only four regions Tigray, Amhara, Oromia, and SNNP are included in the present study.

Originally the combined data of the two surveys consists of 3215 households. However after necessary cleaning was conducted 1660 households remained for the present study. Regional distribution of the 1660 households included in this study show that 39% of the households are from Oromia, 35% from Amhara, 20% from SNNP and 6% from Tigray.

TABLE--1 REGIONAL DISTRIBUTION OF HOUSEHOLDS IN THE STUDY

REGIONS	TOTAL ZONES IN THE REGION	NUMBER OF ZONES COVERED	NUMBER OF HOUSEHOLD S	PERCENT	CUMM. PERCENT
1 .TIGRAY[20]	5	4	91	5.5	5.5
2. AMHARA	10	10	586	35.3	40.8
3.OROMIYA	12	12	653	39.3	80.1
4.SNNPR	16	14	330	19.9	100.0
TOTAL	43	40	1660	100	100

The distribution of the households according to the agro-climatic zonation of EHRS shows that about 498 households or (30%) are in the HPP zone while 692 households (41.7%) are in HPC zone and the remaining 470 households (28.3%) are in LPC zone.

4.3 METHOD OF ANALYSIS

Basically quantitative methods of data analysis will be used for this study and some descriptive statistics such as mean, range, median mode and frequency distributions etc. will be employed. Using the combined data of the two rural household surveys the study will perform the following

[20] In Tigray region four out of five zones have rural settled population in the remaining one zone the entire population is urban resident.

two tasks.

⇒ Aggregate average and frontier production functions will be estimated from the cross-sectional household level production data obtained from the survey.

⇒ Technical efficiency of farmers will be estimated and the poor but efficient hypothesis of Schultz in terms of technical efficiency will be tested.

Since the Ethiopian agriculture is dominated by the subsistence peasant sector and the production of food crops, the focus of this study is tuned towards the production of major annual food crops in the peasant sector.

4.4 MODEL SPECIFICATION

In a country like Ethiopia, where the agricultural sector is predominantly subsistence, factor inputs and product markets are imperfect and capital market are less developed; production function approach is more appropriate than the supply function to model the agricultural sector.

Favourable conditions for the application of supply function in the private agricultural sector are lacking in Ethiopia. Labour supply in this sector (peasant sub-sector) is predominantly family labour and hired labour is not common. Intermediate inputs mainly seeds is retained from previous production. The supply of competitive inputs such as fertilizer and improved seeds are very limited. Draft animals, mainly oxen, are to a large extent a product of the farmers' own livestock activity. All of the above situations confirm the limited application of price influenced factor inputs which are the basis for the formation of supply function. It is with this in mind that the production function is preferred to supply function in the agricultural sector.(For Further Discussion refer K. Moges 1989 & 1990)

Production function is defined as the maximum output that can be produced from a specified set of inputs under a given technology. However, the input output relationship established by the method of Ordinary Least Square (OLS) estimation represents not the maximum output but the average.

Despite the shortcomings of OLS in estimating production function, most empirical studies used it to estimate production functions. The basic model used in this study is **Stochastic Frontier Production Function** approach that will enable us to estimate the maximum output that can be produced from a specific set of inputs.

The stochastic frontier production function is defined as

$$Y_i = f(X_i : \beta) \exp^{(V_i - U_i)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$I = 1, 2, \ldots\ldots\ldots N$

Where N is the number of observations

Y_i and X_i represent the output and input vector respectively .

β is vector of parameters to be estimated.

⇒ V_i represents the symmetric component of the error term. It accounts for the random variations in output owing to factors outside the farmers control such as climate, disease, measurement error, hostile policy etc. V_i can assume positive, negative as well as zero values. V_i is assumed to be independently and identically distributed as $N(O, \sigma^2_v)$

⇒ U_i represents the one-sided error component. It captures technical inefficiencies relative to the stochastic frontier production $f(X_i : \beta) e^V$. U_i assumes value greater or equal to zero which ensures, that all observations lie on or beneath the of inputs under a given technology. However, the input output relationship established by the method of Ordinary Least Square (OLS) estimation represents not the maximum output but the average.

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⇒ V_i represents the symmetric component of the error term. It accounts for the random variations in output owing to factors outside the farmers control such as climate, disease, measurement error, hostile policy etc. V_i can assume positive, negative as well as zero values. V_i is assumed to be independently and identically distributed as N (O, σ^2_v)

⇒ U_i represents the one-sided error component. It captures technical inefficiencies relative to the stochastic frontier production $f(X_i : \beta)\, e^V$. U_i assumes value greater or equal to zero which ensures, that all observations lie on or beneath the stochastic production frontier. U_i is assumed to be identically and independently distributed as | N (O, σ^2_u)| implying that the distribution of U_i to be half-normal or exponential. .

Since the error term in the above model has two components with different distributions, estimation and inference about the parameters of the model cannot be done as usual. Meeusen and Van den Broeck (1977) suggested to consider only the case in which the U_i had exponential distribution (i.e. gamma distribution with parameters r= 1 and $\lambda > 0$)

Aigner, et al (1977) suggested that, the maximum likelihood estimate of the parameters of the model could be obtained, in terms of the parameterization of the variances of the two components of the error term in the following manner

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \quad \ldots\ldots 2$$

$$\lambda = \sigma_u / \sigma_v \quad \ldots\ldots 3$$

The ratio of the standard errors (λ) is an indicator of the relative importance of the two components of the error term in explaining the variation between observed production and frontier production. A value of λ close to zero implies that the discrepancy between the observed and frontier output is largely explained by random factors beyond the control of farmers while value of λ greater than one implies technical inefficiency to be the dominant reason for the discrepancy. λ could also help to test whether any form of stochastic frontier production function is required at all. If the null hypothesis that λ =0 is not rejected this would imply that σ_u is zero and hence that the U_i term should be removed from the model, leaving a specification with parameters that can be consistently estimated using OLS.

The technical efficiency of a given farm is defined to be the factor by which the level of production for the farm is less than its frontier output. If the actual output Y_i, that a certain farm has produced using a given level of input is equal to the frontier output Y_i^* (i.e. $Y_i = Y_i^*$) The farm is technically efficient and if $Y_i < Y_i^*$ the farm is technically inefficient. Thus, technical efficiency of the farm, can be measured by the ratio of actual output Y_i and the frontier output (Y^*)[21]. Given the stochastic frontier model (1) the frontier output for the i^{th} farm will be $Y^*_i = f(X_i : \beta)e^{V_i}$ and technical efficiency denoted by TE_i is defined as

$$TE_i = Y_i / Y_i^* = \left\{ \frac{f(x_i : \beta)e^{(V_i - U_i)}}{f(x_i : \beta)e^{V_i}} \right\} = e^{-U_i} \quad ....4$$

$$0 \leq TE_i \leq 1$$

Before 1982, the prediction of technical efficiency of individual farms associated with stochastic frontier production function was considered impossible due to failure to decompose individual farms residuals into its two components. In 1982 Jondrow et al developed a method to estimate farm specific technical efficiency by calculating the mean value of the conditional distribution of the inefficiency error (U_i) given the total value of random variable $\epsilon = V_i - U_i$. Assuming a normal distribution for Vi and half-normal distribution for U_i, they have shown that the expected value of farm specific technical efficiency measures can be estimated from the following relationship.

[21]Technical efficiency can also be measured using method introduced by KOPP (1981) This method involves the ratio of frontier input levels which would be required to produce the observed level of output to the actual input level used.

$$E(U_i / U_i + V_i) = \frac{\sigma_u \sigma_v}{\sigma} \left\{ \frac{f(\varepsilon\lambda\sigma^{-1})}{1-F(\varepsilon\lambda\sigma^{-1})} - \frac{\varepsilon\lambda}{\sigma} \right\} \text{........................}$$

Where f(.) is the standard normal density function and F(.) is the standard normal cumulative function both estimated at $\epsilon\ (\lambda/\sigma)$. Thus, holding the assumptions on the distribution of U_i and V_i the technical efficiency a population of farms is given by

$$E\left(e^{-u_i}\right) = 2\exp^{\sigma_u^2/2}\left(1 - F(\sigma_U)\right) \text{..........6}$$

Where F' is the standard normal distribution function.

The technical efficiency of individual farm could be measured by

$$TE_i = \exp^{-E\left(u_i/\varepsilon_i\right)} \text{..............7}$$

$0 \leq \text{TEi} \leq 1$

In the present study, it is assumed that the coefficients of the variables do not vary, thus there is no input specific technical efficiency difference among farmers. This is assumed basically on the ground that there is no significant technological difference in input application which could be a source of variation in input specific technical efficiency among farmers. It is believed that the source of technical efficiency variation could be socio-economic, household and farm specific factors.

4.5 FUNCTIONAL FORM

There are three commonly used forms of production functions; Cobb-Dogulas, constant Elasticity of substitution (CES) and Translog.

The Cobb-Dogulas production function is represented by

$$Y = AX_1^{b_1} \ldots\ldots X_i^{b_i} \ldots\ldots\ldots X_n^{b_n}$$

Where Y = Output and i=1,2,............n

x_i = factor inputs

A = Constant

b_i = parameters to be estimated.

The Cobb-Dogulas production function can be linearized by taking the logarithms of both sides. Thus 8 can be rewritten as

$$LogY_i = A + \beta_1 LogX_1 \ldots\ldots + \beta_i LogX_i \ldots\ldots\ldots \beta_n LogX_n$$

Properties of the Cobb-Dogulas Production function are:-

a) $b_1, b_2, \ldots\ldots\ldots b_i$ are the elasticities of production with respect to each input,

b) The function is homogeneous of degree b_i. If b_i exceeds unity there is increasing returns to scale, if it is less than unity it implies decreasing returns to scale and if it is equal to unity it shows constant returns to scale.

c) Marginal physical production of an input declines, if the elasticity of an input is less than 1, as the application of that input increases.

d) The Elasticity of substitution is unity.

The constant elasticity of substitution (CES) is a natural extension of the Cobb-Dogulas in that it permits the elasticity of substitution to be something other than unity. CES is represented by:-

$$Y_i^{-\theta} = Y^{\theta}(\alpha_1 X_1^{-\theta} \quad + \alpha_2 X_2^{-\theta} \ldots\ldots\ldots \alpha_n X_n^{-\theta})$$

Where Y and X are inputs and outputs

α and θ are parameters to be estimated.

CES cannot be linearnized as C-D by simply taking logarithms of both sides. The originator of CES Arrow et al (1961) used stepwise regression to linearize CES while Kmenta (1967) linearized it by taking Maclaurin's series expansion of CES around θ= 0. Both methods of linearization have disadvantages stepwise regression method will not make the best uses of Economic theory while Kmenta's method has only a limited range of elasticity of substitution over which it is valid. Thus it is advised to use the non linearised proposed by Mizon (1977)

$$Y_i = \gamma(\alpha_1 X_1^{-\theta} + \alpha_2 X_2^{-\theta} \ldots\ldots\ldots\ldots \alpha_n X_n^{-\theta}) - {}^{\mu}\!/_{\theta} \quad + e \ldots\ldots\ldots 11$$

In the above equation 1/ (1+θ) = elasticity of substitution

The trans-log production function unlike, C-D and CES allow the elasticity of substitution and returns to scale to change with output and /or factor proportion. Trans-log production function is denoted as:-

$$LogY_i = Log\gamma + \sum \alpha_i LogX_i + \frac{1}{2}\sum_i \sum_j \beta_{ij} LogX_i LogX_j ....12$$

Where $\beta_{iJ} = \beta_{Ji}$

One of the short comings of trans-log is that it necessarily excludes corner solutions since there is no logarithm equivalent of zero.

Despite its restrictions (Unit elasticity of substitution and constant, factor share etc.) Cobb-Douglas production function is widely used. It is preferable to the others because of its simplicity in the theoretical application and interpretation. The function explains neatly the marginal productivity theory and the estimated coefficients can be interpreted as elasticities. However, in this study the selection of appropriate functional form is left to be determined empirically. If the Cobb-Dogulas production function doesn't fit the data and fails to adequately explain the production system both constant. Elasticity of substitution (CES) and translog production functions will be estimated by relaxing the Cobb-Douglas unitary elasticity of substitutions restriction step by step.

4.6 ESTIMATION

The parameters of the stochastic frontier production function can be estimated using Maximum - Llikelihood Estimation (MLE) method. The model may also be estimated by corrected Ordinary Least square (COLS) estimation method. COLS estimation method adjusts the constant term by E (u_i) which is derived from the moments of the OLS residuals. The COLS estimates are easier to compute but less efficient than maximum- likelihood estimates.

In this study The computer programme LIMDEP[22] 7 will be used to estimate the parameters. LIMDEP will provide both OLS and MLE estimates of the parameters under three different assumptions of the distribution of the one sided error term half-normal, Truncated and exponential. The assumptions about the distribution of the error term to be used in this study is

[22] LIMDEP is a computer programme designed by Green 1982 mainly for solving econometric problems of limited dependent variables (i.e qualitative response models)

discussed in section 4.4.

4.7. VARIABLE SPECIFICATION

The way input and output variables have been defined and measured is crucial for the applicability of an empirically estimated production function. In what follows we will provide the detailed definition and computational methods used in specification of the variables.

4.7.1 OUTPUT

Output is the dependent variable in this study. Ideally this variable should represent physical quantity of production measured in certain homogeneous standard units. However, as the types of crops produced are different and have their own physical characteristics, aggregating them using standard measurement of weight may not yield the desired specification for this study. One way of dealing with this problem is to take the net dry weight using certain conversion factor that will exclude the moisture and water content of each crop. This method is specifically applicable and sound for converting root crops into grain equivalent.

Another method is using the calorie conversion factor (i.e converting each crop into the amount of calorie that the crop will provide). However, this method does not reflect the relative importance that the farmer will attach to each crop.

The most often used method is to take value of production. However in a subsistence agriculture farmers' decision of resource allocation depends mainly if not totally on his objectives of fulfilling food requirements of his family. That is why most households produce staple food crops while there are some other more profitable crops. Furthermore, it is very difficult to differentiate or separate, the effect of price variation between different regions, from the effect of increase in productivity.

In order to deal with this problem KGs of quantity produced is adjusted using composite price index for each household which is calculated in the following manner. Assume that P_i is the price of each crop I=1,2,3, ...n and Xi the different crops produced thus:-

$$\text{Total value} = TV = P_1X_1 + P_2X_2 + P_3X_3 + \ldots\ldots\ldots\ldots P_nX_n$$

$$\text{Relative Share of each crop} = S_i = P_iX_i \;/\; TV$$

$$\text{Price index for household } i = PI_i = S_1{*}P_1 + S_2{*}P_2 + S_3{*}P_3 + \ldots\ldots\ldots + S_n{*}P_n$$

Adjusted quantity will be TV/ PI

Although the adjusted quantity is used as the main dependent variable value of production is also used as an alternative variable for the purpose of comparison.

4.7.2 FACTOR INPUTS

The variables which are expected to affect the level of production directly or indirectly are included in the model . The variables which have a direct effect are the essential factor inputs without which production is impossible (e.g. land, labour, seed etc.) and other supplementary factor inputs such as fertlizer and improved seed, which increase level of production. The other group of variables which have indirect effect are the farm/ household specific variations explained in terms of socio-economic characteristics of the household.

a) LAND

The variable land in our model represents the area of land cultivated under each crops. In principle the land input should be represented by a vector of non-homogeneous hectares in order to recognise the qualitative difference that exists between land grades. However, as no standards were established to measure quality of land between different plots complete specification of this variable is impossible. Some studies have used slope and relative steepness of plots as a measure of quality while others have used farmers judgement of their own plot as Lem (fertile), Lem tef (moderately fertile) and Tef

(least fertile). As none of the above is accounted for in our survey land is considered as homogeneous in this study[23].

Land area cultivated both for Meher and Belg seasons are considered independently in the study i.e. in order to control for different land use intensity the land input is expressed in terms of the area effectively cropped or harvested.

b) LABOUR

In a production function ideally we want the variable labour to represent the actual amount of human labour employed in the production of each crop measured in terms of man-hours or man-days. However, it is very difficult to generate such data. The survey provides data on the number of family members in the household engaged in farming activities categorised by sex, three age groups (<10 years, 10-14 years, and >14 years) and intensity of labour (full time or par time)

As children and elders are physically less fit and women are largely engaged in activities other than agriculture(mainly family care), the amount of labour they provide by each group for farming activities is different. Thus in order to arrive at the amount of family labour available for agricultural activities, heterogeneous potential labour supply should be converted into homogeneous man units. The norm for a one man unit is considered to be one male adult worker who is in the age bracket of active working population.

P.A. Yotopolus (1968) used a conversion factor of 0.6 for women (15-64), 0.3 for children under 15 and women over 65 and 0.5 for male over 65. John Strauss (1983) used conversion factors of 0.75 for female over 15 years of age and 0.5 children in the age bracket of (10-15)years.

In the case of Ethiopia, a survey conducted by Solomon Ayalew (1989) for Yetnora and Giraram

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23 Since land degradation is one of the major causes for the deterioration of soil fertility, classification of the variable land based on the the extent of land degradation is assumed to capture some of the differences in land quality.with this assumption land is given three grades based on the results of EHRS (1986). According to EHRS the extent of land degradation is very serious in 24%, serious in 26%, and modest in 25% of the total land area in LPC. These figures are 13%, 16% and 32% for very serious, serious and moderate respectively in HPC while for Hpp they are 4%, 9%, and 21%.Therefore land in HPP is considered to have the highest quality, in LPC the least quality while in Hpc has medium quality.

communities during the busy season of 1984, has shown that in Yetnora males spent 49.8% of their time purely on farming activities while women spent 27.9% of their time. These figures were 57.6% for male and 19% for female in Giraram.

A simple calculation of the above figures shows that if male labour supply is taken as 1.0, the conversion factor of female into male labour will be 0.56 for yetnora and 0.33 for Giraram. The 1973 EPID survey of the area around Debre zeit showed that wives spend about 60% as much time on farm work as their husbands (cited by C.P. Humpreys 1977). The conversion factors used in this study are 0.5 for children in the age bracket of 10-14 years and 0.6 for female adults. In addition any person engaged on a par-time basis (one who is not engaged in agricultural activities through out the year) is assumed to be equivalent to 0.5 of person working on full-time base on the same category. There is no specific calculation used to arrive at these figures; they are simply considered fair compared to the figures used by others.

The number of days per year and hours per day that a farmer works on his specific field depends on many factors (the factors could be household / crop specific and/or group / area specific). Number of holidays observed by the family, rainy days during the year, days spent on marketing, distance of fields from home and growing characteristics of each crops etc., are few of these factors. Therefore, it is very difficult if not susceptible to measurement error, to find the amount of labour input employed by each household for the production of each crops. To avoid unnecessary complications the labour force available in the family after being converted in to man- units is considered as a labour input across crops.

The application of hired labour in Ethiopian agriculture is limited however among the families using it the contribution is significant especially during harvest time. As a result labour variable is categorised as hired and family labour. Although the importance of exchange labour is highly significant in Ethiopian agriculture due to lack of data it is not included in this study.

However This Classification failed because of strong colliniarity of these dummies with regional dummies

c. FERTLIZER

Application of commercial fertilizer was a recent phenomenon in Ethiopian agriculture. It was first introduced in 1971 with a total amount of 947 metric ton (Mulat D. 1995) Since then fertilizer consumption has been growing every year. However, fertilizer application is concentrated in few regions (Shewa, Arsi and Gojam accounting about 70%) and on few types of crops(Teff, Wheat and Maize). Out of The total area covered under Teff, Wheat and Maize 52%, 51% and 36% are respectively fertlized.(Mulat et al 1998).

Besides its concentration over few regions and crops its per hectare application is very low compared to the amount recommended by MOA which is between 150 and 200 kg/hectare. (Croppenstedt and Mulat 1997) In our model fertilizer consumption is measured in total of kg of fertlizer used per household.

d) CAPITAL

Application of modern machineries like tractors and combiners are non existent in the peasant sector in Ethiopia. There are only hand tools like hoe, shovels, sickles, etc. whose ownership does not vary significantly across households.

Assuming that the ability of the farmer to use purchased inputs depends on the level of its wealth, which may be proxied by the number of livestock and productive perennial crops and other cash crops he has. However in our study capital is proxied only by the number of livestock he has. In order to reduce the number of different livestock the farmer owns, in to a comparable units, each animal is converted in to a Tropical Livestock Unit (TLU) which is measured by a live weight of 250 kg[24].

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[24] for our purpose we will use conversion factor estimated by United Nations Economic Commission for Africa (UNECA) /FAO. (1 for camel, 0.8 for horse, 0.7 for cattle, 0.7 for mule, 0.5 for ass and 0.1 for shoats).

e) MODERN INPUT

As the application of modern inputs other than fertlizer is very low, they are considered as one input while fertlizer is treated independently. Households are asked whether they use pesticides, improved seeds and irrigation. A dummy variable is created to distinguish farmers using modern inputs from others. The dummy variable assumes a value of zero if the household does not use the inputs, and one if the household uses any one of the inputs.

f) EXTENSION SERVICE

This variable is included to capture the impact of extension information and consultancy that the farmers receive, however, it is very difficult to find data on the amount of extension service that a household received. The households covered under the new extension programme, i.e Participatory, Demonstration and Training Extension System (PADETES), operate under a close supervision of one extension agent. Thus, it is believed that the impact of extension service on the level of production will be captured if we use a dummy variable to distinguish households participating in the new extension programme of the government or SG-2000 from those who are not covered under these programmes. The variable assumes a value of 0 for those households not participating in the programme and 1 for those households participating in one of the programmes. It should be noted that the dummy variable used here doesn't fully capture all extension efforts conducted in this country but it can reflect the impact of extension service through these farmers.

g) RAINFALL

In a country like Ethiopia where agricultural production is predominantly dependent on the level of rainfall, modelling agricultural production must include rainfall as a variable. However, due to the few meteorological stations Ethiopia has, it is not possible to find rainfall data at farmers' association or enumeration area level. Thus, a five year average rainfall data from meteorological stations assumed to be representative of each woreda is used in this study..

h) EDUCATION

Education level is assumed to represent variation in management efficiency across households. The farmers ability to use available technology, its input allocative efficiency, adoption of modern inputs etc. could be influenced by the education level of head of the household.

Abay Asfaw and Assefa Admassie (1997) had examined the impact of education on technical and allocative efficiency of farmers in Ethiopia. The result revealed that educated farmers are relatively and absolutely more efficient than illiterate farmers. Furthermore education is expected to affect farmers productivity after certain threshold level of education. It is on this ground that in this study education level of heads of the household is represented by two dummy variables. One dummy variable is for those who are grade 3 and below while another dummy variable is for those above grade three. Choosing the threshold level beyond which the impact of education is felt requires an in-depth study. The demarcation level used in this study (grade 3) is not a product of such study. It is simply taken to deal with the problem of fewer observations encountered as one moves up the level of education.

i) CROP DAMAGE

It is estimated that pests and plant disease can cause serious crop loss (15-20%) (Croppenstedt and Mulat 1997). In addition crop damage resulting from trampling by livestock or damage by birds, locust, army worms and other animals as well as, weed damages are significant. In Ethiopian agriculture crop damage could also result from flood, frost, and water logging etc.

In the model households reporting crop damage are differentiated from those not reporting using a dummy variable. The variable assumes a value of zero for households not reporting the crop damage and one for households reporting crop damage.

j) REGIONAL DUMMIES

To capture region specific factors and exclude the regional effect from the parameter estimates 13 regional dummies are included in the production function. Tigray is considered as a reference region because it is the most degraded area in Ethiopia, thus no dummy variable is attached to it. Classification of the regional dummies is based on the Rural Household Food Security Survey classification of domain which reduces the 69 zones in the country into 21 domains. The four regions included in this study have 43 zones that are categorised into 14 domains.

k) CREDIT

Due to lack of information on households access to formal credit, credit received from traders is considered in this study. A dummy variable is attached for farmers who received credit from traders.

l) OXEN

As it is very difficult to find the exact amount of animal power used in the production, animal traction power is proxied by the number of oxen that the households have.

m) FOOD AID

Food aid has been covering significant proportion of domestic food demand for the last few decades. However, the long run consequences of the huge flow of food aid on domestic food production, agricultural labour supply and food prices are little known. There is an opinion that food aid may have disincentive effect (See S.Maxwell, 1986). To analyse this impact of food aid is beyond the scope of this study. However an effort will be made to make an indicative assertion to provoke further study in the area. Hence, the amount of calorie food aid received by each household in 1995/96 is included in the production function as a variable.

CHAPTER FIVE

RESULTS OF THE STUDY

5.1 DESCRIPTIVE ANALYSIS

5.1.1 SOCIO-ECONOMIC CHARACTERISTICS

The average household size is estimated to be 5.31 while the maximum and the minimum sizes are 1 and 14 respectively. The size of the household is expected to be positively related with the household production since the major source of labour supply is the household itself. The age structure of the households shows that about 40% of the members of the households are either under ten (36.1%) or greater than 64 (3.4%). About 13% of the members are teenagers between 11 and 15, while 47.4 % of the members are adults in the age bracket of 16 to 64 .

The age structure with very large proportion of children and very small proportion of elders implies the prevalence of high fertility and high mortality rates which is the characteristics of most developing countries including Ethiopia. Besides, this age structure shows the high dependency ratio of children under 15 that is 103.8% . However in the Ethiopian case to consider children between 11 and 15 as dependants seems unfair as they usually participate in the production process.

There are about 231 households (14%) which are female headed. Female headed households are expected to be less productive than the male headed households. Dessalegn, 1994 has said that productivity of female headed household is very low compared to that of male Hades household due to many factors. Agricultural extension services are mainly male oriented, women, whether plot holders or not, are not expected to attend agricultural extension training programmes, women farmers have to depend on male labour for most of heavy works.

Out of the 1660 heads of households 71% of them are illiterate 11.4% can read and write and the remaining 18% have attended elementary or secondary school (Table 2)

TABLE-2 DISTRIBUTION OF HEADS OF HOUSEHOLDS BY EDUCATION LEVEL

EDUC. LEVEL	NUMBER OF HOUSEHOLDS	PERCENT	CUMM. PERCENT
1. ILLITERATE	1179	71.0	71.0
2. CAN READ AND WRITE	189	11.4	82.4
3. 1 TO 3 GRADE	103	6.2	88.6
4.4 TO 6 GRADE	117	7.0	95.7
5. 7 TO 8 GRADE	42	2.5	98.2
6. 9 TO 11 GRADE	22	1.3	99.5
7. 12 COMPLETE	8	.5	100
TOTAL	1660	100	100

It is believed that, this high rate of illiteracy and lower level of education will have significant impact on the over all productivity of the household. There will be significant technical efficiency difference among literate and illiterate farmers. This is partly due to the influence that education will have on the farmers application of input, crop choice, cultural practices, improved techniques etc. This situation could be observed by examining the changes in input application as heads of household education level increased. The following table will illustrate this fact.

TABLE--3 IMPACT OF EDUCATION ON FARMERS INPUT APPLICATION

education level	total number	fertlizer	other improved input
1. Illiterate	1179	552 (46.8%)	213 (18.1%)
2. literate and above	481	289 (60.1%)	134 (27.9%)
3. grade3 and above	292	179 (61.3%)	85 (29.1%)
4. grade six and above	189	126 (66.1%)	60 (31.7%)
5. grade eight and above	72	50 (69.4%)	23 (31.9%)
6. grade eleven and above	30	21 (70%)	10 (33.3%)
7. twelve complete	8	7 (87.5%)	3 (37.5%)

As can be seen from the table farmers application of fertlizer has increased from 46.8% all the way through changes in level of education and finally reached 87.5%. Similarly the application of other modern inputs (improved seeds, pesticides, etc.) has increased from 18.1% to 37.5%[25]. Inadequate application of modern package inputs is one of the major reasons behind low per hectare yield and productivity of labour in Ethiopia. However, it should be noted that there are many other factors such as price, availability, farmer's wealth etc. affecting the application of inputs by a farmer.

The survey has indicated that out of 1660 households only 42 households (2.5%) use improved seeds, 92 households (5.5%) use irrigated farms, 238 households (14.3%) use pesticides and 841 or (50.7%) use fertlizer[26]. This low level of input application could partly be due to supply shortage or due to farmers lack of interest to apply them or due to the fact that farmers may not have information and access about the importance of these inputs. This and the above result show the importance of education and the emphasis that needs to be given for the development of education in the country side by side with supply improvement.

Average household crop production is 11.7 quintals (see Annex-5) this figure seems to be higher than the national average that is around 8 quintals per hectar . This could be mainly due to the exclusion of households with production less than half quintal.

Average household income from crop production (i.e average value of output) is 1404.62 Birr (see Annex-5), which is equivalent to 201.08 USD. If this figure is divided by average household size, the result will yield a per capita income of 37.87 USD which is far below the national average (100 USD). However the national average includes every thing else besides crops and the farmer has other sources of income including income from sale of livestock and livestock products and other off-farm income. Therefore, the above figure implies that crop constitute the major source of income in rural Ethiopia.

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25 A.Croppenstedt et al (1998) have estimated that farmers who are litereate have a 43% higher demand for fertlizer , while farmers with four or more years of formal education have a 93% higher demand for fertlizer as compared to the reference group.

26 this figure includes those farmers using commercial as well as organic fertlizer. The households using only commercial fertlizer are 519 or 30.2% of the total households.

5.1.2 OWNERSHIP OF ANIMAL POWER & SIZE OF LAND HOLDING

On the average there are 4.29 cattle per household. The maximum cattle ownership is 30, however, there are some households without a cattle. Average Tropical Livestock Unit per household is found to be 1.71 while the maximum is 17.5 TLU and the minimum is 0.

Animal power is one of the basic inputs in agricultural production. All farmers included in this study are those who use animal power for ploughing to avoid other production system e.g. those using hoes. Despite its importance in the production system, about 21.1% of the households do not have even an ox and 31.4% of them reported to have only one ox (Table 4). Lack of oxen will have an adverse effect on the production of the household as it is very difficult to find oxen and prepare the plots at the appropriate time. If farmers do not have their own oxen they have to wait until draught animals are free that may delay the preparation of plots on time.

TABLE-4 DISTRIBUTION OF OWNERSHIP OF OXEN

NUMBER OF OXEN	HOUSEHOLDS	PERCENT	CUMM. PERCENT
NO OX	351	21.1	21.1
ONLY ONE OX	522	31.4	52.5
TWO OXEN	492	29.6	82.1
THREE OXEN	94	5.7	87.8
GREATER THAN THREE OXEN	72	4.3	92.1
MISSING	129	7.9	100

According to the survey about 92% of the households have reported to have lived on the average for more than 10 years in the area and the households have been operating the same farm on the average for about 16 years This shows that land is not a variable factor changing hands with in a short period of time.

To show the situation of land holding before the selection was made all 3215 households are considered. Accordingly the average land holding is estimated to be around 1.22 hectares per household. While the maximum land holding is 37.6 hectares there are 55 landless households. No specific area or region is associated with the concentration of landless households. Land scarcity and unemployment have been exacerbated by a large influx of displaced persons in the rural areas. Out of 1,173,101 displaced persons headed home between 1991 and 1993 573,754 of them returned to country side (Dessalegn 1994). The continuous creation of new families by young married couple is also another source for the emergence of landlessness. The prevalence of landless households is an indication of the problem of shortage of land. Out of the total households 59.1% or 1844 households are operating on less than 1 hectare of land , while 66 households (2.1%) operates greater than four hectare. The detail is presented on table 5.

TABLE--5 DISTRIBUTION OF HOUSEHOLDS BY LAND HOLDING

AREA OF LAND HOLDING IN HECTAR	NUMBER OF HOUSEHOLDS	PERCENTAGE	CUMM. PERCENTAGE
LANDLESS	55	1.7	1.7
0.01 TO 0.5.	926	28.8	30.5
0.51 TO 1.	918	28.6	59.1
1.01 TO 2.	730	22.7	81.8
2.01 TO 4.	290	9.0	90.8
4 AND ABOVE	66	2.1	92.9
MISSING	230	7.2	100
TOTAL	4218	100	100

In order to examine the problem of land, households were asked whether they would like to increase their landholding or not? Whether there is any means of increasing land holding further? According to the survey, 1382 households or 83% reported that they want to increase their landholding while the remaining 17% belonged to those who do not like to increase their land holding , those who are not sure of what they want and missing cases.. Regarding the availability of means to increase landholding, 1450 households (87.3%) responded that there is no means of increasing land holding, confirming the severity of land problem in the highlands of Ethiopia.

5.2 ECONOMETRIC RESULTS

5.2.1 DETERMINANTS OF FOOD PRODUCTION .

To fit the appropriate functional form to the data Cobb-Douglas ,Constant Elasticity of Substitution (CES) and Trans Log production functions are empirically tested and the Cobb-Douglas production function is found to be the one which fits the data and explain the production system.

Selection of appropriate explanatory variables is done by including all variables expected to affect the level of production initially and then excluding those which are statistically insignificant and relatively unimportant as well as those which revealed strong colliniarity problems with others. In the process of selection, age of household head and years of experience on the farm (0.4516) , production and grain availability in the store (0.4183), the number of oxen and the amount of TLU that the household owns (0.5464), have shown strong colliniarity problem (figures in bracket are the respective correlation coefficients). From each pair the latter one was dropped from the final specification to improve the result. The alternative OLS regression result obtained by substituting these variables is presented on Annex 4.

TLU and grain in storage is initially assumed to represent capital, on the ground that they manifest the input purchasing power of the household. However, first it has strong correlation with ownership of oxen and grain in store with the level of production, including them in the production function will bias other estimates. Second, the result of a separate regression, which includes TLU and excludes ownership of oxen (See annex-4) produced a statistically insignificant coefficient for TLU. The coefficient of crop in store is highly significant and positive. This could be robust because farmers may report current production as grain in store. Therefore, it might not represent grain stored from previous harvests, as it was specified in the variable capital.

Although the coefficient of the dummy variable for sex of heads of household is statistically significant, the variable is dropped because of its strong correlation with education level of heads of the household. A cross tabulation of education level of household heads and their sex has revealed that women are less educated compared to males. Out of 231 female household heads only 3 can read and write, four are between first and third grade and three are between four and six grade while the remaining 220(95.2%) are illiterate. In contrast to female household heads only 71% of the male household heads are illiterate.

A regression that includes sex of head of the household and excludes education results a coefficient that is positive and significant at 1% (See annex 4). This variable may capture the productivity difference between male and female headed households. Productivity in female headed households are assumed to be low because of many factors[27].

Hetroscdasticity is a common phenomenon in cross-section studies. Its presence is tested using variance co-variance matrix. The variance, standard errors and the corresponding T-ratios are treated against hetroscedasticity. No serious problem was observed between the hetroscedasticity treated T-ratios and the other.

After a series of regression exercises the estimated average Cobb-Douglas production function that is believed to fit the production process is presented on Table -6. The list of variables selected, the corresponding descriptive statistics and correlation matrix is presented appendix 5 and 6.

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[27] Agricultural extenstion services are male orinted, women whether plot holders or not, are not expected to attened agricultural extension training programmes, women farmers have to depend on male labour for most of the heavy works. This dependency on male labour imposes severe difficulty on them; often enough of their land is not ploughed,seeded, or harvested in time (Dessalegn 1994).

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TABLE-6 OLS ESTIMATES OF THE AVERAGE COBB-DOUGLAS PRODUCTION FUNCTION

VARIABLES	COEFFICIENTS	T-ratios	probability dist.
Constant	5.539	6.164	0.00000
Credit	0.050	0.457	0.6477
Cropd	-0.158	-2.944	0.0032
Exinfo	0.126	2.602	0.0092
Agehd	0.020	1.618	0.1058
age2	-0.019	-1.407	0.1595
Lland	0.570	15.314	0.0000
Lfert	0.073	5.092	0.0000
Lflab	0.224	5.243	0.0000
Lhlab	0.243	3.414	0.0006
Lfaid	-0.019	-3.144	0.0016
Lrain	0.160	1.234	0.2171
Minput	0.127	2.068	0.0386
dedu1	0.089	1.425	0.1542
dedu2	0.109	1.357	0.1742
Loxen	0.622	5.229	0.0000
d2	0.681	4.827	0.0000
d3	0.211	1.358	0.1744
d4	0.276	2.117	0.0342
d5	0.286	1.970	0.0488
d6	0.330	1.876	0.0606
d7	0.813	4.775	0.0000
d8	0.174	1.188	0.2348
d9	0.259	1.713	0.0866
d10	0.875	5.903	0.0000
d11	0.467	2.578	0.0099
d12	-0.206	-1.222	0.2216
d13	0.263	1.645	0.1000
d14	0.438	2.583	0.0098

According to the results of the study, most of the variables have their expected sign. Crop damage, food aid and age squared have negative coefficients while the remaining variables have positive signs. Regarding the statistical significance of the coefficients except credit and rain all other variables have statistically significant coefficients.

All the regional dummies have a positive sign except D12, which is a dummy for north and south Omo Gardula and Konso. This positive sign could explain the high level of land degradation and variability of rainfall prevailing in the reference region Tigray compared to the other regions. The regional dummies are expected to pick-up climatic, environmental, economic, social and other location specific effects. Although six out of the thirteen regional dummies have statistically insignificant coefficients, it is believed that they capture the regional effects and exclude these regional effects from the parameter estimates so that they will not bias and influence the overall estimation.

Credit availability is expected to have a positive influence on the level of productivity as it enables the farmer to buy factor inputs on time. Although many farmers are currently using credit facilities to buy fertlizer, due to lack of data this formal credit is not included in this study. As a result only informal credit received from traders is included. A dummy variable is used to distinguish those who received credit (only from traders) from those who do not. The very high interest rate associated with the credit is prohibitive only 4% of the households reported to have received credit from traders. This small number of observations may not reflect the impact of this variable on the level of production. This could be the reason behind the insignificance of the coefficient.

Although rainfall is the most important variable in rain fed agriculture, the result of this study shows that the variable is insignificant. When all regional dummies are dropped the rainfall variable turns out to be positive and significant. This could be the result of possible correlation of rainfall with the regional dummies. In addition rainfall variation within a certain range may not have a significant impact because more rain beyond the minimum requirement for crops to grow will not have considerable change on its production level. It should be noted that excess rain beyond the maximum requirement for a certain crop will in fact adversely affect production. The interesting behaviour of the rainfall variable is its negative sign and significant coefficient when value of production is used as the dependent variable instead of the adjusted quantity used in the study. This inverse relationship between value of output and rainfall could be explained by the effect of price increase on the value of production. When there is shortage of rainfall there may be crop failure and low production and hence higher price. If the rate at which price has increased due to shortage of rain is greater than the decline in production, then the overall effect will be to increase the value of production which leads to the inverse relationship between value of output and amount of rainfall.

The regression result has confirmed that land is the most important factor input in the agricultural production in Ethiopia. The sign of the coefficient is as expected positive and it is highly significant. The magnitude of the coefficient implies that a 1% change in cultivated land, other things remaining the same, will yield a 57% increase in output.

It is fair to conclude from this result that the basic limiting factor in agricultural production in the highlands of Ethiopia is scarcity of land. This finding is in line with other estimates of agricultural production functions. (Govanni 1985, Shujie 1996, Croppenstedt and Mulat 1997).

The other most important variable is animal traction power that is proxied in this study by ownership of oxen. The coefficient is positive and statistically significant. Although ownership of oxen may not correctly represent the amount of animal power used in the production process, it has a considerable influence on the availability of animal power on time. Farmers who do have their own oxen are free to use them whenever they need , while farmers without oxen have to wait until the animals are free. Thus, the positive and significant coefficient of this variable may explain the relative advantage of oxen owners in preparing their plot on time. In the Food Security Survey farmers were asked whether they can get animal traction at the right time and 54% of them respond that they do not.

The coefficient of family labour behaves as expected; it is positive and significant. The magnitude of the coefficient implies that a 1% change in family labour availability, other things remaining constant, will lead to a 22% increase in output. Hired labour is also important as the coefficient is positive and significant. The households using hired labour are very small compared to the total households included in this study[28]. However, its contribution in the households using hired labour is significant especially during weeding and harvesting periods.

One of the findings of this study is the relationship between production and food aid. The coefficient of calorie food aid received is negative and statistically significant (at 1%). Normally food aid is given to households experiencing crop failure. However, in this study crop failure is expected to be picked up mainly by the variable crop damage and other variables such

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28 Evidence from Ethiopian Rural Household Survey show that the proportion of family labour used in the production of cereals is 84%, 79%,

as rainfall and regional dummies. If crop failure as it is assumed by this study is captured by these variables, the negative and significant coefficient of food aid might be picking-up some adverse effects of food aid on agricultural production.

One possible explanation for the inverse relationship between food aid and production is that food-for-work, as it is a source of off-farm income, may compete for the labour resource with crop production and divert labour power from own farm production[29]. Returns from participating in Food-for-work programmes is certain and some times could be better and attractive for the farmers compared to farm income that is characterised by high production risks. Furthermore, some of the activities covered under food-for-work (such as nursery- seedlings, preparing pits for seedlings, planting seedlings, hillside closure, weeding, etc.) coincides with the peak period for farming activities (May, June, July, August). This could make the influence of competition and the removal of labour from farming consequential.

In addition, there is an opinion that persistent supply of food aid could have an adverse effect on the productive attitude of the farmers. Continuous supply of food aid year after year for a specific area may create an attitude of dependency, eroding farmers confidence and motivation for self reliance. In this regard there is a hearsay that a farmer was overheard telling his colleague farmer not to worry about the rain in Ethiopia as long as it rains in Canada. This could be a joke but it may have some grain of truth reflecting the possibility of attitudinal change.

It is difficult, however, to recommended the withdrawal of food aid but the result could provoke and stimulate an in-depth study of the issue. The disincentive impact of continuous food aid on the supply of agricultural labour, price of agricultural products, farmers' attitude etc., must be assessed thoroughly using long period and large sample data.

Educational level of the household head is expected to capture the difference in management practice as it enables farmers to obtain and understand information about new technologies. As it

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and 57% for ploughing, weeding and harvesting respectively.

29 According to the EHRS there is a situiation where the food-for-work programme is forced to reduce the initiall standard grain ration by one-third due to the flow of farmers to the programme beyond the available ration.. (EHRS 1986). The average number of days spent on food-for-work activities per year by participants was estimated to be 45-55 (Tom.F 1986). In Blate and Mulu cash income from food aid was found to be 66%, and 16% of total income respectively (S. Maxwell, 1986)

was indicated in 4.7, in this study education level is represented by two dummy variables DEDU1 dummy for literate farmers and those who have attended up to grade 3 and DEDU2 dummy for farmers who have attended above grade 4 . The result has shown that the coefficients are insignificant but positive. However, the coefficients turns out to be significant when the frontier production is estimated. This could be showing the impact of education on the level of technical efficiency as it helps in pushing out the average production function to its frontier level.

Extension information, which is represented by a dummy variable for farmers participating in SG-2000 and the new extension programme, is found to be important. These farmers are closely supervised by extension agents and are aware and practice important extension information. Thus, the positive and significant coefficient is believed to capture these condition.

Crop damage is found to be one of the limiting factor in the production. The coefficient for this variable is estimated to be -0.158 and it is statistically significant. This result implies that the output loss caused by crop damage is very high.

5.2.2 TECHNICAL EFFICIENCY

In this study all the variables that are expected to affect the level of production directly and other, household /farm specific, variables which affects the level of production indirectly through improving technical efficiency are included in the production function. However some studies have used these variables separately in a two stage regression. First, the production function, using only the essential factor inputs, is estimated and the inefficiency parameters are predicted. In the second stage the predicted inefficiencies are regressed against farm specific variables expected to explain efficiency variation across households.

The two stage regression system is considered to be helpful to identify and explain factors behind farm level efficiency variations. However this method is criticised for its inconsistency in its assumptions regarding the independence of the inefficiency effect in the two estimation stage. The two stage estimation procedure is unlikely to provide estimates which are as efficient as those that could be obtained using a single stage estimation procedure(Tim Coellie 1994).

Kumbhakar, Gosh and Mcgukin (1991), propose stochastic frontier model in which the inefficiency effect U_i are expressed as an explicit function of firm specific variables and a random error as cited in Tim Colli 1994. It is because of these reasons that this study will use only the one stage regression system.

The maximum likelihood estimation of the stochastic frontier production function is presented on Annex 3, while the important parametrtes which is used for analysis are presented on Table 7

The constant term in the MLE is 7.39 while that of the OLS is 5.54. The difference between the two constant terms shows the amount by which the average production function has shifted up ward to its frontier level.

Table 7 PARAMETERS OF THE MLE ESTIMATES OF THE STOCHASTIC FRONTIER COBB-DOUGLAS PRODUCTION FUNCTION

PARAMETERS	COEFFICIENTS	T-RATIOS	PROBABILITY DIST.
Constant	7.3899	22.052	0.00000
σ_u^2	1.2680	—	—
σ_v^2	0.3885	—	—
$\sigma_u / \sigma_v = \lambda$	1.8068	26.622	0.00000
$\sqrt{\sigma_u^2 + \sigma_v^2} = \mu$	1.2872	8.231	0.00000
Technichal efficiency	0.45 (mean)	0.86 (max.)	0.02 (min.)

According to the maximum likelihood estimates the variance of the one sided error term σ_u^2 is 1.268 which is greater than the symmetric component of the error term σ_v^2 which is equal to 0.3885). As it is explained in the previous section, the ratio of the standard errors (λ) is an indicator of the relative importance of the two components of the error term in explaining the variation between observed production and frontier production. A value of λ close to zero implies that the discrepancy between the observed and frontier output is largely explained by random factors beyond the control of farmers while value of λ greater than one implies technical inefficiency. In this regression equation λ=1.807 implying that the output variation between observed and frontier level is much more explained by farmers technical inefficiency rather than random factors which are beyond the control of farmers. We can also use λ to test whether any form of stochastic frontier production function is required at all. If the null hypothesis that λ =0 is not rejected this would imply that σ_u is zero and hence that the U_i term should be removed from the model, leaving a specification with parameters that can be consistently estimated using Ordinary Least Square (OLS). In the present study as $\lambda$is significantly different from zero at 1% level of significance then it could be inferred that the specification of stochastic frontier production function is correct.

The ratio of σ_u^2 to the total variance (i.e. $\mu = \sigma_u^2 / \sigma_u^2 + \sigma_v^2$) measures the relative importance of technical inefficiency in explaining the variation between observed and frontier output. The estimate of μ in the present study is 0.7655 implying that 76.6% of the variation in observed output from frontier output level is explained by technical inefficiency while the remaining 23.4% of the variation is explained by random factors.

The predicted technical efficiency of farmers associated with the stochastic frontier production function assuming a half normal distribution is measured using the method developed by Jandrow et al (1982). And the result has shown that the mean level of technical efficiency of the whole households included in the study to be 0.454[30] .The maximum is 0.858 while the minimum is 0.0198. The estimated mean technical efficiency implies that there is a considerable potential to increase production by improving the efficiency of resource utilization. According to the result, it is possible to attain about 55% increase in output by improving farmers' efficiency. The inefficiency measured seems to be exaggerated. This could be due to possible measurement error which is a common phenomenon in large sample surveys or it could be due to aggregation across large area which will possibly reduce the accuracy of estimation.

The households are catagorized into nine groups depending on their level of efficiency predicted. It is observed that the technical efficiency of about 38% of the households is below the average

[30] In contrast to inefficiency results obtained by Assefa A. 1995 which is 0.87 and 0.91 for unfertlized and fertlized farms respectively, the present study seems to be exaggerated but when it is compared to results obtained by A. Croppenstedt and Mulat. D (0.41) and Abay Assfaw (0.43) the figures are almost alike.

while 43.1% of them show above average level of technical efficiency. the details are presented in the following table.

TABLE--8 DISTRIBUTION OF HOUSEHOLDS BY EFFICIENCY CATEGORY

EFFICIENCY CATEGORY	FREQUENCY	PERCENTAGE	CUMM. PERCENTAGE
0.001 to 0.1	28	1.7	1.7
0.101 to 0.2	140	8.4	10.1
0.201 to 0.3	199	12.0	22.1
0.301 to 0.4	256	15.4	37.5
0.401 to 0.5	321	19.3	56.9
0.501 to 0.6	302	18.2	75.1
0.601 to 0.7	295	17.8	92.8
0.701 to 0.8	109	6.6	99.4
0.801 to 0.9	10	0.6	100.0
TOTAL	1660		

The comparison of mean technical efficiency between male headed and female headed households showed that female headed households are by far lower in their technical efficiency than male headed households. Wile the female headed households have a mean technical efficiency of 0.42, the male headed households have a mean technical efficiency of 0.46. The median and the maximum efficiency for males are 0.47 and 0.86 respectively while for female headed households the median is 0.42 and the maximum is 0.79. As it was discussed in section 4.7 there is expected productivity difference between male headed and female headed households due to cultural and physical constraints on the female headed households. This then is the main reason for the efficiency difference between the two households.

Plotting technical efficiency and farm size indicated that there is no systematic relationship between farm size and efficiency . A simple regression of Technical efficiency on farm size has resulted in an insignificant coefficient confirming the non systematic relationship. This result is contrary to the government emphasis on land fragmentation as a cause of inefficiency, declining productivity land degradation and agricultural backwardness. (MOA 1989) However it is in line with the findings of Yao.S 1990, Croppenstedt and Mulat 1997 etc.,.

The regional distribution of technical efficiency has indicated that mean level of technical efficiency is lower in some zones: Tigray (0.43) , Sidama, Gedeo, Burji, and Amaro (0.43) Yem, Keficho, Maji and Bench (0.44). Low technical efficiency in Tigray could possibly be explained by the fact that Tigray is in the low potential cereal zone where land degradation is wide spread and sever. As land is taken as homogeneous unit and quality difference is not considered in this study, regional efficiency variation may pickup this quality differences in land. The other zones with low mean efficiency are in the high potential perennial zones where production is predominantly coffee and enset.

TABLE---9 ZONAL DISTRIBUTION OF TECHNICAL EFFICIENCY

GROUP OF ZONES	MEAN	MAXIMUM	MINIMUM
Tigray	0.43	0.81	0.08
North and South Gondar	0.47	0.73	0.12
East and West Gojam and Agew	0.46	0.79	0.04
North Wello and Waghemra	0.46	0.76	0.07
South Wello, oromia zone and north Shewa	0.46	0.80	0.05
East and West Wollega (Oromiya)	0.45	0.86	0.07
Illubabor and Jimma (Oromiya)	0.45	0.84	0.03
North and West Shewa (Oromiya)	0.45	0.80	0.04
East Shewa Arsi, Bale and Borena	0.46	0.79	0.12
East and West Harrarghe	0.47	0.74	0.10
Yem, Keficho, maji, Shekichoand Bench	0.44	0.81	0.07
North and South Omo, Dereshe,and Konso	0.45	0.81	0.05
Hadya, Guraghe and Kembata	0.46	0.73	0.06
Sidama, Ghedo, Burji and Amaro	0.43	0.80	0.02

A comparison of mean technical efficiency of the three different agro-ecological zonation is conducted and the result revealed that the mean Technical efficiency in the Low Potential Cereal (LPC) crop zone is (0.43) which is lower than the two other zones HPC(0.48) and HPP (0.45). Since land degradation is one of the major causes for the deterioration of soil fertility, the efficiency variation might be explaining this fact[31]

The comparison of mean technical efficiency among household holders with different education level has revelled that at lower level of education, it is very difficult to establish meaningful relationship between education and efficiency. At lower level, education may not have substantial influence on the farmers ability to adopt new technology but as the education level increases the ability of farmers to obtain , understand and utilize information towards their

[31] According to the EHRS the extent of land degradation is very serious in 24%, serious in 26% and moderate in 25% of the total land area in the low potential cereal (LPC) zone. These figures are 13%, 16% and 32% respectively for high potential cereal zone (HPC) while they are 4%, 9% and 21% for High potential perennial (HPP) zone respectively (EHRS 1986).

benefit improves[32].

A comparison of technical efficiency of households, by educational level has indicated that education has a positive impact on the productivity of farmers. The mean level of technical efficiency for literate farmers is 0.45 while for those who are twelve grades complete is 0.53.

TABLE-10 DISTRIBUTION OF EFFICIENCY BY EDUCATION LEVEL OF HEAD OF HOUSEHOLDS

LEVEL OF EDUCATION	MEAN	MEDIAN	MAXIMUM	MINIMUM
ILLITERATE	0.46	0.47	0.86	0.02
CAN READ AND WRITE	0.45	0.46	0.82	0.03
1 TO 3 GRADE	0.47	0.49	0.81	0.07
4 TO 6 GRADE	0.47	0.49	0.81	0.07
7 TO 8 GRADE	0.42	0.43	0.80	0.09
9 TO 11 GRADE	0.49	0.45	0.80	0.14
12 COMPLETE	0.53	0.56	0.80	0.20

32 sixteen studies of the relationship between farmers education and productivity in low income countries were surveyed by Lockheed et al (1980). These studies have analysed 37 sets of farm level data that allowed estimation of the effect of farmers education on profit or output controlling for other variables. Averaging the varied effect of education obtained in these studies the productivity of farmers was on the average 8.7% higher if they had completed four years of primary schooling (a threshold level) compared with none. Jamison and lau (1982)estimated that a year of schooling in Malasya, Thailand and South Korea is associated with 5.1, 2.8, and 2.3 percent increase in farm product.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

Over the last few decades Ethiopia has lost the lives of millions of its people due to the failure of the agricultural sector to perform well and feed its continuously growing population. Though many studies have claimed that Ethiopia has substantial potential for increasing agricultural production through horizontal expansion, realisation of this potential is not feasible at least under the present state of technology. The arable area which the existing technology and resource enables the farmer to cultivate seems to have been exhausted. The continuous decline in average holding size, the emergence of landlessness and the cultivation of marginal land are the manifestations of this fact.

The prevalence of severe land degradation is continuously reducing the productivity of land and rapidly changing landscape from a one time fertile land into a waste land. According to EHRS estimate, around 100,000 Km^2 or 18% of the highland area will have less than 10cm soil depth by the year 2010. If the current trend of degradation and the high rate of population growth continues unabated, the gap between food supply and demand is likely to widen further.

As the potential to increase agricultural production by bringing new resources into use becomes difficult and perhaps unattainable in the short run, ways of improving production with the existing resources at hand must be sought. Improvement in the efficiency of utilising available resources is an important means through which additional production could be attained. The prospect of development in Ethiopia also lies heavily on the performance of the agricultural sector.

Studies conducted in developing countries have exhibited that there exists a considerable amount of technical inefficiency among private farmers (Shapiro 1980, Bagi 1982, Ali and Chanduru 1990).

Using cross-sectional data collected from 1660 households in the highlands of Ethiopia, this study has attempted to estimate the stochastic frontier Cobb-Douglas production function and examine the determinants of food production. Most of the coefficients of the variables included in the production function (except that of credit and rainfall) are statistically significant and have the expected sign.

The estimated frontier production function has stated that, the major determinants of food production in the Ethiopian highlands are the traditional inputs of land, oxen and labour (family and hired)The estimated coefficients are 0.57, 0.62, 0.22 and 0.24 for land, oxen, family labour and hired labour respectively. The magnitude of the coefficient implies that a one percent change in cultivated land, other things remaining the same, will yield a 55% increase in output. Similarly a one percent change in oxen , other things remaining the same will result in a 56% increase in output. This finding is in line with other estimates of agricultural production functions. (Govanni 1985, Shujie 1996, Croppenstedt and Mulat 1997).

Although the application of modern inputs (improved seeds, pesticides, irrigation etc.) is very limited except that of fertlizer, their importance in explaining output is confirmed by the positive and significant coefficient observed in the estimated production function. Fertlizer is treated independently and it has apositive and significant coefficient confirming its important contribution in Ethiopian agriculture.

The influence of household specific socio-economic characteristics is also observed in the results of the study. Education level and age of household heads that are expected to proxy management and experience have exhibited positive and significant relationship with output.

This study has also made an attempt to empirically examine the technical efficiency of private farmers in the highlands of Ethiopia. The findings of the study have indicated that there is a significant amount of technical inefficiency among private farmers. The mean technical efficiency of the households covered in this study is estimated to be 0.45 with a minimum of 0.019 and a maximum of 0.858. Besides, the result has figured out that the deviation of actual production from the frontier (the best practice) production is dominantly created by factors which are under the control of farmers (inefficiency). The implication of this finding is that it is possible to attain a maximum of 55% increase in output by improving the efficiency of private farmers up to the point of frontier production level. This figure seems to be exaggerated and to take it at face value could be misleading. However, it can be used as a signal to the presence of inefficiency and as means of comparing efficiency variation among different groups of households.

A comparison of technical efficiency of households by educational level has indicated that education has a positive impact on the productivity of farmers. The mean level of technical efficiency for literate farmers is 0.45 while for those who are twelve grades complete is 0.53.

Another important finding of this study is the inverse relationship observed between food aid received and output. Although it is very difficult to strongly conclude that the negative coefficient of food aid is only capturing the impact of this variable on production it can be used as a clue for further study.

Considering the results of this study the following recommendations are proposed.

- Emphasis should be given to human capital development activities, through giving investment priority to education, extension services, mass media etc,.

- As increasing production through expansion of cultivated land becomes very difficult, measures to improve productivity of land must be considered. In this regard the current effort in the new extension programme (PADETES) should be strengthened and expanded to cover large number of farmers. Moreover, NGO's should be encouraged to participate in the intensification of Ethiopian agriculture.

- One limiting factor in Ethiopian agriculture is shortage of oxen. Thus, the existing little effort to enable farmers to own oxen through rural credit scheme must be organized and conducted at a massive scale. Side by side there must be intensive extension effort to persuade the farmers that ploughing with one ox is practical.

- Alternate energy programmes which reduce the severe shortage of household energy could increase the amount of animal and plant residues returned to the soil, enabling the farmer to practice the traditional soil fertility restoring techniques. Thus emphasis must be given to the dissemination of the already developed alternate energy sources. Further research should also be encouraged to develop other energy sources appropriate to the Ethiopian conditions.

- Effort to reduce crop damage through proper weeding and pest control must be enhanced.

- A wide scale study must be conducted to assess the disincentive impact of food aid in terms of domestic food production, agricultural labour supply, and price of agricultural products.

REFERENCES

Abate.T (1991) **Water Resource Management and Development in Ethiopia** , Paper presented for World Bank Conference on Water Resource Development ,1991.

Abay Asfaw and Assefa Admassie (1997) **The Impact of Education On Allocative and Technical Efficiency of Farmers**: The Case of Ethiopian Smallholders. A paper presented at the seventh annual conference on the Ethiopian Economy. Nov 28-30, 1997 Natherth.

Afriat. S.N (1972) **Efficiency Estimation of Production Functions** International Economic Review 13 , 568-198.

Aigner.D J. Lovel ,C.A.K and Schmidt. p (1972) **Formulation and Estimation of Stochastic Frontier Production Function Models** J. Econometrics 6, 21-32.

Aregay Waktola (1986) **Production of Staple Crops for self-sufficiency in Ethiopia** a paper presented at a national workshop on food strategies for Ethiopia , Dec. 8-13 Alemaya University of Agriculture.

Asmerom Kidane and David G. Abler (1993) **Production Technology In Ethiopian** Agriculture ELSEVIER Science B.V. Agricultural Economics 10 , 179-191.

Assefa admassie (1995) **Analysis of Production Efficiency and the Use of Modern Technology in Crop Production** : a Study of Small holders in the Central Highland of Ethiopia. Wissenshaftsverlag Vauk Kiel KG.1995.

Berhanu Debele (1989)**The Role of Land Use Planning in Ethiopia's National Food Strategy**. A paper presented at the national workshop on food Strategies for Ethiopia Dec.8-12 1986.

Constable .M (1984) **Resources for Rural Development** : Ethiopian Highland Reclamation Study MOA/FAO Addis Ababa.

Croppenstedt A. and Mulat .D (1997) An **Empirical Study of Cereal Crop Production and Technical Efficiency of Private Farmers in Ethiopia**: a mixed fixed- random coefficients approach . Applied Economics, 1997.

Croppenstedt A. and Mulat D (1998) **Technology Adoption in the Presence of Constraints: The Case of Fertlizer Demand in Ethiopia**, April 1998.

Daniel C. Clay , Daneil .M and Debebe.H (1997) **Food Aid Targeting in Ethiopia**: **A Study of Household Food Insecurity and Food Aid Distributions**. GMRP, MEDaC, Working Paper 12 March, 1998.

Daniel Gamachu (1988) **Environment and Development in Ethiopia**, In Angela Penrose's edition Beyond the Famine : An Examination of the Issue Behind Famine in Ethiopia, Switzerland Jan 1988.

Dessalegn Rahmato (1984) **Agrarian Reform in Ethiopia**. Trenton, NJ Red Sea Press.

_______________(1994) **Land Policy In Ethiopia at the Cross-roads.** In Dessalegn's edition **Land Tenure and Land Policy in Ethiopia after the Derg**, Proceedings of the Second Workshop of the Land Tenure Project, IDR, AAU, 1994.

Dejene Aredo, (1997) **The Determinants of Cropping Pattern and Agricultural Productivity in Ethiopia 1980-1995** Department of Economics AAU (mimeo) 1997.

Elisabeth Sadoulet and Alian De. Janvry (1995) **Quantitative Development Policy Analysis** John Hopkins University Press, London.

Farell M.J (1957) **The Measurement of Productive Efficiency** J. R. Stat Soc.Ser A 120 pp 253-295

FAO/MOA (1986) **Highlands Reclamation Study Ethiopia** : Final report Volume 1 & Volume 2, Rome 1986.

FAO/UNDP (1984) **Ethiopia: Land Use, Production Regions and Farming System Inventory** , Technical Report 3, Vol I Rome FAO, 1984.

Frank Ellies (1988) **Peasant Economics Farm Household and Agrarian Development** Cambridge Univesity Press N.Y 1988.

Hurni Hans (1986) **Degradation and Conservation of the Soil Resource in the Ethiopian Highlands** Paper presented at the First International Workshop on African Mountains and Highlands, Ethiopia, 18-27 October, 1986.

Finn R. Forsund et al (1980) **A survey of Frontier Production Functions and of their Relationship to Efficiency measurement**. Journal of Econometrics 13 (1980) 5-25 North -Holland publishing Company.

Gebremeskel Dessalegn, T.s Jayne, J.d Shaffer (1998) **Market Structure, Conduct, and Performance: Constraints on the Performance of Ethiopian Grain Markets**. WP No 8, GMRP MEDaC , Addis Ababa, Jan. 1998.

George E Battese (1992), **Frontier Production Functions and Technical Efficiency: A survey of Empirical Applications in Agricultural Economics.** Agricultural Economics 7, (1992) 185-208. Elsevier Science Publishers B.V. Amsterdam.

Giovanni A. Cornia (1985) **Farm Size, Land Yields and the Agricultural Production Function. An Analysis for Fifteen Developing Countries**. World Development Vol. 13 No. 4 April 1985.

Hla Myint (1965) **Economic Theory and the Under Developed Countries**. Journal of Political Economy Vol. 73, No. 5, pp 477-491.

Hamza A. and Azanaw T (1995) **Structural Adjustment Policy and Ethiopian Agriculture an Assessment of Short-run Response and Structural Problems**. In Dejene A and Mulat. D edition. Ethiopian Agriculture Problems of Transformation A.A. 1995.

H.E. Campbell (1976) **Estimating the Productivity of Agricultural Pest Sides**. Canadian Journal of Agricultural Economics Vol. 24 No. 2 July 1976.

Humpreys C.P. (1975) **An Empirical Investigation of Factors Affecting Peasant Crop Production Survey of the Ada Woreda, Ethiopia**. Unpublished Ph.D. Dissertation.

Ibrahim A.Z. (1995) **"The Impact of Macro Economic Policy Reforms on Agriculture"**. In Dejene A. and Mulat D. edition <u>Ethiopian Agriculture Problems of Transformation</u>. A.A. 1995.

Jamison, D.T and Lau L.J (1982) **Farmer Education and Farm Efficiency** . Baltimore MD Johns Hopkins University press.

Jandrow J. Lovell. C.A.K Materovis and Schmidt.P (1982). **On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model** , Journal of Econometrics, 19 233-238.

J.C. Headley (1968) **Estimating the Productivity of Agricultural Pesticides**. American Journal of Agricultural Economics Vol. No 1 Feb. 1968.

John Straus (1983)..

Kementa J 1967 **On the Estimation of The C.E.S Production Function** International Economic Review pp 180-189.

Kibre Moges (1989) **General, Assessment of the Draft Article "A Model for Food and Agricultural Policy Analysis."** by University of Oxford Food Study Group.

_________(1990) **Modelling the Agricultural Sector in Ethiopia A Specification Issue Part I: Production Function**. Addis Ababa

Kidane A. & kocklaeuner, G. "**A Macro Econometric Model for Ethiopia "Specification, Estimation, Forecast & Control.**" East African Economic Review, New serves, (1985) No.1

Lau.L and P.Yotopulos (1971) **A Test for Relative Efficiency and Application to Indian Agriculture**. American economic Review.

Lockheed. M. Jamison, D. and Lau.L (1980) **Farmer Education and Farm Efficiency: A Survey.** Economic Development and Cultural Change 29:1

MEDaC (1987) **Pricing Policy Study:- Grain Price Determination**. A study conducted by a national task force and issued in Amharic.

MEDaC (1998) **Survey of Water Sector** , MEWRD, MEDaC, 1998

Meeusen and Van Den Broeck (1977). **Efficiency Estimation from Cobb-Douglas Production Function with Composed Error Inter**. Economic Review.

Mesfin Mirotchie, (1994). **Technical Efficiency of Ethiopian Agriculture**, on Berhanu Abegaz's edition Essay on Ethiopian Economic Development , Avebury 1994.

Ministry of Agriculture (1986) **Development Program for the Increased Production of Maize, Wheat and Sorghum**. Addis Ababa.

Ministry of Agriculture (1986b) 1979-81(E.C) **Strategy for Food Self Sufficiency**. Addis Ababa Sept. 1986 , (Amharic Version).

Ministry of Agriculture (1989) **A Study Report on Land Reallocation and Fragmentation**. (Amharic version) Addis Ababa:

Mulat Demeke (1984) **The Supply Response of Subsistence Peasants: The Case of Teff Growers in Some Districts of Showa**. Msc Thesis unpublished.

__________ (1995) **"Fertilizer Procurement, Distribution and Consumption in Ethiopia."** In Ethiopian Agriculture: Problems of Transformation Proceedings of the Fourth Annual Conference on the Ethiopian Economy. Addis Ababa 1995.

Mulat.D et al (1998) **Agricultural Market Performance and Determinants of Fertlizer Use In Ethiopia**, GMRP, MEDaC jan. 1998

Olsen, J.A., P. Schmidt, and D.M. Waldman (1980). **A Monte Carlo Study of Estimators of Stochastic Frontier Production Functions**. Journal of Econometrics, 13(1).

Pan. A Yotopoulos (1967). **Allocative Efficiency in Economic Development: A cross Section Analysis of Epirus Farming**. Centre of Planning and Economic Research Atense.

Prime Minister Office (PMO)(1993) **Demographic Profile and Population Policy of Ethiopia.** PMO, Office of Population July 1993.

Schultz. T.W. (1984) **Transforming Traditional Agriculture.** Yale University Press.

Seifu Ketema (1989) **Food Self-sufficiency and the role of Teff (Eragostis Teff) in Ethiopian Agriculture** A paper presented at the national Workshop on Food Strategies For Ethiopia Dec. 8-12 1986.

Shapiro K.H (1983) **Efficiency Differentials In Peasant Agriculture and Their Implication for Development Policies** . Journal of Development Studies Vol. 19 No2 pp 179 190.

Simon Maxwell (1986) Food Aid: **Agricultural Disincentives and Commercial Market Displacement,** IDS, Discussion paper 224. Dec 1986.

Solomon Ayalew (1989) **"Labour Supply in Agriculture Problem or Springboard for Development."** Paper presented at the national work shop on food strategy for Ethiopia 8-12 December 1986 Alemaya.

Stefan Brune: **The Agricultural Sector Structure Performance and Issue (1974-1988)**. In Siegfried. P. et al eds. Ethiopia Rural Development Options Zed Books London 1990.

Tamre Hawando (1989 **Increasing Agricultural Production In Ethiopia Through Improved Soils, Water and Crop Management Practice**. A paper presented at the national workshop on food and nutrition strategy A.A.

Transitional Government of Ethiopia (1994). **National Conservation Strategy Vol II National Policy on Natural Resources and the Environment**. MNRDEP/MEDaC Addis Ababa, Dec. 1994.

Tim Coellie (1994) **A Guide to FRONTIER Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation** , Department of Econometrics University of New England Armidale, NSW, 2351 Australia (1994).

Tom Franklin (1986) **Food-for-work: A Case Study** Paper presented at the Workshop on food -for-work in Ethiopia, July 25-26, 1986

The World Bank : (1983) **Ethiopia, the Agricultural Sector an Interim Report.** Vol. 1983.

----------------------(1987) **Ethiopia: Agriculture a strategy for Growth a Sector Review** Volume 1 & 2 Report No 6512-Et.

.... **World Development Reports**, 1982,1986, 1993,1994,1995.

UNECA/FAO, (1995) Improving Food Security in Africa: The ignored contribution of Livestock, Monograph 14, Addis Ababa.

Yao. S. (1990) **The Determinants of Cereal Crop Productivity of the Peasant Farm Sector in Ethiopia 1981-87**. Journal of International Development Vol. 8 No. 1.

ANNEXES

ANNEX--1 SUMMARY OF EMPIRICAL WORKS BY VARIOUS AUTHORS

authors	country	production function estimated	purpose of the study	method of estimation	result	
					range	average
Russell and Young (1983)	56 farms in north England	deterministic frontier Cobb-Douglas production function.	To measure technical efficiency of farmers	cols	0.42-1.00	0.73
Konots and Young (1983)	83 Greek farms	deterministic frontier Cobb-Douglas production function.		cols	0.3-1.00	0.57
Taylor et al	brazil	deterministic frontier Cobb-Douglas production function.	to evaluate worl bank sponsored credit programme	cols where ui is assumed to have gamma distribution	participant non participant	0.18 0.17
aly et al (1987)	Illinois 88 grain farms	ray- homiletic deterministic frontier		cols		0.58
Bravo-Ureta (1986)	new England USA	deterministic frontier Cobb-Douglas production function.			0.58-1.0	0.82
Ali and Chaudhry (1990)	four region of Pakistan Punjab	Cobb Douglas deterministic frontier production function		linear programming method	0.80-0.87	
Battese and Cora (1977)	74 Australian grazing industry	deterministic and stochastic Cobb Douglas frontier production			γ>0.95	
Kalirajan(1981)	70 rice farmers in India				γ=0.81	
Bagi (1982a)	small and large farms in west tense	cob Douglas stochastic frontier	to identify efficiency difference between small and large crop with mixed enterprises		mixed enterprise small and large crop	0.76 0.85
Baggy and Hung (1983)	small and large farms in Tennessee	trans logarithmic stochastic frontier production	to identify efficiency difference between small and large crop with mixed enterprises	corrected ordinary least square (cols)	mixed enterprise small and large crop	0.67 0.73
Bagi (1982b)	34 share cropping farms in India	trans log stochastic frontier production function		cols	0.92-0.95	
Kalirajan and Fling(1983)	79 rice farms in the Philippines	trans log stochastic frontier production function		maximum likelihood	0.38-091	
Hang and Bagi (1984)	individual farms in India	trans log stochastic frontier production			0.75-0.95	
Tailor and Shonkwiler (1986)	world bank programme participant and non participant in brazil	both deterministic and stochastic cob Douglas production function		maximum likelihood method	participants non participants	0.71 (.185)for deterministic 0.70(0.06) for detrm.
Hung Tang and Bagi(1986)	two states of India	stochastic profit function			large small	0.84 0.80
Kalirajan and Shined (1986)	Malaysia	trans log stochastic frontier production	to evaluate the impact of Kemubu irrigation project estimating farmers efficiency with and without the project	maximum likelihood method was used	0.40-0.9	
Damson and Lingered(1989)	rice farmers in Philippines	cob Douglas deterministic and stochastic frontier			0.1-0.99	
Shapiro (1983)	cotton farmers in Tanzania	Cobb-Dogulas		Liniar Programmin		0.49

ANNEX 2 LIST OF VARIABLES

LY_1	Log of value of output
LY_2	Log of quantity of output adjusted composite price index
CREDIT	Dummy 1 if the household received credit from traders and zero otherwise
CROPD	Dummy 1 if household reported crop damage and zero otherwise
EXINFO	dummy 1 if the household is covered under SG-2000 governments new extension programme and zero otherwise.
Age	Age of the household head.
Age2	Square of age.
LAND	Hectares of land covered under major crops both Belg and Meher seasons.
FERT	KGs of commercial fertlizer used.
FLAB	Members of the family labour availability measured in one adult man unit
HLAB	Hired labour availability measured in one adult man unit.
FAID	Total calorie food aid (free food aid and food-for-work) received by the household.
RAIN	Five years average rainfall at woreda level.
MINPUT	Dummy 1 if household used any of the modern inputs. 0 if household do not used any of them.
DEDU1	Dummy 1 if the education level of heads of household is grade three and below.
DEDU2	Dummy 1 if the education level of head of the household is greater than grade three.
OXEN	The number of oxen that the household owns.
D_2	Dummy for North South Gondar.
D_3	Dummy for East and west Gojam.
D_4	Dummy for North Wello and Waghemra.
D_5	Dummy for South Wello and Oromia
D_6	Dummy for East and West Wollega.
D_7	Dummy for Illubabor and Jimma.
D_8	Dummy for North and West Shewa
D_9	Dummy for East Shewa Arsi and Bale.
D_{10}	Dummy for East and West Hararghe.
D_{11}	Dummy for Yem, Keficho, Majii and Shekicho.
D_{12}	Dummy for North and South Omo ,Gardula and Konso.
D_{13}	Dummy for Hadya Guraghe and Kembata.
D_{14}	Dummy for Sidama Gedo, Burgi and Amro.

ANNEX 3 MLE RESULTS FOR THE STOCHASTIC FRONTIER COBB-DOGULAS PRODUCTION FUNCTION

VARIABLES	COEFFICIENTS	T-ratios	probability dist.
Constant	7.3899	22.052	0.00000
Credit	0.042455	0.280	0.71068
Cropd	-0.12958	-2.466	0.01259
Exinfo	0.13645	2.836	0.00393
Agehd	0.023665	1.756	0.04461
age2	-0.000229	-1.583	0.08054
Lland	0.55475	14.793	0.00000
Lfert	0.06832	4.827	0.00000
Lflab	0.21178	4.962	0.00000
Lhlab	0.23133	3.633	0.00228
Lfaid	-0.017363	-2..892	0.00645
Lrain	0.023500	0.558	0.84180
Minput	0.15816	2.515	0.00788
Dedu1	0.10833	1.834	0.07828
Dedu2	0.13627	1.594	0.06441
Loxen	0.55936	4.836	0.00000
d2	0.53891	3.470	0.00014
d3	0.18401	1.145	0.18113
d4	0.15776	1.045	0.18333
d5	0.22049	1.372	0.08315
d6	0.36838	2.064	0.01328
d7	0.80379	4.726	0.00000
d8	0.16025	0.938	0.18138
d9	0.17137	0.997	0.21815
d10	0.70283	4.260	0.00000
d11	0.51693	2.745	0.00047
d12	-0.21784	-1.197	0.12144
d13	0.16626	0.920	0.27009
d14	0.47629	2.225	0.00021
$\sigma_u / \sigma_v = \lambda$	1.8068	26.622	0.00000
$\sqrt{\sigma_u^2 + \sigma_v^2} = \mu$	1.2872	8.231	0.00000

ANNEX- 4 ALTERNATIVE OLS REGRESSION *RESULTS FOR THE AVERAGE COBB-DOGULAS PRODUCTION FUNCTION*

VARIABLES	COEFFICIENTS	T-RATIO	probability dist.
Constant	8.056	7.94	0.0000
Credit	-0.065	-0.61	0.5403
Cropd	-0.176	-3.44	0.0006
Exinfo	0.072	1.58	0.1136
YOPR	0.014	2.47	0.0137
YOP2	-0.001	-1.61	0.1083
Lland	0.524	14.84	0.0000
Lflab	0.244	6.06	0.0000
Lhlab	0.183	2.70	0.0069
Lfaid	-0.021	-3.59	0.0003
LFERT	0.069	5.06	0.0000
LCSTORD	0.001	13.00	0.0000
SEXHD	0.272	4.10	0.0000
LELE	-0.256	-0.83	0.4095
MINPUT	0.089	1.54	0.1239
LTLU	0.025	0.85	0.3907
d2	0.283	3.38	0.0007
d3	-0.157	-1.98	0.0475
d4	-0.042	-0.48	0.6311
d5	-0.069	-0.87	0.3847
d6	0.038	-0.53	0.5972
d7	0.445	6.15	0.0000
d8	-0.274	-3.06	0.0022
d9	-0.060	-0.61	0.5406
d10	0.369	3.72	0.0020
d11	0.187	2.07	0.0385
d12	-0.563	-6.03	0.0000
d13	-0.071	-0.65	0.5188
d14	-0.021	0.18	0.8567

ANNEX-5
DISCRIPTIVE STATSTICS OF THE VARIABLES

VARIABLES	MEAN	MINIMUM	MAXIMUM	N	LABLES
LAND	1.21	.11	8.74	1660	TOTAL LAND OPERATED IN HECTAR
FLAB	2.66	1	21	1660	TOTAL AVAILABLE FAMILY LABOUR
HLAB	.20	0	20	1660	TOTAL AVAILABLE HIRED LABOUR
OXEN	1.28	0	8.00	1660	NUMBER OF OXEN OWENED
KGFERTLI	23.82	0	800.00	1660	KGS OF FERTLIZER USED
MINPUT	.21	0	1.00	1660	USED ANY TYPE OF MODERN INPUTS
TLU	1.71	0	17.5	1660	TROPICAL LIVESTOCK UNITS
EXINFO	.12	0	1	1660	PARTICIPATED IN NEW EXT PROGRAMME
CROPD	.73	0	1	1660	HAVE YOUR CROP DAMAGED?
EDUC	1.65	1	7	1660	EDUCATIONAL LEVEL OF HEAD OF HH
CREDIT	.05	0	1	1660	RECIVED CREDIT FROM TRADERS,
SIZEHD	5.31	1	14	1660	NUMBER OF HOUSEHOLD MEMBERS
YRSOPRAT	15.44	1	70	1660	# OF YEARS OPERATNG THE FARM
STORE	221.36	0	9329.16	1660	KG OF GRAIN REPORTED TO BE IN STORE
KGTPRODU	1166.47	51.03	3042.28	1660	KG OF TOTAL PRODUCTION
RAINFALL	1211.24	471	2100	1660	AVERAGE RAINFALL AT WOREDA LEVEL
VALOUT	1404.62	116.13	22186.14	1660	TOTAL VALUE OF CROP PRODUCED
ELEVATIO	2086.73	1500	3000	1660	AVERAGE ELEVATION AT WOREDA LEVEL
FAID	49777.55	0	3163500	1660	TOTAL CALORIE FREE FOOD AID RECIVED

ANNEX- 6

Correlation coefficients of some variables

	TLU	OXEN	STORE	KGTPRODU	RAINFALL	ELEVATIO
TLU	1.0000	.5464	.1724	.1318	-.0657	.0736
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .	P= .000	P= .000	P= .000	P= .007	P= .003
OXEN	.5464	1.0000	.2522	.1910	-.0408	.0249
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .000	P= .	P= .000	P= .000	P= .097	P= .311
STORE	.1724	.2522	1.0000	.4183	.0387	.0176
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .000	P= .000	P= .	P= .000	P= .115	P= .474
KGTPRODU	.1318	.1910	.4183	1.0000	.0755	-.0272
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .000	P= .000	P= .000	P= .	P= .002	P= .269
RAINFALL	-.0657	-.0408	.0387	.0755	1.0000	-.2126
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .007	P= .097	P= .115	P= .002	P= .	P= .000
ELEVATIO	.0736	.0249	.0176	-.0272	-.2126	1.0000
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .003	P= .311	P= .474	P= .269	P= .000	P= .
SEXHD	-.0734	-.1048	-.0114	-.0787	.0072	.0652
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .003	P= .000	P= .642	P= .001	P= .770	P= .008
EDUC	-.0034	-.0253	.1153	.0691	.0823	.0030
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .889	P= .302	P= .000	P= .005	P= .001	P= .902
SIZEHD	.3209	.3111	.1076	.1702	.0195	-.0775
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .000	P= .000	P= .000	P= .000	P= .426	P= .002
FLAB	.1292	.1467	.0135	.0615	.0718	-.1036
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .000	P= .000	P= .583	P= .012	P= .003	P= .000
CROPD	-.0172	.0223	-.0076	.0269	-.0338	-.0071
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .483	P= .363	P= .759	P= .273	P= .169	P= .773
FAID	-.0815	-.0394	-.0580	-.0708	-.1730	-.0089
	(1660)	(1660)	(1660)	(1660)	(1660)	(1660)
	P= .001	P= .108	P= .018	P= .004	P= .000	P= .716

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Annex-7 Supplementary Tables

AX7-1 Average Area Under Crop '000ha , (1961-1994).

PERIOD	MAIZE	WHEAT	SORGHUM	TEFF	BARLEY	MILLET	TOTAL
1961-1965	773	576	1238	2835	1229	291	6942
1966-1970	829	1029	1155	2154	1693	299	7159
1971-1975	850	918	1043	1805	1232	263	6111
1976-1980	780	510	806	1393	744	256	4489
1981-1985	854	537	792	1334	752	229	4498
1986-1990	1054	670	754	1302	950	162	4938
1991-1994	955	579	534	1354	690	186	4106
AVERAGE	870	688	903	1740	1041	241	5463

Source : 1961-1985 Data Book on Land Use and Agriculture in Ethiopia, LUPRD/FAO 1984 cited on Aregay Waktola 1986, 1986-1994 author's computation from results of CSA publications.

AX7-2 Average Crop Production ('000 qt), (1961-1994)

PERIOD	MAIZE	WHEAT	SORGHUM	TEFF	BARLEY	MILLET	TOTAL
1961-1965	7244	4254	9932	16018	9910	1424	48782
1966-1970	8526	7624	9684	14254	14318	1504	55910
1971-1975	9042	7426	9080	11942	10504	1420	49414
1976-1980	10352	5076	9324	11066	7786	2306	45910
1981-1985	9926	6040	9142	11718	10163	1957	48946
1986-1990	16922	7854	9099	10532	10514	1480	56956
1991-1994	14166	7749	6232	14515	7986	1618	50141
AVERAGE	10882	6575	8928	12864	10169	1673	50866

Source : 1961-1985 Data Book on Land Use and Agriculture in Ethiopia, LUPRD/FAO 1984 cited on Aregay Waktola 1986, 1986-1994 author's computation from results of CSA publications.

AX7-3 Average Yield Of Major Crops qt/ha, (1961-1994)

PERIOD	MAIZE	WHEAT	SORGHUM	TEFF	BARLEY	MILLET	TOTAL
1961-1965	9.4	7.4	8.0	5.7	8.1	4.9	7.0
1966-1970	10.3	7.4	8.4	6.7	8.5	5.0	7.8
1971-1975	10.7	8.1	8.7	6.9	8.5	5.4	8.1
1976-1980	12.1	9.9	11.2	8.0	10.5	9.0	10.2
1981-1985	12.0	10.0	10.5	8.6	13.5	8.5	10.9
1986-1990	16.1	11.7	12.1	8.1	11.1	9.1	11.5
1991-1994	14.8	13.4	11.7	10.7	11.6	8.7	12.2
AVERAGE	12.5	9.6	9.9	7.4	9.8	6.9	9.3

Source : 1961-1985 Data Book on Land Use and Agriculture in Ethiopia, LUPRD/FAO 1984 cited on Aregay Waktola 1986, 1986-1994 author's computation from results of CSA publications.

AX7-4 Average Size of Rainfed Arable Land Area Available to Each Rural Household in Ethiopia

Regions	estimated number of rural household	Estimated raifed arable area	Arable area per household
1. Northern	2603310	136940	5.30
Tigray	539270	19930	3.70
Wello	842680	36220	4.30
Gondar	655360	73470	11.2
2. Eastern			
Hararghe	958840	47990	5.00
3. Central			
Shewa	1807020	77490	4.30
4. Southern	1756250	177030	10.10
Arsi	358720	22990	6.40
Bale	216830	54890	25.30
Sidamo	878820	68080	7.70
Gamogofa	301880	31070	10.30
5. Western	2197920	233610	10.60
Gojam	764650	62560	8.20
Wollaga	581390	70980	12.20
Illubabor	236000	49190	20.80
Kefa	615880	50930	8.30
Total Ethiopia	9323840	673060	7.20

Source: Danel Gemachu, 1990

AX7-5 Estimated Cultivated Area and Input Application

	1990/91	1991/92	1995/96	1996/97	average
Total area Cultivated in 000'ha.	5410	5297	8687	8825	7055
- Area covered by improved seed	49	33	62	165	77
percentage share	0.90%	0.62%	0.71%	1.90%	1.09%
- Irrigated area in hectare	54	41	85	68	62
percentage share	0.10%	0.77%	0.98%	0.77%	0.88%
-Area covered with pesticide	213	346	821	624	501
percentage share	3.94%	6.53%	9.45%	7.07%	7.10%
-Area covered by fertlizer application	1845	1712	2840	2845	2311
percentage share	34.1%	32.32%	32.69%	32.24%	32.76%

Source:- Various CSA Publications on Agricultural Practice. 1992/1993 and 1993/1994 are the two periods when CSA Agricultural Sample Survey was interrupted because of the preparatory activities for the 1996 population and housing census

AX7-6 Estimated area production and yields of major crops in Ethiopia private smallholders and total (1979/80-1996/97)

Area in '000ha & production in 000'qts

	TOTAL			PRIVATE FARMERS				
				Cultiv. land		Production		
YEAR	Area	Production	Yield	Area	%	volume	%	Yield
1979/80	6060	74955	12.37	5573	92.0	69473	92.7	12.47
1980/81	5678	65605	11.55	5184	91.3	60186	91.7	11.61
1981/82	5653	62962	11.14	5118	90.5	57349	91.1	11.21
1982/83	6088	78053	12.82	5546	91.1	71871	92.1	12.96
1983/84	5733	63366	11.05	5391	94.0	60095	94.8	11.15
1984/85	5865	48553	8.29	5343	91.1	44005	90.6	8.24
1985/86	5985	54036	9.03	5395	90.1	47882	88.6	8.88
1986/87	6076	68450	11.27	5650	93.0	62600	91.5	11.08
1987/88	6053	65320	10.79	5502	90.9	57800	88.5	10.51
1988/89	5743	63770	11.1	5148	89.6	57310	89.9	11.13
1989/90	5836	68950	11.81	5390	92.4	62990	91.4	11.69
1990/91	4949	68260	13.79	4818	97.4	65920	96.6	13.68
1991/92	4803	53550	11.15	4742	98.7	52780	98.6	11.13
1992/93*	-	-	-	-	-	-	-	-
1993/94*	-	-	-	-	-	-	-	-
1994/95	-	-	-	6960		70418		10.12
1995/96	-	-	-	7849		92791		11.67
1996/97	-	-	-	8072		96452		11.95

Source; Results of Central Statistics Authority annual Agricultural Sample Surveys

* 1992/93 and 1993/94 are the two periods when CSA Agricultural Sample Survey was interrupted because of the preparatory activities for the 1996 population and housing census. The figures after 1994/95 are only that of private farmers.

DECLARATION

I, **Wendwosen Feleke**, hereby declare that this thesis is the product of my original research work, all materials are duly acknowledged, and that it has not been submitted to any other university for an award of any academic degree.

Signature: ____________________

Date: May 1998