IMPACT OF EDUCATION ON AGRICULTURAL PRODUCTIVITY: THE CASE OF TEFF PRODUCTION IN TWO RURAL COMMUNITIES IN ETHIOPIA

Negus Negatie[*] & Workneh Negatu[**]

ABSTRACT: *Low level of education is considered to be one of the explaining factors for poor agricultural productivity. The objective of this paper is to empirically determine the effect of education on agricultural (Teff) productivity and to examine conditions under which education exhibits significant impact on productivity. The study is based on data gathered from a total sample of 239 households in two communities – Sirba-Godetti (95 households) located in East Shewa and Shumsheha community (144 households) located in North Wollo.*

A Cobb-Douglass production function was employed to analyze the data. The results of the analysis indicated that formal and non-formal education have significant and positive impact on Teff productivity. The results also showed that agricultural technology and agroecology affect Teff productivity. The implication drawn by the study emphasizes the importance of strengthening human capital, particularly farmers' access to primary education, and strengthening farmers' access to improved agricultural technologies.

[*] Micro-Link College, P.O. Box 21634
[**] Institute of Development Research, Addis Ababa University, P.O. Box 1176

INTRODUCTION

It has been said time and time again that agriculture is the mainstay of the Ethiopian economy. As the main source of rural livelihood, agriculture remains the principal occupation of the majority of people in the country. Agriculture is the major source of raw materials for industries, and the main purchaser of simple farm implements and services (e.g. transport service). Farmers are the major consumers of industrial goods since they constitute the majority of the population (World Bank, 1997).

Despite the importance of agriculture to Ethiopia, its performance has remained below its potential. Information from MEDaC (1998) indicated that the average growth rate of agriculture during the Derg period (1974-1992) was merely 2 percent, which was significantly lower than the rate of population growth. The food deficit in the country increased during this period. Agricultural production in the period did not show a significant improvement. Similarly, the average rate of growth of this sector was 2.27 percent per annum between 1992 and 1998 (National Bank of Ethiopia, 1999). In any case, the rate of growth is much lower than the population growth. The scope of increasing food production through expanding the size of cropland, unlike in the past, is now very limited. In most parts of the low land country, horizontal expansion of local food production to keep pace with the population growth is difficult because of physical, social and economic infrastructure constraints.

With regard to food crop production in the country, cereals contribute about 70 percent of the total field crop production. Teff production covered 23 percent of the total cereal production as observed between 1981 and 1997. On average, about 1.5 million-hectare of land was cultivated with teff annually in the period 1980/81 to 1996/97; i.e., 31 percent of the total area cultivated. But, the yield of teff did not show any significant increase between 1980/81 and 1996/97. On average, teff yield was 8.9 quintals per hectare while those of barley and wheat were 11.9 and 12.21 quintals per hectare, respectively. Thus, the yield of teff was 26 to 28 percent lower than that of barely and wheat. Although teff accounts for the highest share in the total fertilizer consumed by the peasant sector (45.2 percent of the total fertilizer applied in the peasant sector or 49.3 percent of the fertilizer applied on cereals in 1996/97), it did not exhibit any significant change in its yield in the past (FAO, 1998).

A number of reasons can explain about the poor performance of agriculture in general and of teff production in particular in this country. It is not necessary to catalog here all the factors. But as low level of productivity is one of the main constraints of this sector, it is enough to remember, and to keep bringing to the attention of policy-makers, that achieving an increase in agricultural productivity is a complex business; hence, to obtain maximum results, a range of factors, many of them interdependent, must be considered. The major constraints include:

- Poor technology base of peasant agriculture;

- Lack of access to modern inputs. For instance, on average only 1.7 percent of the teff area was planted with improved seeds in 1996/97 (FAO, 1998);

- Dependency of agriculture on erratic rainfall. Irrigated cereal production covered only 0.6 percent of the total area. Similarly, from the total teff production only 0.2 percent was produced by irrigation (CSA, 1997). Such poor access to irrigation has made the use of improved seeds and other technologies very risky and less profitable;

- Poor agricultural research and extension performance: the performance has remained low due to lack of adequate resources and ineffective strategies. For example, expenditure on agricultural research in Ethiopia in 1993/94 was only 0.2 percent of the agricultural GDP (i.e., investment in agricultural research in 1994 amounted to Birr 26.59 million, while agricultural GDP for the same year (in nominal price) was roughly Birr 14 billion). This amount was below the recommendation that the World Bank has called for the target of 2 perecent of the agricultural GDP to be invested in agricultural research (National Bank of Ethiopia, 1998).

Low level of education is also one of the explaining factors for poor agricultural performance. Education is a means to develop and convey essential information required by farmers to increase their labor productivity and the productivity of their land. Poorly educated people in rural areas lack conceptual knowledge to grasp skill required in the transformation of backward traditional agriculture. Investing in people's education boosts the living standards of households by raising productivity, expanding employment opportunities, attracting capital inflow and enhancing earning power (Teffera Woldie, 1996).

Despite the expansion of education in Ethiopia, the drastic growth of population has impeded the significant reduction of adult illiteracy, which was estimated to be 77 percent for the female and 55 percent for the male population in 1995 (World Bank, 1996). Moreover, there is a wide disparity between urban and rural areas to access in education. While 68.06 percent of primary gross enrolment in 2000/01 accounted from rural areas, only 2.19 percent of senior secondary enrolment is accounted from same rural areas (MOE, 2001). This shows that there are a number of school age children in rural Ethiopia still lacking the opportunity for education.

It seems, therefore, that the potential contribution of education in promoting the productivity of small-scale resource-poor farmers has not yet been tapped. The role of education, therefore, has to be increased (improved) in the agricultural sector where nearly half of the GDP is produced, more than 90 percent of the export revenue is generated, and more than 80 percent of the employment opportunity is created.

It is hypothesized in this paper that formal and non-formal education have a positive effect on productivity. Thus, the major objective of this paper is to empirically determine the effect of education on agricultural productivity and to examine conditions under which it can exhibit significant impact on productivity.

The paper is organized in six sections. In section two, an attempt is made to highlight farmers' access to formal and non-formal education. Section three reviews the literature about the role of education in agricultural productivity. Source of data, study areas and research methodology are discussed in section four. Section five presents data analysis and discussion of the results. Finally, summery of the main findings, conclusion and recommendations are presented in section six.

ACCESS TO FORMAL AND NON-FORMAL EDUCATION IN ETHIOPIA

Formal education

Basically, the development of Ethiopian education system was deeply rooted in religious education of both - Christianity and Islam. Though education has a very long history in Ethiopia, modern public education made a modest entry into the history of the country at the beginning of the 20th century with the establishment of School in 1908 (Teffera Woldie, 1996). Modern education crept into the country and was designed to serve the interest of the ruling class of that time. It was after the Italo-Ethiopian (1940) War that a system of modern education began to develop in this country under the leadership of Emperor Haile Selassie.

Ethiopian education system has two main sub-sectors that are institutionally separate; (1) the formal education sub sector, which consists of academic and technical training at primary, secondary, and tertiary levels; and (2) non-formal education, which includes technical vocational skills training, and extension advice and training for youth and adults.

Between 1962 and 1994, general education was divided into three levels: primary school (grades 1 - 6); junior secondary school (grades 7-8); and senior secondary school (grades 9-12). Education reforms in 1994 revised the structure so that it now consists of primary education (grades 1-8), where grades 1-4 aim at achieving functional literacy and grades 5-8 prepare students for further education; general secondary education (grades 9-10), which enables students to identify areas of interest for further education and training; and a second layer of secondary education (grades 11-12) that prepares students for higher education.

In Ethiopia, primary school attendance is characterized by a poor participation rate. The highest recorded primary gross enrolment ratio (GER) for Ethiopia was 38 percent in 1986, only slightly more than half of the average of Sub-Saharan Africa. This is due to the very low enrolment rates in rural areas. Nearly universal primary education has been achieved in urban centers. Low enrolment in the rural areas is therefore mainly responsible for the low national average (World Bank, 1994).

Primary school enrolment in Ethiopia has declined continuously. In absolute terms it declined from a level of 2.9 million in 1987/88 to 1.9 million in

1992/93 (World Bank, 1996). On the other hand, the 1995 estimates by MOE indicates that primary GER was 34.6 percent for grades 1-6 and 30.1 percent for grades 1-8. Similarly GER for secondary and tertiary school was very low: 19 percent for junior secondary and 9 percent for senior secondary. But in 2000/2001, primary school (grades 1-8) GER is 57.4 percent and GER for secondary school (grades 9-12) is 12.9 percent. Table 1 below shows the recent gross enrolment ratios of both primary and secondary schools.

Table 1: Primary (1-8) and Secondary (9-12) Gross Enrolment Ratios in Percentages

Year	Primary (1 – 8)	Senior Secondary (9 – 12)
1996/97	34.7	8.4
1997/98	41.8	8.9
1998/99	45.8	9.7
1999/2000	51.1	10.3
2000/2001	57.4	12.9

Source: MOE, 2001

Problems of organization, management and financing of education system contribute to the poor access of people to formal education. On the other hand, even if the supply of schooling increased in absolute terms for the last seven years, high rate of population growth and low demand for schooling (due to high opportunity cost of children's time) hinders school enrolment.

Rural access to non-formal education

One of the central objectives of a non-formal education program ought to be to increase and deepen indigenous knowledge pertaining to technologies of food production, health, clothing and shelter (Tekeste Negash, 1996). Non-formal education is defined as any educational activity organized outside the established formal systems designed to serve identifiable groups with identifiable educational objectives (ibid: 28)

Definition of Non-Formal Education (NFE) in the rural sector could also be based on the type of techniques utilized. On the other hand, classification by the objectives of the programs in the rural sector could provide more meaningful basis for taxonomy (Niehof and Wilder, 1974). Accordingly, the first group of non-formal programs in Ethiopia were Agricultural Development and Agriculture- based Multipurpose Programs. It is identified that there were more than one non-formal educational techniques employed in the programs of this group. The one group concentrated on public health. The other group was concerned with programs engaged in training personnel to conduct rural development programs.

This study focuses on agricultural non-formal education. Agricultural extension package programs are a form of non-formal education system for farmers. The package is based on agricultural inputs necessary for the farmer to increase his/her production. The number of components on a package may vary from program to program.

The Chilalo Agricultural Development Unit (CADU) is one of the earliest (1967-1974) examples of large-scale package programs in Ethiopia and it was a joint project of the Ministry of Agriculture and Swedish International Development Agency (Nekby, 1971 as cited in Alemneh Dejene, 1989). The educational/ development program of CADU was composed of four principal elements: (1) the model farmer, (2) agricultural extension and marketing agents, (3) experimentation and research to feed ideas to the educational processes, and (4) agricultural services such as credit, marketing, and other services to provide essential substantive ingredients to the educational processes (Bergam, 1970).

The CADU 'package' was the most comprehensive package in Ethiopia. The program's major emphasis was on increasing agricultural production and productivity; it also contained extensive women's programs, including home skills, and literacy programs.

The CADU 'package' demonstrated the value of a package approach to agricultural improvement and the participants had greatly increased their agricultural yield (including the production of milk) and their income. The principal particles espoused; including the use of better seeds, increased use of fertilizers and other improved practices, had been widely replicated. Innovations were created in agricultural machinery. Improved methods of providing credit and securing repayment of loans were demonstrated. A plan for initial and continued research was included in the program's strategies and operations. Effective non-formal education program were devised to strengthen the participation of men and women, largely illiterate, in the developmental process, thus improving their own welfare and increasing their contribution to national goals (Hunter and others, 1974).

Wollamo Agriculture Development Unit (WADU) initiated two years after CADU, was the second major agricultural package program initiative in Ethiopia funded by a loan from the International Development Agency (IDA). CADU, as a comprehensive package program, included the full range of inputs needed for agricultural development: extension, cultivation techniques, seeds, fertilizer, credit, marketing, women's programs, roads, crop trials, and so forth. WADU, however, had no farm implement and manufacturing component, no women's program, and no water development program (Tesfay Tecle, 1975).

Generally stated, the overall objective of the package programs was to increase agricultural production, both in terms of quantity and quality of the crops and animals raised. Non-formal education techniques were used in the program to facilitate the adoption of new agricultural practices and inputs, principally improved seeds and fertilizers. Two very interesting non-formal education activities, which were being conducted in the area of the WADU project, were the UNESCO Work Oriented Adult Literacy Program (WOALP) and the Agri-service Ethiopia program. The UNESCO literacy program was centered in agriculture, women's program and handicrafts, mainly, weaving. The Agri-service Ethiopia program was carried out in areas of the country where agricultural extension agents were working (Niehoff and Wilder, 1974).

The UNESCO/WOALP program was fairly extensive, with enrolment in the WADU area in the first few months of 1972 with approximately 6,800 students. This figure was big in relation to the total number of farmers in the area. But all those enrolled were not active farmers. Many were women, older men who were not necessarily heads of households, and many children who were not able to enter the regular school system. The non-formal education techniques utilized focused largely on demonstrations that were based on techniques proven by other developmental projects in Ethiopia.

An important non- educational agricultural program is the training and visit (T & V) extension system. It was introduced in June 1983 as a pilot project in the Tiyo and Hetosa sub districts of Arssi region, Ada and Lume sub districts of Shewa region, in the Shashemene and Arssi-Negelle sub districts in the southern part of Shewa (MOA, 1998). The T&V system was characterized by a systematic time bound program of staff training and farm visits. Discipline, a concentration of staff effort on agricultural problems, and deliberate linkages with researchers were assumed to assist in improving the effectiveness of extension services. The training and visit pilot project was based on the assumption that the effective communication of relevant message was crucial for adoption of a new technology. As indicated by Benor (1984), the basic features of T&V include: a) a regular schedule of visit by extension agents, involving person-to-person contact with farmers so that production recommendations can be communicated effectively; (b) regular training of extension agents to upgrade their skills, (c) attempts to link extension and research (ibid.)

The T&V method was applied as extension approach in the PADEP (Peasant Agriculture Development and Extension Program) until the National Extension Package Program replaced it in 1994/95. The latter non-formal education/agricultural programs adapted the SG 2000 package model. The new' Extension Package Program' is based on the agricultural inputs necessary for the farmer to increase production.

The National Agricultural Extension Program assists small-scale farmers to improve their productivity through dissemination of research-generated information and technologies. The program, which was only limited to 7 regions and 35,000 farmers in the initial year, has expanded to all regions involving some 3.5 million farmers in the 2000 production season (Table 2).

Table 2: Farmers Participation in the Extension Package Program

Year	No. of Regions	No. of Farmers
1994/95	7	36,600
1995/96	11	350,000
1996/97	11	650,000
1997/98	11	2,909,244
1998/99	11	3,008,156
1999/2000	11	3,226,678
2000/2001	11	3,508,112

Source: MOA, 1999/2000

The extension program has demonstrated to farmers the possibility of increasing production and productivity of crops and livestock, which in turn increased demand for agricultural services. The extension program has enabled the participating farmers to increase their production per hectare. However, even if extension program is expanded in different parts of the country, the production of major crops is still low. Fore example, in 19997/98, cereal production fell by 23 percent (National Bank of Ethiopia, 1999).

LITERATURE REVIEW

Theoretical background

Education, in its different forms, is considered as one of the important aspects in human resource development. Most fundamentally, development requires change in the attitude and action of individuals. Education can help people understand why change is necessary and can prepare them to acquire the knowledge necessary for achieving change. To increase agricultural productivity it is not sufficient, for example, that a farmer merely knows that fertilizer increases yield. Rather, he must have enough understanding on how to apply the proper kind and quantity of fertilizer in relation to the nature of the soil, rainfall or to the quantity of irrigated water at his/her disposal.

Three different types of education are often distinguished in the literature. "Formal", which consists mainly of schooling; "non-formal", which includes different kinds of extension and organized apprenticeships; and "informal", which refers to a wide definition of learning-by doing, including not only direct experience in a particular job but the multi-dimensional processes of learning that arise from being exposed to different circumstances (Coombs and Manzoor, 1974: Figoeroa, 1986).

Education can have "cognitive" and "non-cognitive" effects. The cognitive effects consist of the development of general reasoning skills and the transmission of specific knowledge. The non-cognitive effects modify attitudes and beliefs. In the cognitive area there exist strong interactions between developing a generalized capacity of thinking and learning, on the one hand, and the specific subjects learned, on the other hand (Figoeroa, 1986).

It has been argued that the greater the structure, longer duration and specific age group of school attendance makes formal education best suited for the "formation of competence", while the greater flexibility of non-formal services, which allow them to deliver a message closer to the work place, makes this type of education best suited for the "transmission of information". Informal education can provide either cognitive or non-cognitive effects depending on the specific type of experience. For example, a migration experience as an urban street seller may improve the numerical capabilities of a peasant, facilitating future calculations of costs and returns on the farm, whereas his experiences as a farm wage-laborer can put him in touch with specific information about new technologies that he can then apply to his own farm (Bowman, 1976; Jamison and Moock, 1984).

Empirical studies

Benhabib and Spiegel (1994) found that education level was an important determinant of differences in agricultural productivities among countries. They hypothesized and confirmed that education had a positive effect on farmers' productivity from analysis of all data sets of 38 countries. Their argument was that schooling helps farmers to use production information efficiently.

Appleton and Balihuta (1996) reviewed several additional African studies and found that the effect of schooling on agricultural output was usually not significant. The authors mention several possible reasons for the lack of significance of education in the African studies which include small sample sizes (for a few of the studies), errors in measurement of farm production, and wide variation in the actual effects of education on agricultural output in different areas under different farming systems. These reviews illustrate the need for further investigation of the effects of education on farm productivity in Africa.

Studies specific to Ethiopia

Assefa (1995) followed the three-stage procedure to test the impact of education on technical efficiency of small holders in Ada and Baso woreda. First, he formulated a stochastic frontier production function with composed errors and then he estimated the coefficients using the maximum likelihood technique. Then he concluded "secondary school education, oxen, time of fertilizer delivery, and extension contact are the most important factors influencing technical efficiency in Ada sub district".

Abrar (1996) also used the same procedure to identify differences in technical efficiency among his sampled farmers and he attributed these variations to differences in farmers' socio-economic factors such as farm and household size, age, education and the level of off-farm activities. Abay (1997) tested the hypothesis of equal allocation and technical efficiency of educated and illiterate farmers by using the modified Y-L profit function model under various linear restrictions. The results showed that educated farmers were relatively and absolutely more efficient than illiterate farmers. This implies that at the existing level of factor endowments and technology there is a potential to increase agricultural output by enabling illiterate farmers to operate closer to the efficient level achieved by their educated neighbors. He also indicated that education increases not only the efficiency of farmers but also the probability of farmers adopting to improved inputs such as fertilizers.

Assefa and Abay (1997) estimate a stochastic frontier profit function to investigate technical and allocative efficiency of farmers. Their data are also drawn from the ERHS (Ethiopian Rural Household Survey). However, only four of the 15 sites were considered, and within those four sites, only those households which used fertilizer and hired labor were included (120 households in total). Education was measured as a dummy variable equal to one if at least one household member reports being able to read and write or has the ALP certificate. They estimated the average inefficiency over their sample. Educated farmers were found to be relatively and absolutely more efficient than those without education.

DATA, STUDY AREAS AND METHODS OF ANALYSIS

Data source and study areas

The data used in this study are based on the fifth round of the 1999/2000 Ethiopian Rural Household Survey conducted by the Economics Department of Addis Ababa University. The survey was conducted in four regional states; namely, Tigray, Amhara, Oromia and SNNP. The total number of sample households covered by the survey was 1861 from 21 Peasant Associations located in 18 sites. The sample households were randomly selected from purposively selected communities (PAs). The PAs were selected purposively to ensure that farming systems are represented. The issues addressed by the survey include household demographic features, asset ownership, land and other input uses, crop production and marketing, education, livestock ownership, land use arrangements and other socio-economic aspects of rural households. Thus, those 18 sites included in the sample are independent and may not be statistically representative of the entire rural Ethiopia at large. But, they are quite representative of its agro-ecological, ethnic and religious diversity. Description of the sites and data collection is given in Croppenstedt and Mulat (1997).

Study areas

Two communities (PAs) in two woreda of contrasting socio-economic and infrastructure situation were selected for this specific study. One is from the Amhara region (Shumsheha PA) and the other is from the Oromia region (Sirba-Gudeti PA).

(i) Sirba-Gudeti PA

The village Sirba-Gudeti is located in Ada woreda in East Showa zone. The village is connected to the main road that runs from Addis Ababa to Adama (Nazret). It is located about half way between Debreziet and Modjo. According to the census of 1994, the total population of the village was 1,900, with 180 households. Of these households, 176 are male headed and the rest (25 percent) are female headed. The sample size used from this village is 95 households.

The site is adjacent to an all-weather road; there are two large towns within 20 km, Debrezeit and Modjo, each town has a large market place. The nearest small market is in Denkaka PA. The farming technology used in the PA is dependent on the plough, draught-oxen, and family and group labor. There has been no significant change in the basic farm technology. Recently, however, new (improved) technologies (e.g. fertilizer and improved seeds) have been introduced into the area. Teff, wheat, horse bean, chickpea and barley are the major crops grown in the area. Teff and wheat are in particular the most important crops (Economics Department, 1996).

(ii) Shumsheha PA

Shumsheha is located in Bugna woreda, North Wollo administration zone. It is about 630 Km. north of Addis Ababa, about 110 Km. from the zonal town of Woldia, 335 Km. from Bahirdar, the regional capital and 12 Km. south of the woreda town - Lalibela. The population of Shumsheha PA was about 6,000 in 1994. About 40 percent of the total area of the woreda is not arable. Only about 10 percent of the land area is cultivated. The sample size from this village is 144 households.

The 80 Km. dry-weather road links Lalibela with the Woldia-Woreta all weather road. A dry-weather road connects Shumsheha to Ayna, the former capital of Bugna. It is connected to Sekota by dry-weather road. Lack of well-constructed bridges and muddy roads make road transportation during the rainy season impossible. Lalibela is the nearest weekly retail and wholesale (grain and livestock) market and is held on Saturdays. Some farmers go as far as 30 to 40 km to get to larger markets.

In Shumsheha, the ox-drawn plough is the main farm implement. The traditional way of production has persisted in the area. The main livestock reared in this PA include cattle, goats, sheep and donkeys. Teff, wheat, beans, barley, maize and sorghum are grown in the area. Teff and wheat are the most important crops. The agro-ecological characteristics of the study villages are shown in Table 3.

Table 3: Agro- ecological Characteristics of the study villages

Characteristics	Sirba-Gudeti	Shumsheha
Altitude, meters	1800-1900 meter	1500-2000 meter
Average rainfall, millimetres	860 mm	650-750 mm
Average temperature, degree-centigrade	14°c-17°c	16 °c -18 °c
Soil type	Sandy, black and red soil	Sandy
Major crops	Teff,wheat, horse bean, chickpeas and barely,	Teff, wheat, horse bean, chickpeas, barely and field pea

Source: Economics Department, 1996

Methods of analysis

Model specification

Differences in productivity among farms imply that different outputs are obtained from a given bundle of physical inputs. If we are interested in examining whether physical inputs and certain characteristics of households such as education level, have effects on productivity, we need to apply production function (model). In this case, the function reads:

$$Q = f(X,E) \qquad (1)$$

Where Q is the quantity of output, that is the (maximum possible) level of output.

X is a vector of physical inputs (which include area cultivated, animal power, labor input, chemical input, land quality, and rainfall).

E is a vector of variables that characterizes a particular farm (which include schooling, contact with extension agent, age, and access to formal credit).

There are different types of production functions. The most common function, which is employed for this analysis, is the Cobb-Douglas production function. The Cobb-Douglas (C-D) production function is used because of its convenient properties :

- It is linear in the logarithmic form and easy to estimate;
- The parameters measure the elasticities (assumed constant, and ranges between zero and unity) of output with respect to inputs;
- The parameter may be regarded as efficiency parameter, since for fixed inputs, the larger the parameter, the greater is the maximum output obtained from such inputs, and;
- It may show diminishing marginal returns and estimate returns to scale.

The possible disadvantage of the C-D production function is that it cannot show both increasing and diminishing marginal returns in a single response curve (i.e. it assumes constant elasticity of returns).

An alternative functional form widely used for production function analysis is the trans-log function. It is described as a "flexible function form" since the scale coefficient can vary for different levels of production and different factor properties. Furthermore, the curvature of isoquants measured by the "elasticity of substitution" can also vary at different points on the production surface, whereas it is fixed at unity for the C-D function. Trans-log production function, however, is widely used in non-agricultural contexts. It is possible to compare the value of R^2 obtained or use statistical tests of whether one model is an improvement over another. Accordingly, the F-test has shown that the Cobb-Douglas function is a more appropriate model for the data of the study communities. Therefore, C-D production function is used in this particular study.

If we begin with the C-D model in its simplest form, education excluded, we have

$$Q_i = \pi (X^{\beta j}_{ij}) e^{\alpha + ui} \quad \textbf{(2a)}$$

Where Q_i is the output of the i^{th} household, X_{ij} is the use by the i^{th} household of the j^{th} physical input, β_j is the elasticity of Y with respect to X_j and α and u_i are the constant and random error terms, respectively. The linear form of the model can be written as,

$$\ln Q_i = \Sigma\beta_j \ln X_{ij} + \alpha + u_i \quad \textbf{(2b)}$$

In this paper, a Cobb-Douglas production function of the form shown in (2b) is specified to estimate the contribution of education in output in addition to capital, labor and land. Therefore, if E_i is a measure of education in the i^{th} household, how should this variable be included in equation 2a? One way that education might be considered in the production function is in neutral fashion, that is, without altering the elasticity (β_j) of any of the X_j. In this formulation, E appears as an additional multiplicative input (Moock, 1984).

$$Q_i = \pi (X^{\beta j}_{ix}) E_i^{\gamma} e^{\alpha + ui} \qquad (3a)$$

Where γ is the elasticity of output with respect to E, education.

Since the C-D production function assumes constant elasticity of substitution, it is possible to standardize output and physical input dividing both sides by hectare (i.e. land becomes an indicator of scale in the C-D production function). Therefore, Yield can be obtained from equation (3a) dividing it through out by land. That is,

$$Y_i = \pi (x_{ijj}{}^{\beta j}{}_{jj}) E_i^{\gamma} e^{\alpha + ui} \qquad (3b)$$

Where Y_i is output per hectare (which is yield) and x_{ij} is physical input (for the procedure followed to arrive at 3b, refer to Thomas, 1993 : 303-304).

To measure the effect of schooling, Cobb-Douglas (C-D) production functions may be specified in semi- log linear form as follows:

$$LnY_i = \alpha + \beta_1 LnL_i + \beta_2 LnN_i + \beta_3 LnOX_i + \beta_4 LnF_i + \beta_5 Lq_i$$

$$+\gamma_1 S_i + \gamma_2 Ex_i + \gamma_3 Cr_i + \gamma_4 Ag_i + \gamma_5 Ag_i^2 + D_I \qquad (4)$$

Where;

LnYi is the natural logarithm of farm output per hectare for household i;

LnN_i is the natural logarithm of total adult man-days of household i;

LnL_i is the natural logarithm of number of hectares under teff cultivation during the year by household i;

$LnOX_i$ is the natural logarithm of oxen owned by households i;

LnF_i is the natural logarithm of the quantity of fertilizer used by household i;

Lq_i is land quality of household i;

S_i is the formal education status of household i;

Ex_i is the extension contact of the household i;

Ag_i is the age of the household head i;

Ag_i^2 is the age square of the household i;

Cr_i is the received credit of the household i; and

D_i is the dummy variable for region / site

Definitions and measurement of variables

1. **Formal education** is defined as learning that takes place in schools.

Several different measures of education may be used, and different members of the household may be considered (e.g., households' head versus all other adults in the household). For this particular study, formal education is measured by an average year of schooling of all household members in order to get the educational status of those individuals above 9 years old. To account for the possibility that different level of schooling have different effects upon output, a set of dummy variables representing different levels of schooling have been used. That is, for illiterate household members we use the dummy variable 1, for read and write or adult literacy program we use 2, for a range of 1-6 years of schooling we give number 3, and finally for a range of 7and above years of schooling we give 4. Then we multiply these weights by the number of members of households in each range and can calculate average schooling of the household (i.e., by dividing the total weight by the total number of members of the household).

2. Non-formal education is any organized or deliberate set of educational activities carried out outside the normal school curriculum. This category includes agricultural training program (or extension practice) and adult literacy classes.

In this study the non-formal education is proxied by extension contact of the head of the household in the year before the survey time. The variable takes 1 if there was any extension contact and 0 otherwise.

3.Yield (Y) is measured by teff output in kg per hectare.

4. Land (L) is area of land cultivated with teff in hectare.

5. Labor (N) is the total adult equivalent man-days (family and hired plus labor exchange) per hectare of teff production

6. Oxen (OX) is the number of oxen owned by a household

7. Fertilizer (F) is chemical fertilizer in kilograms applied per hectare for teff farm.

8. Age (Ag): Age in years of the farm household head. Age is a proxy for experience in farming, it affects productivity of farmers, but the direction is not clear.

9. Received formal credit in cash and/or in kind (Cr) the variable indicates whether a household received credit from a formal institution for agricultural activity previous to the survey. Those farmers who obtained credit are coded as 1 and 0 otherwise. It is expected that this variable would have a positive impact on productivity.

10. Woreda or site (D_1): 1 code is used if farmer is operating in Sirba-Gudeti woreda, 0 if farmer is operating in Shumsheha woreda. Sirba-Gudeti is located in a relatively modern environment (an area where access to infrastructure and market facilities is relatively better; utilization of fertilizer is more and located closer to an urban locality). Shumsheha is located in a traditional environment (an area where access of infrastructure to market facilities is relatively low; utilization of fertilizer is less and distance from town is far).

11. Land quality (Lq) 1 is used if the soil is *lem* and/or *lem-teff* soil, 0 if the soil is *teff*.

Lem soil is the most fertile type of soil.

Tef soil is the least fertile type of soil.

Lem-tef soil is soil of fertility between teff and lem (i.e., medium fertility).

Estimation Technique

The estimation technique employed in this study is OLS (Ordinary Least Square). The OLS estimator has statistical properties that have made it one of the most powerful and popular method of regression analysis: linearity, unbiasedness, and minimum variance (Johnes, 1995). All variables hypothesized to influence farmers' productivity were checked for both multicollinearity and hetroscedasticity. The existence of multicollinearity was checked against a bivariate correlation matrix. Variables that showed highly significant co-linearity were systematically excluded from the model (for example rainfall). On the other hand, in the OLS estimation method, the disturbance term, which accounts for errors in the measurement and omitted variables, need to have constant variance.

The existence of hetroscedasticity problem that violates the assumption of constant variance was checked. The graph of standardized residual against frequency of their occurrences showed the normal distribution of the residuals, which indicate the absence of a hetroscedasticity problem. The computer packages that are used to enter and estimate the data are the Statistical Package for Social Sciences (SPSS) and STATA, respectively.

RESULTS AND DISCUSSION

Descriptive statistical analysis

The variables hypothesized to affect farmers' productivity were selected to fit the Cobb–Douglas model. While Table 4 shows the means and standard deviations, Table 5 shows the frequency distribution of discrete variables used in the analysis. Table 4 illustrates teff yield, fertilizer use and number of oxen owned are significantly higher in Sirba-Gudeti compared to those in Shumsheha.

As can be easily worked out from Table 4, labor productivity is also considerably high in Sirba-Godeti compared to that in Shumsheha. The mean values of both formal and non-formal education are higher in Sirba-Godeti than in Shumsheha (Table 5). That is, access to education seems better in Sirba-Godeti than in Shumsheha.

Table 4: Mean and standard deviation of continuous variables used in the production function

Variable	Sirba-Gudeti (Size = 95)		Shumsheha (Size = 144)		
	Mean	S.D	Mean	S.D	t-value
Teff Grain yield, kg	1614	1.31	997	1.48	
Cultivated teff land, ha.	0.78	0.52	0.79	0. 34	3.032
Labor per ha.of teff, man-days	150	88	143	52.4	2.881
Number of Oxen	2.5	2.1	2.1	2.2	2.924
Fertilizer per hectare of teff, kg	196	104	152	52	2.622
Average Formal education index	2.0	0.4	1.8	0.49	2.712

Table 5: Frequency of responses for discrete variables.

Variable	Response	Sirba-Gudeti		Shumsheha	
		Frequency	%	Frequency	%
Loan Accessed	No	131	84.0	222	87.7
	Yes	25	16.0	31	12.3
Extension Accessed	No	134	85.6	215	85.6
	Yes	22	14.4	38	14.4

Source: Survey data

Regression analysis

The Ordinary Least Square (OLS) estimates of the production function for both sites combined are presented in Table 6. Some of the farm variables are presented in logarithmic form. Input values of zero were transformed by adding the constant 1 to facilitate processing of logarithm function (see for example; Jacoby, 1992). Jacoby notes that the choice of a constant is arbitrary, but should be small relative to the average value of the input for the whole sample. Therefore, for this particular study, man-days and oxen values of zero were transformed by adding a constant 1.

Major input variables (land, labor, oxen, fertilizer and land quality) and characteristics of the households (education, extension, age and credit) were included in the Cobb-Douglas production function. The result of the regression analysis shows that there are significant differences in the contribution of the variables towards the productivity Teff (Table 6).

Table 6: OLS Estimation of a Cobb- Douglas Production Function (Dependent variable = Natural Log of Teff yield per hectare)

Variables	Coefficient
Constant	3.01 (1.64)*
LN-LAB	0.289 (3.17)***
LN-OX	0.416 (2.90)***
LN-LAN	0.331 (2.97)***
LN-FER	0.165 (2.31)**
AVEDU	0.0022 (2.61)**
EXT	0.0023 (1.76)*
AGE	-0.251 (0.68)
AG^2	0.044 (1.11)
WD (Woreda or Site)	0.0063 (3.12)***
R^2	0.430
F-value	3.23**
Number of observations	240

Source: Survey data

Note: Figures in parentheses are t-values; *, **, and *** indicate significant level at 10%, 5% and 1%, respectively.

(i) Physical Inputs

Before analyzing the effect of education on teff productivity, a brief discussion of the results with respect to other variables is in order. The coefficients of labor, land and oxen are positive and highly significant in the production function. It can be seen that the output elasticity of the teff yield with respect to labor and oxen is larger than that those of household characteristics (education, extension, credit and age).

The results imply that, assuming all other factors constant, a one percent change in the size of teff land will bring about more than 0.30 percent change in the level of teff productivity. The possible explanation is that if farmers have more access to land, they are encouraged to use improved farming practices (e.g. use of chemical fertilizer, pesticides and improved seeds) through extension participation, thus increasing output per hectare. This result on farm size goes in line with the finding of Croppenstedt and Mulat (1997) and Wondwoson (1998). Assuming other inputs constant, more of the variation in productivity would come from change in the size of cultivated land. This is related to higher efficiency of farmers and economies of scale when they use improved input on relatively larger farm size.

On the other hand, other inputs remaining constant, the respective percentage output variation attributed to a one percent change in the number of oxen and man-days of the households are 0.40 and 0.28, respectively. This supports the notion that oxen and labor are among the most important and basic farm resources. The positive and significant coefficient of labor suggests that labor availability, possibly at times of peak farm activities, is a limiting factor to teff production. Oxen are important to prepare fine seedbeds on time. Oxen are also proxy indicator of wealth status of a household. They are a source of cash and security against risks of crop failure that may result in crucial food shortage. This result is consistent with the results of Donel et al (cited in Sharada, 1997) and indicates that oxen-rich farmers are relatively averse to risk and hence are relatively quicker to use new technologies.

(ii) Formal education

The relationship between formal education and agricultural productivity is positive, and statistically significant at the 5 % level. That is, keeping other inputs constant, the higher the level of education of members of a household, the more likely the household to be more productive. In other words, additional year of schooling has positive effect on teff productivity. This supports the working hypotheses of this study that formal education has a positive effect on productivity.

A set of threshold dummy variables were created in order to understand better the relative importance of different level of schooling of the household head. As indicated earlier, schooling variables are measured in the following levels in order to capture the threshold effect of formal education: 1 if household head is of grade 1 to 6, otherwise 0; and 3 if household head is of grade 7 and above, otherwise 0.

Table 7 provides strong evidence of a threshold effect for schooling. The results show that household heads with 1 through 6 grades of education effect a positive and significant change in teff productivity. However, secondary schooling did not show any significant effect on teff productivity. Indeed, the negative (though non-significant) coefficient of school grade of seven or above are not unexpected, since those who spend more years in school are inclined to spend less time on the farm fields as most may have developed negative attitude towards farm labor and seek alternative urban-oriented occupations.

Table 7: OLS Production function: impact of thresholds of schooling on productivity (Dependent variable = Natural log of teff yield)

Variable	Coefficients
1-6 years of schooling	0.21**
7 and above years of schooling	-0.21
R^2	0.34
F-values	2.66**
Number of observations	156

Source: Survey data Note: **= significant at 5 % probability

(iii) Non-formal education

We argued that if extension transmits specific information about technologies or market structures, the impact of extension participation is measured by a productivity differential it entails. The coefficient for the effect of extension is positive and significant at 10 percent probability. Although at higher probability of error (10 percent), the result indicates the importance of more effective transfer of new and productive technology package and associated knowledge.

(iv) Technology

In this study, only fertilizer is taken as a technology variable, for other technological variables like improved seed and pesticide were utilized only by small number of farmers in the sample. The use of fertilizer is positively related to the farmers' productivity and is significant at 1 percent probability. Other factors remaining constant, the respective percentage productivity variation attributed to one percent change in the use of fertilizer is 0.16. Thus, utilization of fertilizer can have substantial effect on teff yield.

(v) Other variables

Age, being a proxy for experience as well as attitude towards modernization and risk-taking in agriculture, is expected to have a positive impact on output. However, the coefficient of age (although not statistically significant) shows a negative sign (Table 6). It seems that productivity declines as the head of the household gets older. It seems that, older farmers are not physically able to be as effective as younger farmers. In other words, farm experiences are countered by declining physical strength and perhaps by negative attitude towards innovation.

(vi) Impact of site/region

The site or region dummy variable (WD) is found to have a positive and significant impact upon productivity. Agro-ecological difference (e.g. altitude, level of soil fertility and access to infrastructure) may explain for positive and significant impact of site on productivity. According to farmers, erratic and heavy rains that delay planting and other operations are the primary factors affecting yield. In addition, if seed and fertilizer arrive late, farmers are forced to plant later than they would have liked. Therefore, under the assumption of high transport cost, conditions are relatively favorable for farmers in areas (Sirba-Gudeti in this case) with better access to road and relative nearness to towns.

CONCLUSION AND POLICY IMPLICATIONS

Agriculture is the mainstay of the Ethiopian economy. It provides livelihood for the majority of the population and constitutes a large share of the country's GDP. However, agricultural productivity has been low for decades and the food security problem is quite precarious in most regions of the country. Several reasons can be cited for the low production of agricultural outputs among which is the low level of education in rural areas.

This study has attempted to look into the role of education on teff productivity. Any form of education that imparts knowledge about the production process directly or that enhances the capacity to acquire knowledge about production process from other sources is expected to raise agricultural productivity of small farmers.

The study used a cross-sectional data gathered by the Ethiopia Rural Household Survey conducted by the Economics Department of Addis Ababa University in 1999. Indicators of educational background of farm households used in the study are years of formal education (index) and agricultural/rural extension service (non-formal education). The findings of the study show that formal education and non-formal education (agricultural extension) are important and significant productivity-raising factors among small farmers.

The findings also show the effect level of schooling level on productivity. Primary schooling (1-6) results in a positive impact on productivity, while the impact of schooling of grade 7 and above did not show a positive relationship. This suggests that primary/ basic education could be effective in speeding agricultural productivity in general and teff production in particular. Positive roles of oxen, farm land size, labor and fertilizer in enhancing teff productivity have been observed in the study.

The study findings, thus, imply the importance of strengthening human capital, particularly farmers' access to primary education, and enhancing farmers' access to land, labor and fertilizer markets in order to enhance agriculture productivity and development. The importance of land size may imply the need for improving land access through transparent and legal land transaction and facilitating transfer of land from less efficient user to more efficient user. The study points out also the need for improving road and market infrastructure, an important element to effectively use and enhance human capital and technological change for agricultural productivity growth.

REFERENCES

Abay Asfaw, 1997, The Impact of Education on Allocative and Technical Efficiency of Farmers: The case of Ethiopia Smallholders. M.sc. Dissertation, Addis Ababa University (unpublished).

Abrar Soleman, 1996, "The Linkage between Small Holder Efficiency and Sustainable Development: An Empirical Guidance," AAU, 1996 (unpublished).

Alemneh dejene, 1989, "Agricultural Extension in Africa", a World Bank Symposium, Washington, D.C.

Appleton, S. and Balihuta, 1996, Education and agricultural productivity: Evidence From Uganda. Journal of International Development, 8: 415-444.

Assefa Admassie, 1995, Analysis of Production Technology in Crop Production, a Study of Small Holder in the Central Highlands of Ethiopia. Ph.D. Dissertation Wissenschattsverlag Vauk Kiel.

Assefa Admassie and Abay Asfaw, 1997, The Impact of Education on Allocative and Technical Efficiency of Farmers: The Case of Ethiopian Small Holders. Paper Presented to the Seventh Annual Conference of the Ethiopia Economic Association held in Nazreth, Ethiopia.

Benor, D. and Michael, B. 1984, Training and visit Extension in Alemneh Dejene paper, Agricultural Extension in Africa. A world bank Symposium, Washington, D.C

Bergam, G. 1970, CADU Evaluation studies: Training of Model Farm. CADU Duplication 60.Asella, Ethiopia: Chilalo Agricultural Development Unit. In Alemneh Dejene paper, Agricultural Extension in Africa, A World Bank Symposium, Washington, D.C.

Bowman, M.J. 1976, Through education to earning? In Proceedings of the National Academy of Education, 221-292.

CSA (Central Statistics Authority), 1997, Agricultural Sample Survey, Addis Ababa.

Coombs, P. and Manzoor A. 1974, Attacking Rural Poverty: How Non-formal Education can help. Baltimore : the Johns Hopkins University Press.

Cotlear, D. 1990, The effects of education on farm productivity. In Sharada Weir Working Paper Series, Central for the Study of African Economies, University of Oxford.

Croppenstedt, A. and Mulat Demeke , 1997, An empirical study of cereal crop production and technical efficiency of private farmers in Ethiopia. A mixed fixed- random approach, Applied Economics, 29 : 1217-1226, in Sharada Weir Working Paper Series, Central for the Study of African Economies, University of Oxford.

Economics Department/Addis Ababa University(AAU), 1996, Ethiopian Village Studies. Addis Ababa.

FAO, 1998, Crop and Food Supply Assessment of Ethiopia, No 4. Rome: FAO.

Figueroa, A. 1986, Productividady education en la agricultural Campesina de America Latin Rio de Janeiro: program of Joint Students on Latin America Economic Integration. *Journal of Development Planning*, No.19, pp.135

Hunter, G. and Others, 1974, Final Report of the Appraisal of CADU and EPID, Stockholm: Swedish International Development Institute. In Alemneh Dejene, Agricultural Extension in Africa, A World Bank Symposium, Washington, D.C.

Jacoby, H. 1992, Productivity of men and women and the sexual division of labor in Peasant agriculture of Peruvian Sierra. Journal of Development Economics, 37 : 265-87.

Jamison, D. and Moock, P. 1984, Farmer education and farm efficiency in Nepal: the Role of schooling, extension services and cognitive skills. *World Development Report*, vol. 12 pp. 67-86.

Johnes, Charles I. 1995, Time Series Test of Endogenous Growth Model. The quarterly Journal of Economics, No (2)

MEDaC (Ministry of Economic Development and Co-operation), 1998, Survey and Current Economic Conditions in Ethiopia. Addis Ababa.

Mesfin Mirotchie, 1994, Technical efficiency of Ethiopian agriculture. In Berhanu Abegaz, ed., Essay on Ethiopia Development, Aldershot: Aebury.

MOE (Ministry of Education), 1996, Transitional Government of Ethiopia, Basic Education Statistics, Education management. Addis Ababa.

----------------(2001) Education Statistics Annual Abstract, 2000-2001.

MOA (Ministry of Agriculture), 1998, Crop Extension Package for Semi-arid and Arid Areas, (Amharic), Addis Ababa.

Moock, P.R. 1984, Education and Technical efficiency in small Farmer production. Economic Development and Cultural Change, vol.29, 1980.

National Bank of Ethiopia, 1998, Quarterly Bulletins (Various issues).

Niehof and Wilder, 1974, Program of Studies in Non- Formal Education Study Team Report- Non- Formal Education in Ethiopia. Michigan State University.

Schultz. T.W. 1961, Investment in Human Capital. American Economic Review, Vol. 51:1-17.

---------------,1975,. The Value of the Ability to Deal with disequlibrium. Journal of Economic Literature, 13, 3 : 827-46.

Tesfay Tecle, 1975, An Approach to Rural Development: A Case Study of the Ethiopia Package Project, Rural African 28. East Lansing. Michigan State University.

Tekeste Negash, 1996, Rethinking Education in Ethiopia. Upsala, Sweden.

Teffera Woldie, 1996, Education as Basic Factor in Ethiopia's Economic Development. Senior Essay in Economics, Addis Ababa.

Welch, R. 1970, Education in Production. Journal of Political Economy, 78, 1 : 32.

Wondwosen Feleke, 1998, Technical Efficiency and Determinants of Food Production in the Highlands of Ethiopia. M.Sc. Dissertation, A.A.U, Addis Ababa (unpublished).

World Bank, 1997, World Development Report. Oxford: Oxford University Press.

----------------, 1996, World Development Report. Oxford: Oxford University Press.

----------------, 1994, World Development Report. Oxford: Oxford University Press.

INSTITUTE OF DEVELOPMENT RESEARCH
ADDIS ABABA UNIVERSITY
ETHIOPIAN JOURNAL OF DEVELOPMENT RESEARCH
(EJDR)

The Ethiopian Journal of Development Research (EJDR) is a bi-annual journal devoted to development oriented research and published by the Institute of Development Research.

The publication covers wide areas of the development process. It is devoted to the multi-disciplinary study of development problems of Ethiopia in particular and the less developed world in general. Book reviews, synopsis of major research, theoretical and methodological approaches in the general area of development are also acceptable to the publishers of this journal. Contributions are welcome from any part of the world.

Subscription rate: *In Ethiopia, Birr 12.00 per issue for individuals and Birr 15 per issue for institutions.*
Elsewhere, U.S. $20.00 per issue for individuals and US $25.00 per issue for institutions.

Address: *For editorial and all other communications:*
Managing Editor, EJDR, IDR
Addis Ababa University
P.O. Box 1176, FAX 55-13-33, Telephone: 55-68-22/ 57-46-50
Addis Ababa, Ethiopia.