THE EFFECT OF FARMERS' EDUCATION ON FARM PRODUCTIVITY AND INCOME IN GHANA: IMPLICATION FOR FOOD SECURITY

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DECLARATION

I, **EDWIN AFARI**, author of this thesis, do hereby declare that the work presented in this thesis: **"THE EFFECT OF FARMER'S EDUCATION ON FARM PRODUCTIVITY AND INCOME IN GHANA: IMPLICATION FOR FOOD SECURITY "**, was done entirely by me in the Department of Agricultural Economy and Farm Management, University of Ghana, Legon, from September, 2000 to September, 2001.

This work has never been presented either in whole or in part for any other degree of this University or elsewhere.

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This work has been submitted for examination with our approval as supervisors.

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DEDICATION

To God Almighty, Nana Akua Afriyie , Eme and all Ghanaian farmers.

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ABSTRACT

Low agricultural productivity has been identified as the major cause of food insecurity and food self-insufficiency in Ghana. Human capital improvement through farmer education (both formal and informal) is essential for increasing agricultural productivity and farm income of rural farmers. The study estimated and quantified the contribution of education and exposure to extension service contact to farm productivity and farm income. The findings show that the average schooling years of farmers sampled from the GLSS 4 survey data is just below the primary level. Weighted Least Squares estimates for cassava farm production function indicate that household heads' education, as measured by years of formal schooling completed, had a positive but insignificant effect on farm productivity. We find similar results for maize farmers. Farm productivity increases *ceteris paribus* by 0.59 percent and 1.43 percent for cassava farmers with primary and secondary education respectively. Percentage increase in cassava output is as much as 3.7 for one (each) additional year of schooling above the mean educational level of sampled farmers. For maize farmers, at least middle school education was found to be necessary for significant benefits of schooling and returns to schooling are highest for farmers with middle and post secondary education in the farm income estimation. Maize output is likely to increase by 3.1 percent for one extra year of schooling at the mean educational level of the sampled farmers. Extension service contact was found not to significantly enhance productivity in any way for both cassava and maize farmers. The study recommends that higher levels of investment in basic and secondary education should be a priority for the government, with special attention going to smallholder staple crop farmers in the area of informal education to enable them improve on their efficiency on the farm. Increase in farm productivity through improved education would ultimately contribute to the attainment of food security in the country.

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ABBREVIATIONS

COCOBOD	Cocoa Board of Ghana
EAP	Economically Active Population
FAO	Food and Agriculture Organisation
GLSS	Ghana Living Standards Survey
ISSER	Institute of Statistical, Social and Economic Research
MoFA	Ministry of Food and Agriculture
PPMED	Policy Planning, Monitoring and Evaluation Department
NGO	Non-Governmental Organisation
SADAOC	Securité Alimentaire Durable Africain Occidental Centrale (Sustainable Food Security in Central West Africa)
WLS	Weighted Least Squares
C-D	Cobb – Douglas
SOW-VU	Stichting Onderzoek Wereldvoedselvoorziening van de Vrije Universiteit (Centre for World Food Studies at the Free University)
MSLC	Middle School Leaving Certificate
BECE	Basic Education Certificate Examination
CES	Constant Elasticity of Substitution

CHAPTER ONE

INTRODUCTION

1.1 Background Statement

1.1.1 The Agricultural Sector and the Ghanaian Economy

The Ghanaian economy is broadly divided into three main sectors, agriculture, services and industry. The agricultural sector is the dominant sector in the Ghanaian economy in terms of its share of Gross Domestic Product (GDP), employment and foreign exchange earning. In 1997, the sector employed about 70% of the labour force, contributed about 47% to GDP and accounted for over 57% of foreign exchange earnings (PPMED of MoFA , 1998).

The broad agricultural sector, which includes fishing and forestry, contributes on the average over 40% of the total GDP (Ghana-Vision 2020, 1995). In the 1980s, its contribution to GDP averaged about 52 percent (Nyanteng and Dapaah, 1997). A high proportion of the economically active population (EAP) depends on farming as their main source of income. It offers job avenues to many people as farmers, farm labourers and workers, among others. The proportion of EAP in agriculture was about 52% in 1987, 50% in 1990 and declined further to 48% in 1994 (Nyanteng and Dapaah, 1997), though the absolute number has been increasing over the years. According to FAO (1998), the EAP in agriculture in absolute numbers increased from 4.2 million in 1990 to 4.8 million in 1995 and to 5.2 million in 1998. At a population growth rate of about 3% and an expected increase in population from 18.5 million to about 36 million by the year 2020, the agricultural labour force is expected to increase substantially. The percentage of the EAP in agriculture in Ghana is far higher than that recorded for Canada, USA, Brazil, Nigeria and some other African countries

(FAO, 1998) but agricultural growth in Ghana has been low and disappointing. During the period 1991-1994, agricultural growth averaged 1.9% only, recording a negative value (-0.6%) in 1992 (ISSER, 1998). Between 1995 and 1998 however, agriculture GDP increased at an average of 4.2% per year (MoFA, 1998).

The performance of the agricultural sector has serious implications not only for most of the rural inhabitants, since farming in Ghana is largely a rural phenomenon, but also for the agro-industrial sector growth. The role of the agricultural sector is crucial for the attainment of the goals set in Ghana's Vision 2020. The sector is expected to ensure food security and adequate nutrition for all Ghanaians, to supply raw materials and other inputs to other sectors of the economy as well as to provide producers with farm income comparable to earnings outside agriculture. It has been argued that if the agricultural sector does not grow at a rate higher than 4%, lower income in agriculture would be translated into lower income for unskilled labour throughout the economy (PPMED, 1998; Ghana-Vision 2020, 1995).

1.1.2 Constraints and problems facing the agricultural sector

Though the agricultural sector has been the backbone of the Ghanaian economy, its contribution to GDP growth has fallen behind the contribution made by the services sector. According to Ghana Statistical Service national accounts, the agricultural sector recorded a real growth rate of 2.3% in 1993 as against 5.4% by the industrial sector and 7.2% by the services sector. In 1995, the growth rate was 4.2% as against the 3.3% by the industrial sector and 4.9% by the services sector. However in 1998, the food and agriculture sector grew at a rate of 5.3% (ISSER, 1998) below the services sector (6%) and above the industrial sector (2.5%). In 2000, the agricultural sector recorded a less than expected growth rate of 2.1 per cent as against the 3.9 per cent achieved in 1999 (National Budget, 2001). The performance of the agricultural sector has not been adequate to ensure food nutrition and food security and to satisfactorily increase real farm income (Ghana-Vision 2020, 1995). A number of factors and problems have contributed to the poor performance of the sector. They include low level of technology used by most agricultural producers, the heavy dependence on climatic conditions especially rainfall and the inadequacy of farm credit.

Nyanteng (1994) has observed that the productivity of land and labour in small-scale agriculture is generally very low, and for most of the crops, the average yield for the period 1987-1991 was only about 25-50% of the yields achieved in isolated cases and elsewhere in Africa and the World (see Table 1). The same is true for average carcass weight of livestock (kg/head). He attributed the above phenomenon to the extensive use of traditional technology and methods of cultivation. In addition there are problems associated with the type, quantity and quality of inputs used, farmer education (human capital) improvement, inadequate moisture for plant growth, land tenure and several other factors (Nyanteng and Dapaah, 1997).

Table 1.1: Average Yield per Hectare of Major Crops 1987-1996(Mt)

Crops	Ghana		Africa	World	Percentage Achievable for Ghana (%)
	Actual	Achievable			
Roots/Tuber					
Cassava	7.8	28.0	7.7	9.9	28
Yam	6.1	10.0	9.1	9.0	60
Cocoyam	5.6	8.0	4.3	5.6	70
Plantain	7.1	10.0	19.0	25.0	70
Cereals					
Maize	1.2	5.0	1.6	3.7	24
Sorghum	0.7	2.5	0.8	1.3	28
Millet	0.7	2.0	0.7	0.8	35
Rice	1.0	3.0	2.0	3.5	33
Pulses/Nuts					
Groundnut	1.4	2.0	na	na	70
Cowpea	0.9	2.0	na	na	45

Sources: Ministry of Agriculture (1991); Ministry of Food and Agriculture (Files)

Ghana's agriculture is characterised by low–skill and low-pay work and most of the labour force are engaged in less productive smallholder agriculture. The nation can achieve food self-sufficiency, be secure in food and enjoy a successful agricultural intensification, if it has a healthy and knowledgeable agricultural workforce in crop and livestock production. The individuals in the sector, especially rural farmers, need to have farming skills improved through enhanced educational programmes to adopt modern and sustainable technologies and methods.

1.1.3 Farmer Education and Agricultural Productivity

Lele (1990) has observed that an improvement in farm human capital through farmer education is essential for increasing agricultural productivity. Farmers who have acquired high education are likely to adopt new technologies earlier than others with low educational levels, and use inputs that make them more productive. Most Ghanaian crop farmers as shown in the various GLSS reports have had no formal education (never been to school) and farm with relatively unproductive local farming implements like cutlass, hoe, and other traditional farm implements. The average farm size is very small and the farming system that is practised goes to increase land and soil degradation through the depletion of soil nutrients. The "slash and burn" is still the predominant land preparation method and modern agronomic practices are not common.

Also, low earnings from farms are partly the result of their relatively lower human capital endowment and partly of labour market discrimination (World Bank, 1995). The illiteracy of most farmers in Ghana creates communication problems and constrains proper understanding, adoption and also application of modern and improved farm technologies (ISSER/SOW-VU, 1999; Nyanteng and Dapaah, 1997).

Education is critical for economic growth and poverty reduction (World Bank, 1995) and if the nation is to achieve high productivity and incomes from small and medium scale farms and ultimately alleviate poverty, then the relationship between human capital development and productivity in agriculture should be explored fully. The nation will enjoy a successful agricultural intensification envisaged under the First Medium-Term Development Plan (1997-2000), if farmers have all the required skills and knowledge to adopt recommendations on sustainable methods in farming to reduce the adverse impact on the environment that modern farming methods brings. Resulting from the above, a policy framework aimed at generating employment for poverty reduction, needs to focus on increasing substantially productive employment opportunities in agriculture, especially those targeted at the poorer segments of the rural work force.

1.2 Problem Statement

Food security, as an important indicator of human welfare, tells us a good deal about changes taking place in human life (Asenso-Okyere et al, 1997). However, in the last decade, food insecurity has remained a problem in many households in Ghana and other countries in the West African sub-region. This problem has persisted in both dimensions of food insecurity: availability and accessibility to food (Asenso-Okyere at al, 1997). Not only are many households unable to produce sufficient food for themselves, they also lack the income from cash crops and non-farm activities to purchase food. The whole situation of food insecurity in the country may better be understood by considering its interconnections with human resource development, since human resources can be seen to have a direct impact on farm productivity (ISSER/SOW-VU, 1999).

Agricultural production in Ghana is characterised by low yield due to several of the factors enumerated above. Returns to farm labour and land are low and most of Ghanaian rural farmers have low incomes from their farm because of several factors among which are the small size of farm-holdings and low educational level and training. Investing in human capital is essential for raising farm productivity, which is a key to the enhancement of living standards. This is underlined by the fact that such investments constitute effective ways of increasing the poor farmer's access to productive resources and to the enhancement of farm level efficiency and increased incomes. The various interrelationships between education (schooling), extension training and farm productivity in Ghana is not well known because of few empirical studies that have been conducted in this direction. This trend can be attributed to the qualitative nature of most of the human capital variables that affect agricultural farm productivity. Apart from Jollife (1998) and a few other related human resource-productivity studies, the empirical evidence on the effects of education on agricultural productivity in Ghana is very scanty.

Available evidence shows a low educational level of farmers in Ghana (GLSS-4 Report, 2000). When both sexes are considered (see Table 2), 42.9% of the active population who had never been

Table 1.2: Educational Levels of the Active Population (both sexes) by Main Industry (Percent)

	Education Attainment					
Main Industry	Never been to school	Less than MLSC/BECE	MLSC/ BECE	Secondary or Higher	Total	Sample Size
Agriculture	42.9	24.8	28.3	4.0	100.0	4644
Manufacturing	29.8	24.3	36.3	9.6	100.0	987
Construction	10.3	20.5	44.4	24.8	100.0	117
Financial Services	1.4	4.3	34.8	59.4	100.0	69
Transportation/Administration	4.9	15.9	55.5	23.6	100.0	182

Source: Ghana Living Standards Survey (GLSS 4) Report, 2000.

to school were in the agricultural sector, 24.8% had attained less than MSLC/BECE, 28.3% had attained MSLC/BECE and only 4.0% had secondary education or higher. It must be stressed that among the main industries, agriculture recorded the lowest for secondary school attainment (GLSS 4 Report, 2000). It is evidenced from Table 2 that a significant number of agricultural workers have never been to school formally. This should be a cause for concern for agricultural policymakers. There is the need to quantify the effects that education, and exposure to extension training and service have on farm productivity at the household level in Ghana. In Ghana, extension education has largely been limited to agricultural services. The Ministry of Food and Agriculture (MOFA) and COCOBOD (Asenso-Okyere et al, 2000) manage extension education programmes in the country. The ratio of farmers' to extension officers in the country is very large and has been increasing, resulting in farmers training needs not being met (Asenso-Okyere et al, 2000).

The study therefore seeks to address the following questions;

1. What are the major factors that impact on farm productivity in Ghana?
2. What has been the effect of exposure to extension contact and educational status of the farmer on farm productivity in Ghana?
3. To what extent has educational status of farmers and their exposure to extension contact affected farm income earnings in Ghana?
4. What relevant recommendations can be made to inform policy on the effect of education on farm productivity and farm income in Ghana and its implication on food security?

1.3 Objectives

The main objective of this study is to estimate and quantify the contributions of education and exposure to extension service contact on farm productivity and income in Ghana.

The specific objectives are the following:

1. To identify factors affecting farm productivity (output per acre) in Ghana.
2. To estimate the impact of education (schooling) and extension service on farm productivity in Ghana.
3. To estimate the impact of education (schooling) and extension service on farm household income earnings in Ghana.
4. Finally to provide recommendations that will inform policy on education and farm productivity relationships and their implication for food security.

1.4 Justification of the Study

Low agricultural growth recorded in Ghana are mostly attributed to the vagaries of the weather, costly and low use of physical inputs (Nyanteng, 1994) but scarcely to the low productivity of the labour force in the agricultural sector. Ghana, as a developing nation, is aiming at becoming a middle-income country by the year 2020 and therefore the development of our human resource should be paramount. There is the need for research into the effect that human resource of the nation has on the productivity of the people engaged in important sectors of the economy. The key to food security is sustainability and this calls for increased productivity, which can be achieved, largely through the acquisition of skills and knowledge (Asenso-Okyere *et al*, 1997). The identification and analysis of the relevant factors that determine the productivity level will help decision–makers to formulate appropriate policies that could correct the gross disparities that exist between the rural and urban farming communities in terms of education, health care and nutrition.
The nature of farm productivity-education linkages of workers on family farms have been largely unexplored, despite the overwhelming importance of the family farms in developing countries and for that matter Ghana. Many closely related empirical studies have used data from several countries in Asia, South America and other African countries to estimate the effect of education on agricultural productivity (see Weir, 1999; Lockheed *et al*, 1980; Phillips, 1994; Moock, 1981). The only notable exception is the work done by Jollife (1998) using data from the GLSS 3. He estimated the effect of cognitive skills on total household income, farm income and non-farm income. The other studies using data on Ghana mostly centred on the situation of education in Ghana (Abban, 1986; Asenso-Okyere *et al*, 2000), impact of health and nutrition status on productivity (Nubé *et al,* 1999; Croppenstedt and Muller, 1998) and returns to education (Psacharopoulos, 1985,1993; Glewwe and Twum-Baah, 1990).

This present study seeks to bridge the gap and contribute to existing knowledge on the relationship between education and farm productivity and incomes in Ghana. In particular, the study establishes the link and the possible effects and interrelationship between education (schooling) farm productivity and farm income in Ghana. Policy recommendations based on the findings will also help policy and decision-makers in the education and agriculture ministries to target specific areas to improve agriculture development and growth in Ghana. The study establishes a baseline data (subset from survey data), method(s) of analysis and research information on the links between human resource development, farm productivity and farm incomes in Ghana for further research.

1.5 Organisation of the Study

The study is organised into six main chapters. The second chapter reviews the relevant literature on the effect of education on farm productivity and farm incomes and the methodologies that have been employed in estimating such effects. The chapter also focuses on issues pertaining to education, economic growth and development relationships. Chapter three provides a detail overview of the methodology to be used to achieve the study's specific objectives and comprises the theoretical and analytical framework of the study and empirical models. The results of the study and the discussion of these results are embodied in the fourth chapter. The summary, conclusion and policy recommendations from the study form the last chapter.

1.6 Scope and Limitations

The present study covered only respondent farmers who are involved mainly in maize and cassava production as sole crops. These crops were chosen because, a high percentage of respondents whose main occupation was farming, cultivated these crops and also because of their importance as major staples in the country. The study utilised data from only the fourth round of the Ghana Living standards Survey (GLSS 4) though it is believed a more detailed work could be done if all the four rounds were used to show policy effects from the late 80's. Also, due to insufficient information on cassava input price data, farm income regression analysis was only possible for maize.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The literature on the effect of education on productivity and income in specific sectors and enterprises focuses predominantly on the estimation of social and private rates of returns to education and the impact human capital has on the productivity of wage earners. Psacharopoulos (1985; 1993) summarised the results from more than 55 such wage studies from Africa, Asia and Latin America. In this study, the available literature comes from studies that use data from all over the world including two[1] from Ghana.

The literature on the definition of education and its importance to economic growth and development is outlined. The main issues discussed include education's contributions to economic growth and poverty reduction, and education as a source of technical change, especially in agricultural production through increased productivity. Studies on the determinants of farm productivity and income are also reviewed. The last part of the chapter concerns itself with some of the competing methodologies used in the estimation of education effects on productivity especially at the farm household level.

2.2 Education and Development

Education is broadly defined as the act of acquiring knowledge, skills, values, attitudes and best practices (Asenso-Okyere *et al,* 2000). Education can be divided into two broad categories namely formal and informal education. Formal education has been recognised as the most effective way to

[1] see Jollife (1998) and Vijverberg (1995)

develop the human potential. Formal education represents all forms of education that requires people to acquire education or skills through a structured system or institution recognised by the Ministry of Education (Asenso-Okyere *et al,* 2000). People who pass through these centres of education are presented with some certificate of award in recognition of the successful completion of the programme. Formal education in Ghana is divided into three divisions and these are:

i. Basic Education (Primary and Junior Secondary)[2]

ii. Secondary Education

iii. Tertiary Education

Informal education largely deals with the education of adults or people not through the means that are rigid and do not follow formal classroom education culminating in the award of certificates or degrees (Asenso-Okyere *et al,* 2000). To a large extent, informal means of education are aimed at making people either functionally literate or enable them acquire some skill or vocation. There are three basic types of informal education and these are:

i Adult Education (Non-formal Education)

ii Artisanal Training (Apprenticeship)

iii Extension Education

The functional literacy programme is action-oriented and is designed to address the educational needs of adults, especially the rural poor with emphasis on women and girls. Extension Education programmes are managed by the Ministry of Food and Agriculture (MOFA) and COCOBOD and have been largely limited to agricultural services. Formal extension education are concerned with the training of personnel to recognise farmers' problems, identify farmers' training needs, design training programmes and, above all, plan intelligent and appreciable extension programmes for the rural people. The various forms of informal extension education given to farmers include technical

[2] The division came about after 1987, when the Educational Reform Programme was initiated. Previously we had Basic Education (Primary School of 6 years and Middle school of 4 years).

advice on production, multiplication and supply of improved planting materials, advice to women farmers on home management and nutrition, among others (Asenso-Okyere *et al,* 2000).

Education, as one of the components of human capital has long been recognised as one of the major cutting edges of development and growth of the economies of developing countries. Education is a major instrument for economic and social development.

According to World Bank (1995), education is central to its strategy for helping countries to reduce poverty and improve their living standards through sustainable growth and investment in people. The two-fold strategy, according to the World Bank (1990) calls for promoting the productive use of labour - the principal asset of the poor and providing basic social services to the poor.

Education is critical for and contributes to economic growth and poverty reduction (Becker, 1964 and 1993; Singh *et al*, 1986; World Bank, 1986 and 1995; Peaslee, 1965 and 1969), but by itself it will not generate growth (World Bank, 1995). The strongest growth comes about when investment in both human and physical capital takes place in economies with competitive markets (World Bank, 1995). It contributes to growth both through increased individual productivity brought about by the acquisition of skills and attitudes and through the accumulation of knowledge. Indeed, education produces the knowledge, skills, values and attitudes that are used in the productive sectors of the economy of most countries to earn income and generally for development. Improved attitudes, beliefs and habits may lead to greater willingness to accept risk, adopt innovations, save for investment and generally to embrace productive practices (Appleton and Balihuta, 1996; Cotlear, 1990).

A large part of economic growth stems from improvement in the quality of the labour force, including increased education and better health, together with technological progress and economies of scale (Becker, 1993; Schultz, 1964; Denison, 1967; World Bank, 1991). A report by the World Bank (1995) has observed that investment in education leads to the accumulation of human capital, which is key to increased incomes and sustained economic growth. The accumulation of human capital-knowledge as noted by Romer (1986) facilitates the development of new technologies and is a source of self-sustaining growth (Lucas, 1988; Barro, 1991). The role of human capital in the development process has attracted a lot of attention (Schultz, 1964 and 1972; Becker, 1964 and 1993; Welch, 1970). Growth theorists such as Romer (1986,1990), Lucas (1988,1993) and Azariadis and Drazen (1990) have shown that the accumulation of human capital can sustain long-term growth.

Economies develop and grow as a result of increased productivity in all sectors and this can only be achieved if the labour force in these important sectors are well educated. The labour force should as a matter of fact possess all the requisite skills, ideas and attitude that will aid them to increase productivity and achieve high rates of return to investment (Psacharopoulos, 1984; Becker, 1993; Weale, 1993) by embarking on value for money projects and programmes. The outstanding economic records of Japan, Taiwan, and other Asian economies in recent decades dramatically illustrate the importance of human capital to growth (Becker, 1993). According to Becker, knowing their limitation and lack of physical resources, the so–called Asian tigers grew rapidly by relying on a well-trained, educated, hard-working and conscientious labour force. Primary education is the largest single contributor to the economic growth rates of the high-performing Asian economies (World Bank, 1993).

Education is also a source of technical change and source of improvement on technical knowledge and, hence of labour efficiency (Diwan, 1971). Economic benefits of schooling include the potential to obtain paid employment or to generate income through self-employment, using skills learned in school (Weir, 1999). Colclough (1980) reviewed the relationship between education and economic growth, and concluded that primary schooling increased productivity and thus economic growth. Also education contributes by reducing fertility (Population control) and improving health (Croppenstedt and Muller, 1998; Colclough, 1980) and by equipping people to participate fully in the economy and in society. Also, education is an important determinant of nutritional status (Thomas, 1989; Strauss, 1990; Behrman and Deolalikar, 1988). Education, especially basic (primary and lower secondary) education contributes to poverty reduction by increasing the productivity of the poor's labour (Lockheed *et al*, 1980; Moock, 1994; Philips, 1994; Villaume (1977); World Bank, 1995).

As stated by Singh, Squire and Strauss (1986), education should result in an economy's growing demand for adaptable workers who can readily acquire new skills to support the continued expansion of knowledge in the nation. Also higher education contributes to self-sustaining growth through the impact of graduates on the spread of knowledge (Becker, 1964). In fact more educated workers can and are known to deal more effectively with a rapidly changing environment (Schultz, 1971,1975; Mincer, 1989; World Bank, 1991). Also, schooling may speed the adjustment in use of new technologies (Huffman, 1974).

Weir (1999) pointed out that formal schooling is not only useful after new technologies have been adopted but education may also help to determine whether a farmer decides to be an early adopter of innovations and the extent to which new innovation will be used. There are at least three reasons for this phenomenon (Weir, 1999). First, those with schooling tend to be more affluent and are less in danger of starvation if a prospective innovation is unsuccessful. Second, educated farmers may be more likely to be contacted by agricultural extension workers looking for model farmers to test innovations. Lastly, literate farmers are better able to acquire information about potential innovations and to make rational evaluations of the risks involved in trying new inputs, crops or methods.

Studies in the early 1990s, notably Azariadis and Drazen, (1990); Lau, Jamison and Louat, (1991) have confirmed the overwhelming importance of education, especially primary education for growth. Cross-country studies have shown that there exists a threshold level of human capital accumulation beyond which a country's growth may accelerate. Most empirical studies (Lockheed, Jamison and Lau, 1980; Moock, 1981; Philips, 1994; Weir, 1999) on the impact of farmer education on farm productivity have established that primary education is very important in increasing productivity.

Agriculture provides a compelling evidence of the link between human capital-education and technology (Becker, 1993). However, he pointed out that education is of little use in traditional agriculture because farming methods and knowledge are readily passed on from parents to children. This is supported by the low social rates of return to education recorded in most studies using data from Africa (Lockheed, Jamison and Lau, 1980; Moock, 1981; Philips, 1994; Weir, 1999). This assertion also receives a lot of support from African studies reviewed by Appleton and Balihuta (1996). They found that the effect of schooling on agricultural output is usually not significant, though in some cases it can be large. They suggested several possible reasons for the low and sometimes insignificant effect of education on farm output, including small farm and sample sizes, errors in measurement of farm production and wide variation in the actual effects of education on agricultural output in different areas and under different farming systems. Arrow (1973) postulated that individual farmers with higher ability receive more education and more income and not education itself generating higher incomes. Farmers in developing countries are among the least educated members of the labour force (GLSS 4 report, 2000). By contrast, farmers in developed countries deal with hybrids, breeding methods, fertilisers and other chemicals, complicated equipment, and intricate futures markets for commodities (Becker, 1993) and are therefore well-educated and exposed to more extension contacts to increase productivity on the farm.

According to Welch (1970), education is of great value since it helps farmers adapt more quickly to new hybrids and new technologies, and it is the most important to farm production in a rapidly changing technological or economic environment (Schultz, 1964; 1975). Agricultural households are the main forms of economic organisation in developing countries (Singh, Squire and Strauss, 1986). The agricultural sector plays a major role in economic development in Ghana and since about 60-70% of the labour force is involved in it, the educational status of this labour force should be of concern to policy makers.

Education may enhance farm productivity by improving the quality of labour, by increasing the ability of the farmer to adjust to disequilibria and through its effect upon the propensity to successfully adopt innovation. The importance of formal schooling to farm production becomes more apparent as technological innovations spread more widely within a country (Weir, 1999). He emphasised on the efficiency advantage for farmers who are better prepared to anticipate and cope with disequilibria. Thus, even in the absence of innovation, farm productivity may be enhanced by investments in education.

Education may have both cognitive and non-cognitive effects upon labour productivity. Cognitive outputs of schooling include the transmission of specific information as well as the formation of general skills and proficiencies. Education also produces non-cognitive changes in attitudes, beliefs and habits. Increasing literacy and numeracy may help farmers to acquire and understand information and to calculate appropriate input quantities in a modernising or rapidly changing environment (Weir, 1999). In fact schooling enables farmers to learn on the job more efficiently (Rosenzweig, 1995).

Becker (1964) established that basic literacy and numeracy (lower occupational levels) and greater logical reasoning capacity, heightened self-expression and sound technical knowledge (higher occupational levels) had a significant impact upon worker effectiveness. Education may either increase prior access to external sources of information or enhance their ability to acquire information through experience with new technology. That is, it may be a substitute for or a complement to farm experience in agricultural production (Weir, 1999). Education may indirectly increase output through its interaction with other institutional variables. For example, schooling may substitute for access to credit by providing the skills necessary to obtain waged employment, thereby generating cash to finance agricultural investments (Appleton and Balihuta, 1996).

2.3 Determinants of Farm Productivity and Income

Reardon *et al* (1996) uncovered differences in patterns and determinants of farm productivity over agroclimatic zones, types of technology, degrees of environmental degradation, and levels of improved inputs. They reported on studies that employed data from Burkina Faso, Rwanda, Senegal and Zimbabwe. Generally the main findings indicated that, rates of growth in yields and returns per labour-day were low in the four study countries. They also identified productivity determinants in the four study countries to include fertiliser, improved seeds, animal traction, organic inputs and conservation investments. Other determinants were farm size and land tenure, non-cropping income and well-functioning input and output markets. They recommended that, to improve long-term food security in Africa, farmers must be able to pursue sustainable intensification of farm production by use of improved inputs. They concluded that the use of fertiliser, organic inputs, animal traction and conservation investments need to rise dramatically.

They however failed to examine the role-played by the farmer viz. a viz. his or her educational level and ability to use these inputs effectively. A vast number of available empirical studies include environmental and other human capital variables like health and nutritional status in addition to agricultural inputs as explanatory variables when estimating productivity changes.

Strauss (1986) used household level data from Sierra Leone to test whether higher calorie intake enhanced family farm labour productivity. He estimated a farm production function using the Non-Linear Two Stage Least Squares (NL2SLS) developed by Amemiya (1983), accounting for the simultaneity in input and calorie choice. He found a highly significant effect of calorie intake on labour productivity at the farm level. In all three cases of estimation procedures,[3] both the calorie and calorie squared coefficients were significant at more than the 0.01 level, with calorie consumption contributing positively to output. Nutrition (measured in calorie intake) is found to be a major determinant of farm productivity. Because nutrition and health variables are known to be collinear with education (Strauss and Thomas, 1995), they were excluded from this study.

2.4 Effects of Education on Farm Productivity: Empirical Evidence

The development of the human capital concept has provided economists with a useful framework for investigating the relationship between education and productivity in the agricultural sector and income (Hansen 1970; Knight, 1987). Human capital analysis assumes that schooling raises earnings and productivity in the agricultural sector mainly by providing knowledge, skills and a way of analysing problems. As stated by Becker (1993) an alternative view, however, denies that schooling does much to improve productivity, and instead it stresses "credentialism"- that degrees and educational qualification convey information about the underlying abilities, persistence, and other valuable traits of people. Becker admits that credentialism exist but explains that it does not explain most of the positive association between earnings from agricultural activities and schooling.

[3] He used the linear two-staged least squares estimate, the NL2SLS and a repeated NL2SLS with upland and land-upland interaction variables dropped.

Microeconomic evidence on the impact of education on farm productivity is abundant. The conclusions however varied, depending on where the data used in the analysis is taken from. Generally, while it has been established that better-educated workers earn higher wages in the modern sector (Fafchamps and Quisumbing, 1998), it remains a contentious issue whether education raises farm productivity. Studies using survey data from Asia, South America and other developed countries have come out with a positive effect of education on farm productivity (Jamison and Moock, 1984; Lockheed, Jamison and Lau, 1980; Philips, 1994, King, 1980). But evidence from Africa indicate otherwise- low rates of return to formal schooling and sometimes negative marginal effects (Moock, 1981; Appiah-Kubi *et al*, 2001; Weir, 1999).

2.4.1 Evidence from Developing Countries

Weir (1999) challenged the hypothesis put forth by Croppenstedt and Demeke (1997) that demand for schooling in rural Ethiopia was constrained by the traditional nature of farm technology and lack of visible benefits of schooling in terms of farmer productivity. He examined the effects of schooling upon farmer productivity and efficiency by employing data drawn from Ethiopia Rural Household Survey (EHRS) conducted in 1994. Weir (1999), reported of a positive and significant effect of land, labour, capital and fertiliser when a standard Cobb-Douglas production function is estimated (without education variables). When education attainment variables were introduced, the results showed that there were positive and significant returns to formal schooling in agriculture in rural Ethiopia. In the case of household heads that farm, the returns were greatest for those who had attained some upper primary schooling (grades four to six) and no more. He argued that given the traditional nature of farm technology in rural Ethiopia, it wasn't surprising that secondary schooling added nothing to the productivity of household heads who were farmers. He explained that those who spent more years in school had spent less time in the fields to learn traditional farm methods from their fathers and may have developed negative attitudes toward farm labour.

Weir found out that an additional year of schooling for the household head decreased output by one percent (insignificantly), when site-fixed effects are included in the model specification. Overall, the effect of one extra year of schooling for a farmer was to increase output between 1.0 and 2.0 percent and for non-farmers between 3.0 and 4.1 percent. His findings compared well with Lockheed, Jamison and Lau (1980) and Philips (1994), who reported small or negative effects of an additional year of schooling. The average farm-specific efficiency estimated from a stochastic frontier production function was 54 percent with an assumed distribution of one-sided error term and concluded that formal education had no influence upon placement of a stochastic production frontier (Weir, 1999).

Moock (1981) attempted to measure the worker effect of education in the production of the staple food crop in an area of Western Kenya characterised by small farms and considerable off-farm employment. He developed a modified Cobb-Douglas production function, where a measure of education was incorporated into the function as an explanatory variable. The effect of educational attainment on production was problematic. Men who had completed 4 or more years of school seemed to produce nearly 2% more maize, *ceteris paribus*. However, a negative coefficient (-0.111) for the category of respondents with 1-3 years of schooling, which he described as surprising, was reported in the study. He however reported that exposure to the extension services enhanced technical efficiency, a 10% increase in extension contact was associated, *ceteris paribus*, with a 0.2% increase in yield of maize.

Eisemon, Schwille and Prouty (1990) conducted a survey, which examined the effect of primary education on the cognitive skills of farmers in Kenya. They found that farmers who had been to school were able to construct causal models of events in the natural world and to demonstrate how humans could control these events. They were also able to actively observe, diagnose and correct common agricultural problems better than farmers with fewer years of education.

Using data covering 300 farmers of five villages in Irepodun Local Government Area of Kwara State, Awolola (1998) related three socio-economic factors with the use of agrochemicals such as herbicides, pesticides, insecticides, and fertilisers. On the basis of simple cross-tabulations, he found that the educational status, farm size, and income were positively associated with farmers' use of agrochemicals. The study further reveals that adoption of agrochemicals is related to the type of education a farmer has. For example, farmers who have secondary and post-secondary education used more agrochemicals than illiterates and adult uneducated farmers. The implication here is that agricultural development involves a sequence of innovations and adjustments, which increasingly demand a more sophisticated and better-educated farming community. For a successful agricultural development, extension agents were advised in the study to team up with the farmers so as to identify and solve their farm problems.

In establishing a relationship between education and technological innovation, Cotlear (1986) stressed the importance of non-cognitive aspects of education, such as the receptivity to new ideas, which allowed farmers to employ new technologies. Using survey data from Peru, he estimated the effect of education on farm output using production functions. He reported that education also affected production by developing analytic modes of problem solving, by allowing farmers to think more abstractly and thus realise the relationship between technology and output.

In their study of the relationship between farmer education and farm efficiency in Nepal vis a vis the role of schooling, extension services and cognitive skills, Jamison and Moock (1984) found that farmers who could read, write, and understand numbers could allocate inputs more efficiently and thus increased productivity. In general, the study found that direct returns to education were stronger in developing countries than in developed countries. Jamison and Moock (1984) posited that this could simply reflect shortages in minimal skills in developing countries.

Lau, Jamison and Louat (1991) studied the effects of primary education on economic growth in East Asian and Latin American countries. They found that primary education significantly affected economic growth in twenty-two East Asian and Latin American countries. They also found that secondary education affected growth in fifty-four East Asian, Latin American, African and Middle Eastern countries.

Lockeed, Jamison and Lau (1980) reviewed and summarised the findings of 18 studies containing thirty-seven data sets from thirteen developing countries (primarily in Asia) and found that most reported a significant positive effect of education upon output, though the results were mixed. They concluded that four years of primary education increased the productivity of farmers 8.7 percent overall and 9.5 percent in countries undergoing modernisation. However, for the group of studies concerned with the effects of education in traditional agriculture, the increase in output owing to four years of schooling was only 1.3 percent on average. Education increased the ability of farmers to allocate resources efficiently; enabled them to improve their choice of inputs; and enabled farmers to estimate more accurately the effect of those inputs on their overall productivity. They concluded that as the education level of an individual increased, so did the individual's ability to perform more complicated tasks or to adapt to changing conditions or tasks.

Phillips (1994) reviewed additional 12 studies using 22 data sets (with more recent data and greater representation of Latin America), and was able to confirm the general trends noted above. The average increase in output owing to an additional four years of schooling in the studies he considered was 10.5 percent, with the relevant figures for traditional versus modern farming systems at 7.6 and 11.4 percent, respectively. However, his survey was sufficiently geographically diverse to show that (under certain conditions) the effects of schooling were stronger in Asia than in Latin America, irrespective of the degree of modernisation. This may have implications for the assumed applicability of Asian findings to Africa, though too few studies using Africa data were included to draw strong conclusions.

Croppenstedt, Demeke and Meschi (1998) found that literate farmers were more likely to adopt and use fertiliser than those who were illiterate, though the quantity of fertiliser demanded did not depend upon literacy. They used data from a USAID fertiliser marketing survey. In 1997, Croppenstedt and Demeke using data from the Ethiopia Rural Household survey (ERHS), found that literacy had a positive effect upon productivity and that education was weakly correlated with farm efficiency.

A study carried out by Colclough (1980) to establish the relationship between primary schooling and economic development asserted that the benefits of primary schooling arose from cognitive and non-cognitive behavioural changes induced by the schooling experience--even in systems of very low quality. It also asserted that evidence from fertility and farmer productivity studies suggested that individual behavioural changes that resulted from schooling were stronger when literacy is widespread than when it is concentrated. He postulated that an interactive effect existed between individual and community attitudes and values, which significantly strengthened the economic and social case for universalising access to primary schooling.

Croppenstedt and Muller (2000) estimated the impact of both health and nutritional status on the productivity and efficiency of cereal-growing Ethiopian peasant farmers. They examined the distribution of residual technical efficiency (TE), after including the various agricultural inputs, including health and nutrition. Analysis was carried out using data from the first round of the Ethiopian Rural Household Survey, conducted in 1994. They estimated a wage equation by including an education variable of the head and other members. The results showed that generally, the education of the head and members of the household was very low with an estimated coefficient of 0.8 from the estimated wage equation. Estimated output elasticity of Weight-for-Height (WFH-wasting) was between 1.90 and 2.26. Returns to investment in nutrition were clearly high in Ethiopia using stochastic production frontier models.

An exception to the literature reviewed above is the work done by Diwan (1971). He provided a quantitative estimate of the impact of education (education defined in terms of school years) on the efficiency of labour using time-series data on United States Non-farm Economy for the period 1909-1960. He employed a linear labour efficiency education function and estimated the elasticity of labour with respect to education. The findings showed a positive impact of education on labour, and the elasticity of labour efficiency with respect to schooling was around 1.6.

2.4.2 Evidence from Ghana

Jolliffe (1998) examined the impact of cognitive skills on the income of households in Ghana. He used scores on mathematics and English tests to measure cognitive skills and estimated the returns to these skills based on farm profit, off-farm income, and total income. The analysis used data from the Ghana Living Standards Survey (GLSS), which covered 3,200 households between the ages of 15 and 55. He argued that using test scores in lieu of years of schooling to measure human capital eliminated the fact that years of schooling fail to capture any effect that school quality may have on the creation of human capital. He reported that cognitive skills had a positive effect on total and off-farm income but its effect on farm income was statistically insignificant. Basing his arguments on the fact that school quality varied over Ghana and that test scores reflect this variation, the study showed that the returns to skills, as measured in the total income models, were positive and significant. He alluded that the results supplemented the human capital literature because it made it clear that skills were rewarded and also provided evidence against the screening and credentialism theories of the returns to schooling.

In his study of returns to schooling in non-farm self-employment, Vijverberg (1995) examined the relationship between education attainment (schooling) and income from family enterprises. The study also tried to distinguish between productive efficiency and allocative efficiency in studying the contribution of schooling, using data (a sample of 2,970) derived from the Ghana Living Standards Survey (GLSS). The GLSS data cover September 1987 to August 1988 and give a complete information on 2,983 enterprises. Of these, eight were omitted by imposing a maximum value of ¢2,000,000 on both Capital and Inventory, in order to avoid problems with outliers. Furthermore, five enterprises were dropped because of measurement errors associated with outlier's.

Based on a variety of specifications of the enterprise income equation and a variety of estimation strategies, he found that, in Ghana in the late 1980s, schooling of the entrepreneur increased the income of his enterprise, primarily by raising the firm's allocative efficiency and less so through increased productivity efficiency. The study reported of a rate of return of 4.1% to the entrepreneur's own elementary education. The crossover effect of human capital was significant among entrepreneur's who had no education themselves because family enterprise income rose by 3.3% for each additional year of completed education of the most educated other family members.

He concluded that education contributed positively to firm performance and stated that the estimates could be refined by means of correction for self-selection of the enterprises and for the endogenous choices of the quantity of inputs.

2.5 Educational Effects: A Review of Competing Methodologies

2.5.1 Technical and Allocative Efficiency

Husain and Byerlee (1995) note two important ways in which education may increase farm output: (1) general skills acquired in school reduce technical and allocative inefficiencies in production; and (2) attitudes acquired in school encourage the adoption of new technologies, which cause the production frontier to shift outward.

When two farmers are observed using similar amounts of inputs to produce very different quantities of output, it does not necessarily follow that one is more efficient than the other. Both may be equally efficient at using their chosen technology, but one may be using a more effective production technology and operating on a higher production frontier (Jamison and Lau, 1982). Education may cause movement towards the production frontier, in the case of technical inefficiency (Weir, 1999). A farmer is technically efficient if it is impossible to raise farm output without increasing use of at least one input (Weir, 1999). Technical inefficiency may arise because of inappropriate timing or method of input application, which is often caused by a lack of information but may also reflect problems of input supply (Ali and Byerlee 1991).

For allocative inefficiency, education causes movement along the frontier to a profit maximising point. Allocative (or price) efficiency is achieved when the cost of producing a given output is minimised, as evidenced by the equality of the marginal products of inputs to the input price ratio (Weir, 1999). Ali and Byerlee (1991) pointed out some of the causes of allocative inefficiency. They include lack of information, failure to choose the most cost-efficient combination of inputs, unreliable input supply, sub-optimal tenancy arrangements, risk aversion, and other institutional constraints.

Efficiency measures provide an indicator of performance. Rates of return to education investments and other physical inputs have often provided a good indicator of measuring efficiency (Psacharoupolus, 1985, 1994; Appiah-Kubi *et al*, 2001). Other studies (Afari, 1998; Asuming-Brempong, 1987; Darko, 1998) have used the concept of Domestic Resource Cost (DRC) and Pay-Off Matrix to measure efficiency of resource-use. As farmers gain experience, inefficiency in using the new inputs fall (Weir, 1999). Thus measures of efficiency at anyone point in time may not reflect the equilibrium situation, but rather indicate deliberate trial and error on the part of farmers (Welch 1978). Technical progress of farmers in a particular area may be measured by the proportion of the population who take up new innovations or by the quantities of modern inputs, such as fertiliser, which are used.

Psacharopoulos and Woodhall (1985) described a framework of four stages of agricultural technology adoption and the role education may play in each stage. Stage 1: Traditional farming. Information is passed from father to son, and little or no schooling is needed. Stage 2: Single input adoption (e.g., fertiliser). Basic literacy and numeracy are very useful to farmers for understanding instructions and adjusting quantities of the new input. Stage 3: Adoption of multiple inputs simultaneously. Here, more than literacy and numeracy are necessary. Some basic science knowledge is helpful. Stage 4: Irrigation-based farming. The farmer must make complex calculations of effect of changes in crops and weather. More education is needed for efficient production at this stage.

2.5.2 Estimation of the effect of Education on Agricultural production: Production Function Approach

The approach of examining the effect of education on agricultural productivity is divided into two major camps: frontier versus non-frontier (direct) methods for estimating the production function (Weir, 1999). He states that if the researcher is interested mainly in the estimated coefficient on schooling in the production function, non-frontier techniques will suffice. Estimation of the average (non-frontier) function permits efficiency ranking of firms, in this case farm units or enterprises (Weir, 1999).

2.5.2.1 Non-frontier (Direct) Production Function Approach

Estimation of the effects of education upon productivity using direct, non-frontier methods dates back to the 1960s (Weir, 1999). Griliches (1964) was the first to use a production function to estimate the effect of education on agricultural output. Kislev (1965) used non-frontier methods to carry out analysis on the same aggregated data in 1965, but he obtained different result from that obtained by Griliches. Chaudhri (1979) explained that the difference in the results obtained from the two studies (Griliches, 1964 and Kislev, 1965) was due to the level of aggregation of the data used. He discussed four possible effects of schooling: the worker effect, the allocative effect, the innovative effect and the external effect. Based upon his own empirical work, he concluded that an examination of data at household level would reveal only direct (worker) effects of schooling on output. As the level of aggregation is increased up to the state level, more of the allocative, innovation and external effects are internalised.

Welch (1970) estimated a production function with physical output of one farm product as the dependent variable and education and other inputs as explanatory variables. The estimates disclosed only the worker (direct) effect of education. Using gross output sales of two or more products as the dependent variable reveals both the worker and allocative effects of schooling. In this way, the role of education in allocating inputs across different outputs can be captured. Estimating a value-added (or profit) production function makes it possible to examine the worker, allocative and input-selection effects of education, if education is included in the specification and other purchased inputs are excluded.

Ram and Singh (1988) examined the allocative effect of schooling in Burkina Faso. They used alternative Mincer/Chiswick-style[4] earning (income) function to estimate the effect of education upon income, one with education plus other farming inputs as the explanatory variables, and one including only education. The coefficient of education variable in the first equation captures both the worker and the allocative effects because other inputs were no longer held constant. The difference between the coefficients on schooling in the two equations provides an indication of the size of the allocative effect.

To establish causality from education to input choice, Appleton and Balihuta (1996) run regressions with each input as the dependent variable and education and other regressors as explanatory variables in their research on Uganda agricultural productivity. Since they found that education did not have a strong positive effect upon use of capital and other purchased inputs, they concluded that the usual Cobb-Douglas production function which included physical inputs explicitly (i.e., inputs held constant) understated the importance of education in explaining output. They then estimated the production function without these physical inputs, as suggested by Welch (1970), to capture more fully the effect of schooling.

Weir (1999) observed that when there is adequate information about input and output prices, it is possible to investigate the full effects of schooling without omitting other inputs from the production function. Wu (1977) estimated the worker, allocative and scale effects of schooling for small-scale farmers in Taiwan using a model of profit maximisation. Farm profits were a function of fixed and variable inputs plus education less cost. Optimal input demand functions were specified as functions of fixed inputs and education to give an expression for optimal profits.

[4] Estimating returns to education and experience on earnings (both social and private rate of return)

Totally differentiating the actual and optimal profit functions with respect to education provided information on the allocative, worker and scale effects of education.

Jollife (1998) used non-frontier models to estimate the effect of cognitive skills on farm, non-farm and total income using data from Ghana. He used Powell's Censored Least Absolute Deviations (CLAD) and Symmetrically Trimmed Least Squares estimators to estimate farm and off-farm income after estimating the income functions by Ordinary Least Squares (OLS). He pointed out that in contrast to Heckman's two-step or the Tobit estimator, Powell's estimators are consistent in the presence of heteroscedasticity and are robust to other violations of normality.

2.5.2.2 Frontier Production Function Approach

A production frontier is estimated based on the most efficient observed use of inputs to produce each level of output. The extent to which a production level of a firm differs from the frontier provides a measure of technical inefficiency for the sample as a whole or for each individual firm. The causes of technical inefficiency can be investigated by regressing inefficiency on education and other explanatory variables (Ali and Byerlee 1991). Phillip and Marble (1986) noted that the frontier production function may be more relevant to the study of the effects of education on farm productivity than the conventionally used average function because it focused attention on the best-practice farmers in the sample with schooling as an important determinant.

Statistical estimation of production frontiers has had two incarnations: stochastic and non-stochastic (deterministic). The deterministic frontier takes the following general form:

$$Y = f(X)e^{-u}, \tag{2.1}$$

where, Y is output, X a vector of production inputs and u is a non-negative error component representing technical inefficiency (Weir, 1999) .

Aigner, Lovell and Schmidt (1977), Meeusen and van den Broeck (1977) and Battese and Cora (1977) have developed the stochastic production frontier methodology. Stochastic frontier estimation involves specification of a two-part error term:

$$Y = f(X)e^{v-u}, \tag{2.2}$$

where, v represents random shocks, such as measurement error or factors which are external to the firm(e.g., weather), and is symmetric and distributed normally. The second component, u, is a one-sided, strictly non-negative, error representing technical inefficiency.

Jondrow *et al.* (1982) show how to decompose the v-u term from equation 2.2 to provide estimates of technical inefficiency by calculating the expected level of inefficiency for each farm, $E(u_i)$, conditional on the random component, v_i (Ali and Byerlee, 1991). Battese and Coelli (1988) provided a formula to estimate farm-specific efficiency in the case of a logged dependent variable.

One weakness of the frontier approach is that empirical results are very sensitive to the number of inputs included, the degree of aggregation of the data and whether or not environmental factors, such as soil quality, are included (Hussain and Byerlee, 1995).

Lovell (1993) noted that the Cobb-Douglas production function is the most commonly used functional form to estimate the production frontier. It has the advantage of ease of estimation and interpretation of the coefficient, u. However, since it assumes constant elasticity of scale and unitary elasticity of substitution, variations in elasticity of scale or substitution may be erroneously attributed to inefficiency. Hence, functional form is a relevant consideration when estimating the production frontier. Results are also highly sensitive to the assumed distribution of u, the component of the error term attributed to inefficiency. Commonly assumed distributions include: half-normal, truncated normal, exponential, and gamma (Greene, 1993).

Lovell (1993) noted again that the two-stage procedure rested on the assumption that factors such as education affected the efficiency of the farmer in transforming inputs into output, but did not affect the process by which production occurs. If the variables used in estimating the efficiency were correlated with the variables used to explain the efficiency, the coefficients on the variables used in the first stage to estimate efficiency will be biased. A one-stage model in which all variables, including education, appear in a single equation to estimate efficiency may alternatively be specified. This reduces the problem of omitted variable bias, but may lead to multicollinearity. There is an important difference between the two-stage and one-stage model: in the one-stage model, efficiency is measured controlling for variables such as education; two-stage model, efficiency is measured without controlling for variations in education in the first stage, and regressors such as education are used to explain variations in efficiency in the second stage (Lovell, 1993).

Ali and Byerlee (1991) surveyed 12 frontier production function studies, of which approximately half investigated the sources of measured inefficiency. They noted that variables related to managerial ability of farmers, including education and technical know-how, were found to be significant in every case, whereas mixed results were found for other potential sources of inefficiency such as input use and soil quality among others.

2.5.3 Summary

In summary, we see that the effect of education on productivity and income at the farm household level has received a lot of attention with most of the studies employing data from other developing countries. It has been well noted that education (both formal and informal) contributes significantly to economic development and growth, poverty reduction through increased productivity. Also education can be treated as a factor of production together with other fixed and variable inputs and it has a positive effect on output through increased productivity. Some studies though reported a negative effect of education on output when different levels of schooling years are considered. The studies reviewed point out the different competing methodologies often used in the estimation procedure. Most of the studies reviewed used the non-frontier production function by employing the Cobb-Douglas technique with few others using the stochastic frontier approach. The stochastic frontier function approach is not used in the estimation carried out in this study due to data limitation associated with the manner in which answers were solicited from respondents and the difficulty associated with the decomposition of the error term into its components. The frontier model is used when the measurement error has a symmetric component[5] and one-sided component, which captures the effects of inefficiency relative to the stochastic frontier. The Cobb-Douglas production function is employed because the estimated coefficients can be interpreted easily.

[5] Random shocks outside the firms control, variations and other statistical 'noise'.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The study employs the theory of production and profit maximisation at the firm level to derive the empirical models that are used in estimating the factors that affect farm productivity and incomes in Ghana. The traditional Cobb-Douglas production function is adopted in the study to estimate the effect of factors affecting farm productivity in Ghana. The non-frontier production function is repeated for the second objective with the inclusion of an education variable as a factor of production. The first and second specific objectives are estimated based on the theory of production by specifying a model without and with education of the farmer as a variable input. The third objective is estimated based on the theory of profit maximisation by a farm unit. In estimating the effect of education of the farmer on farm income, a restricted net farm income function is specified with education measured in formal years of schooling completed as an explanatory variable.

Section 3.2 focuses on the theoretical and analytical framework on production function and profit maximisation. Empirical models used in the estimation are provided in section 3.3. The data to be used in the estimation and its source is outlined in the last section of the chapter.

3.2 Theoretical and Analytical Framework

Available literature on various theories used to explain the effect of education on productivity has mostly dwelt on the theory of the firm where education is incorporated into Cobb Douglas production function (see Weir, 1999; Moock, 1981; Lockheed et al, 1980) and the human capital model developed and pioneered by Shultz (1961; 1972), Becker (1964; 1993) and Mincer (1958; 1974).

The Human Capital Model (HCM) has been the most widely used model to estimate the rates of return especially in the estimation of social and private rates of return to education. According to the theory, given that wage earners are paid their marginal product and that this marginal product rises as more human capital is accumulated, it is possible to estimate rates of return to additional years of schooling from earnings data among persons who have different levels of education.

3.2.1 Production Function

The set of all combinations of inputs and outputs that comprise a technologically feasible way to produce is called a production set. The function describing the upper boundary of this set is known as the production function and it measures the maximum possible output that can be obtained from a given amount of inputs applied (Varian, 1999). Inputs for production, which are often called factors of production are often classified into broad categories such as land, labour, capital (financing and physical), raw material among others (Varian, 1999).

The firm (in this case the farm unit) is a technical unit whose entrepreneur (owner or manager) decides on how much of and how one or more commodities will be produced, (Henderson and Quandt, 1980). The entrepreneur (farm manager) transforms inputs into output(s), subject to the technical rules specified by his production function and he either gains or bears the loss which results from his decision (Henderson and Quandt, 1980). The farm production technology or function expresses the relationship between the quantities of inputs he employs and the quantities of output produced.

Following from Varian (1999) and (Henderson and Quandt, 1980), we consider a farm unit which utilizes m variable inputs $z = (z_1, \ldots\ldots, z_m)$ and one or more fixed inputs in order to produce a single output, Q. The production function states that the quantity of farm output Q is a function q of the quantities of inputs:

$$Q = q\,(z_1, \ldots\ldots, z_m, A) \qquad (3.1)$$

Where,

A is a vector of fixed inputs

The production function, q shows the maximum output obtainable from various input vectors. We assume that the farm owner or entrepreneur is rational and operating in a competitive market (is a price taker). The function is assumed to be a single valued continuous function with continuous first and second-order partial derivatives. It is also an increasing function of Z_i:

Where, i = 1, 2, 3, 4........m.

For output maximization or cost minimization, it is assumed that the production function is a regular strictly quasi-concave function. The production function presupposes technical efficiency and states the maximum output obtainable from every possible input combination. When we assume two inputs Z_1 and Z_2 with one of the inputs assigned a fixed value, (say Z_2^*), the output produced, Q becomes a variable function of the other (Z_1). The average and marginal products for

Z_1 are defined in an analogous manner for particular values of Z_2^*. The average product (AP) of Z_1 is its total product divided by its quantity:

$$AP_{z_1} = Q / Z_1 = q(Z_1, Z_2^*) / Z_1 \tag{3.2}$$

The marginal product (MP) of Z_1 is the rate of change of total product (Q) with respect to a unit change in Z_1, thus, the partial derivative of (3.1) with respect to Z_1 is

$$MP_{z_1} = \partial q(.) / \partial z_1 = \partial q(Z_1, Z_2) / \partial Z_1 \tag{3.3}$$

Output elasticity of Z_1 is defined as the proportionate rate of change of Q with respect to Z_1

$$\omega_{z_1} = \partial(\ln Q) / \partial(\ln z_1) = \frac{MP}{AP} \tag{3.4}$$

Output elasticities may be expressed as ratio of marginal and average products and are positive if both MP and AP are positive (AP is always positive).

3.2.2 The Cobb Douglas Production Function

The Cobb-Douglas production function has a constant elasticity of substitution of one and is a member of the CES class and is homogenous of degree one (Henderson and Quandt, 1980). If a production function has the form $q(z_1, z_2) = Az_1^a z_2^b$, then it is a Cobb-Douglas production function. The parameter A measures the scale of production: how much output one would get if one used one unit of input. The parameter a and b are elasticities and they measure how the amount of output responds to changes in the input. We generally assume some properties of farm production technology. First, we assume that farm technologies are monotonic: that is, if we increase the amount of at least one of the inputs, it should be possible to produce at least much output as you were producing originally. Second, the study assumes a convex farm technology.

3.2.3 Profit Maximization

In addressing the third specific objective, the study has profit maximization of the farm unit as its theoretical underpinning to the estimation of the effect of education on farm income (profit). The farm unit chooses a production plan so as to maximize profits (Varian, 1999). The profit, is the difference between his total revenue and his total cost:

$$\pi = pq(.) - c \tag{3.5}$$

where,

π is profit from the farm unit

p is output price

c is total cost

Suppose that the farm unit produces n outputs $(q_1, \ldots, q_n)$ and uses m inputs $(z_1, \ldots, z_m)$. The profit received by the farm unit can be expressed as:

$$\pi = \sum_{j=1}^{n} p_j q_j - \sum_{i=1}^{m} r_i z_i \tag{3.6}$$

The first term on the right-hand side of equation 3.6 is revenue and the second term is cost. The total revenue of an entrepreneur who sells his output in a perfectly competitive market is given by the number of the units he sells multiplied by the fixed unit price (p) he receives (Henderson and Quandt, 1980). The costs include all the factors of production used by the farm unit, valued at their market prices. The prices of inputs are denoted in equation 3.6 as r_i.

Under certain regularity conditions and the conditions required by the duality theory, efficient production technology is provided by the profit function:

$$\pi(p_1,\ldots p_n;r_1,\ldots.r_m)\equiv\max_{q,z}\{pq-r'z|f(z)\geq q,z\geq 0,q\geq 0\}, \qquad (3.7)$$

Equation 3.7 shows the maximum profit available at output price p and input prices, r (Lovell *et al.*, 1980).

3.2.3.1 Short and Long-run Profit Maximization

Let $f\ (Z_1, Z_2)$ be the production function for the firm with two inputs, p represents the price of output, and r_1 and r_2 the prices of the two inputs Z_1 and Z_2 respectively. Then the profit-maximization problem facing the farm unit can be written as:

$$\max_{z_1}\ pf\left(z_1,\overline{z_2}\right)-r_1z_1-r_2\overline{z_2} \qquad (3.8)$$

If Z_1^* is the profit-maximising choice of factor Z_1, then the product of the output price and the marginal product of factor Z_1, should be equal to the price of factor Z_1. Assume Z_2 fixed for convenience.

That is,

$$p.MP_{z_1}\left(z_1^*,\overline{z_2}\right)=r_1 \qquad (3.9)$$

That is, the value of the marginal product of a factor should be equal to its price. If the value of marginal product is less than its cost, then decreasing the usage level of input factor Z_1, can increase profit. Other two conditions for changing the level of input usage are when the value of marginal product is more than the cost and when they are equal (i.e. value of marginal product = cost of input). In the long-run the firm is free to choose the level of all inputs. This long-run profit-maximisation problem can be posed as:

$$\max_{z_1, z_2} pf(z_1, z_2) - r_1 z_1 - r_2 z_2 \tag{3.10}$$

Setting the partial derivatives of equation (3.10) to zero for all inputs we obtain:

$$p.MP_1(z_1^*, z_2^*) = r_1 \tag{3.11}$$

$$p.MP_2(z_1^*, z_2^*) = r_2 \tag{3.12}$$

The first order condition for profit maximization requires that each input be utilized up to a point at which the value of its MP equals its price. The farm entrepreneur can increase his profit as long as the addition to his revenue from employment of an additional unit Z_1 exceeds its cost. The marginal value product of Z_1 is the rate at which the entrepreneur's revenue would increase with further application of Z_1 (Henderson and Quandt, 1980).

In the production process the farm household utilizes both fixed and variable farm inputs. The optimum output and profit from the farm is obtained when we have the most efficient production process where all inputs into the process are used to their optimum at the right time, and in the correct quantity. This could only be attained if the farm entrepreneur (who is the decision-maker in the household) has the required skills and knowledge to select the right crop mix and to move into off-farm job if returns from the agriculture enterprise are low. The education or schooling of the farm household head is hypothesised to be an important input in the production process, helping to achieve high output per unit physical input. The Cobb-Douglas production function is used to estimate the effects of education, in addition to conventional inputs on agriculture output per unit area cultivated.

3.3 Empirical models

3.3.1 Introduction

First, the study employs the Cobb-Douglas production function to estimate the effect of inputs and household characteristics on the value of output per acre. To achieve the second objective, educational level of the household head is introduced as an additional factor of production to find out if there are positive returns to education for farmers in Ghana.

3.3.2 Farm Technology

We estimate a general farm production function denoted as:

$$Q_j = Q_j\ (F_{lj}, X_{ij}, R_{dj}, Z_k) \qquad (3.13)$$

l = labour
j = 1,2,….., J (Crops)
i = 1,2,……, I (non-labour variable inputs)
d = 1,2,……, D (non-labour fixed inputs)
k = 1,2,……,K (household composition variables)

From equation 3.13 a Cobb-Douglas production function is stated as

$$Q_j = F_{lj}^{\alpha_1} X_{ij}^{\alpha_2} R_{dj}^{\alpha_3} Z_k^{\alpha_4} e^{\alpha_0 + u_j} \qquad (3.14)$$

Finding the natural logarithms of both sides we obtain a specified double-log function of farm production.

$$\ln Q_j = \alpha_0 + \alpha_1 \ln F_{lj} + \sum_{i=1}^{I} \alpha_2 \ln X_{ij} + \sum_{d=1}^{D} \alpha_3 \ln R_{dj} + \sum_{k=1}^{K} \alpha_4 \ln Z_k + u_j \qquad (3.15)$$

Where,

Q_j = farm production of jth crop (Farm output per acre)

F_{lj} = Labour employed in the production of jth crop (man equivalent person days)

X_{ij} = Vector of non-labour variable farm inputs i used on the jth crop.

R_{dj} = A vector of non-labour fixed inputs d

Z_k = A vector of household characteristics or composition variables

$\alpha_0 = \quad constant$

$\alpha's \ are \ parameters \ or \ coefficients \ to \ be \ estimated$

u = Error term with zero mean and constant variance

3.3.3 Education as a factor of Production

3.3.3.1 Introduction

The study employs a non-frontier technique to estimate the coefficient on years of schooling in a modified Cobb-Douglas (C-D) production function. We estimate only the "worker effect" of education. Estimating the "allocative effect" was not possible because of problems encountered with the aggregation[6] of the two main crops selected.

3.3.3.2 Non-Frontier Empirical Model: Worker Effect of Schooling

The worker effect of schooling refers to the increase in farm output that is attributed directly to education, holding other physical inputs constant (Chaudri, 1979; Welch, 1970). An empirical

[6] In measuring the allocation effect of schooling, the dependent variable must be the total value of farm output aggregated over at least two crops, since no account is taken of allocation of inputs across competing uses in the case of only one output.

model is developed to capture the worker effect of education and extension exposure on farm output per unit land area cultivated using a Cobb-Douglas (C-D) production function.

$$Q_j = \prod_{i=1}^{I} (X_{ij}^{\beta_i}) E_f e^{A+\mu_j} \qquad (3.16)$$

i=1,2,.......,I (inputs)

j=1,2,.......,J(outputs)

Taking the natural logarithms of both sides of equation 3.15, we obtain

$$\ln Q_j = \sum_{i=1}^{I} \beta_i \ln X_{ij} + aE_f + A + \mu_j \qquad (3.17)$$

Where,

Q_j is farm output per unit land area cultivated; X_{ij} is a vector of inputs into production; E_f is a measure of education of household head *f* in the j^{th} farm and μ_j is a stochastic error term.

3.3.3.3 Hypothesis to be tested

The following hypotheses are tested, where Ho is the null hypothesis and Hi is the alternative hypothesis.

Ho: Education **exerts no effect** on farm productivity

Hi: Education **exerts a positive effect** on farm productivity

The hypothesis is repeated same for labour input (L), except the vector of household head characteristics, Z whose coefficients can be positive or negative.

3.3.4 Percentage gain per year of education.

Following Lockheed et al (1980), the study computed the percentage gain in output value for one additional year of education of an individual farmer using equation 3.18a. The percentage increase is obtained by computing the ratio of output value when the level of education is ½ year greater than R, to the value when it is ½ less, subtracting one (1), and multiplying by 100. Increases in productivity are estimated for two different specifications. In a specification where formal years of education completed is not logged, the percentage increase in output is estimated by using the formula in equation 3.18a:

$$\% \ \ increase \ \ in \, output = \left[\frac{\ell^{a}(R+0.5)}{\ell^{a}(R-0.5)} - 1 \right] \times 100$$

$$= \left[\ell^{a} - 1 \right] \times 100 \qquad (3.18a)$$

Where,

R = Average educational level of the sample

a = Estimated coefficient of education

e = Natural exponential

In the other specification where a set of threshold dummy variables are created to better understand the relative importance of different levels of schooling, the formula in equation 3.18b can be utilised:

$$\% \ increase = \left[\frac{\ell^{a} - 1}{N} \right] \times 100 \qquad (3.18b)$$

Where, N is years of education in the level specified by the dummy variable indicator. In this calculation it is assumed that the percentage increase due to education can be proportionally attributed to the years of education.

3.3.5 Farm Profit (Income) Function

From a profit maximization problem of the farmer, we define a restricted profit function:

$$\pi_j (P_i, r_i; A, H; E) = p_i q_j(.) - \sum_{i=1}^{m} r_i x_i \qquad i = 1, 2, ..., m \qquad (3.19)$$

subject to a production constraint

$$Q_j \leq q_j(X_i; A, H; E)$$

where,

Q_j is of farm output of crop i in kilogram per acre.

In the short-run, the opportunity cost of the fixed inputs is zero. The farmer needs only to maximise the returns to fixed inputs i.e. the sales value of output less the cost of variable inputs used on the farm. The profit from the j-th farm is expressed as a function of the price of output and variable input prices and fixed input quantities with education level of the household head as an input.

$$\pi_j^* = \pi_j^* (p_j, r_1, r_2, ... r_m; A, H; E) \qquad (3.20)$$

For easy computation and estimation, equation (3.20) is expressed in a restricted net farm income function, Y_f. The natural logarithm of which is estimated as:

$Y_f = f(A, H; P_f, E)$

Where, f is increasing and concave in (X_i; A, H) and homogeneous of degree one in (X_i; A, H) meaning it exhibits constant returns to scale. Y_f is restricted net farm income in cedis; A is household owned land in acres; H is labour employed for the cultivation in full-time worker equivalents. E is a vector of variables denoting education and extension training; P_r is a vector of input and output prices (Farm input and output prices are cluster averages) and p_j is price of output (cedi/kg). r_i is price of input i (cedis).

Since the survey price data on output and inputs are cluster averages, we include them for every farmer found in that particular cluster; therefore the estimated coefficients should be interpreted with caution.

3.3.6.1 Hypothesis to be tested

Ho: Education **exerts no effect** on farm income and **Hi:** Education **exerts a positive effect** on farm income. The hypothesis is repeated same for Farm Size (A), Labour input (H). Output price, p_j has a positive effect on farm income but the prices of variable inputs, r_i's are expected to be inversely related to farm income.

Where,

Ho is the null hypothesis and Hi is the alternate hypothesis

3.4 The Data

The analysis uses data from the Ghana Living Standards Survey (GLSS)[7]. The GLSS is a nation-wide household survey carried out by the Ghana Statistical Service with technical assistance from the World Bank. With its focus on the household as a key social and economic unit, the GLSS survey provides valuable insights into living conditions in Ghana.

[7] See the GLSS Report of the fourth round for detail description of the sampling technique and the selection of households

The survey administered from October 1998 to September 1999, covers 5,998 households, containing over 25,000 persons, with detailed information on formal and informal labour activities, household farm activities, expenditures, education status of household members and many other determinants of household welfare.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The analysis of the effect of education on farm productivity and farm income is carried out at the level of two farm enterprise activities. The farm activities are cassava and maize production. Section 4.2 of the chapter focuses on the definition of variables and discussion of the mean values of the variables used in the analysis. Section 4.3 provides descriptive statistics on the head of households selected for the analysis. Descriptive statistics are provided on their age-sex structure, level of educational attainment, and extension contact. Cross-tabulations are also presented to show the distribution of farmers in the three ecological zones in Ghana by locality; and also educational level completed by locality and sex. Farm productivity regression results obtained from production function without accounting for the education of the household head or his skill are presented in section 4.4, followed by results of the regression analysis done with education variables as inputs in the production technology of the farmer. Section 4.5 focuses and discusses the results obtained for the farm income function. Farm income is estimated for each farm enterprise activity, which is expressed as a function of a vector of output and input prices, fixed input variables, formal schooling variables, extension service contact and household composition variables. Linkages between farm productivity, education and food security is provided in the last section.

4.2 Sample selection and variable definition

The data for study is drawn from the fourth round of the Ghana Living Standards Survey (GLSS). The final sample employed for the descriptive analyses are 175 for cassava and 290 for maize farmers. First, the study considered and concentrated on only household heads whose main occupation was crop farming. These farmers were further grouped into cassava and maize crop production with only those who reported as having harvested the crop for sale and were primarily involved in the two activities. Second, farm household heads that had mentioned these crops (cassava and maize) as their main activity but sold other different crops apart from the main activity crop were dropped from the analysis. The number of observations dropped was small and most had no data on sales and other important indicators and cannot significantly bias the results.

Observations with missing data or inconsistent information and negative values were not included in the final analysis. In addition, the following outliers were omitted from the sample: household heads who are above 65 years and those below 15 years; households using less than 1 acre of land and more than 30 acres for the production of these crops. For maize and cassava production, only two-thirds of farmers used inputs such as fertiliser (inorganic and organic), pesticides and insecticides but most of them responded as having spent some money on hired labour, hand tools and other inputs like planting materials, bags and containers.

Because of the difficulty in obtaining actual physical quantities of inputs from the data, hired labour employed on farm, hand tools and capital inputs are measured in their value terms as determinants of farm productivity (see Table 4.1).

Table 4.1: Variable Definitions and Mean Values

ariable Name	Definition	Cassava		Maize	
		Mean	Std. Dev	Mean	Std. Dev
ependent variable					
⅃n_Cropacre	Natural log of harvested output per acre	6.67	1.14	5.52	0.96
arm and household ıriable					
⅃n_Lab	Natural log of family labour (man equivalent person days)	6.02	0.81	5.76	0.88
⅃n_Land	Natural log of cultivated land area in acres	0.79	0.65	0.98	0.69
⅃n_Hlab	Natural log of hired labour cost per acre	9.97	1.18	9.78	1.24
⅃n_Cfert	Natural log of the value of fertiliser and other agro-chemical	9.04	1.17	8.65	1.22
⅃n_Htool	Natural log of value of hand tools in cedis (local hand imported) per acre	8.64	0.86	8.36	0.88
⅃n_Capinpts	Natural log of cost of capital input equipment per acre	8.96	1.37	8.66	1.33
⅃n_hhsize	Natural log of household size	4.76	2.57	4.76	2.76
Agey	Age of household head (years)	43.15	11.36	41.73	12.16
Agesq	Square of age of household head (years)	1990.35	992.78	1888.78	1058.58
Sex_1	Dummy:1 if household head is male	0.53	0.50	0.77	0.42
Pwork	Father's occupation (farming = 1, otherwise=0)	1.70	4.19	1.58	3.97
ducation Variables					
Schyrs	Years of schooling of the household head	5.83	4.88	5.12	4.81
Eduprim	Dummy:1 if head has completed primary school	0.18	6.39	0.14	0.36
Edumid	Dummy:1 if head has completed middle school	0.37	0.49	0.31	0.46
Edujss	Dummy:1 if head has completed junior secondary school	0.011	0.10	0.04	0.20
Edusec	Dummy:1 if head has completed secondary education	0.05	0.21	0.03	0.17
EduPsec	Dummy:1 if head has completed school above secondary level			0.006	0.08
Extserv	Dummy:1 if head has extension service contact	0.10	0.30	0.09	0.29
Aveschyrs	Average school years of all other family members apart from the head	4.06	3.56	2.97	3.5
ite Dummies					
Rural	Dummy:1 if head is located in the rural area	0.86	0.34	0.89	0.31
Forest	Dummy:1 if head is located in the forest ecological zone	0.76	0.43	0.57	0.49
Coastal	Dummy:1 if head is located in the coastal ecological zone	0.11	0.31	0.10	0.30
arm income estimation ariables					
Farminc	Crop revenue less total input cost in production			5.33	0.49
Mprice	Cluster average price of maize (per kg)	-		6.08	0.36
Pfert	Cluster average price of fertiliser (average for N.P.K/15-15-15 and Sulphate of Ammonia) per mini bag			10.18	0.24
Phtool	Cluster average price of hand tool (a proxy using the price of one standard cutlass)			8.80	0.18

Source: Author's calculations from GLSS 4 Survey Data

Fertilizer and other agro-chemicals are included as an aggregated figure for the estimated regression in the cassava and maize production functions. Though individual effects are lost through the aggregation, it was necessary in order to avoid several zero observations found in the data. Land cultivated is measured in acres. Some farmers report unit of land cultivated under crop in acres while a greater percentage stated units in ropes and poles. All units stated in ropes and poles are converted to acres[8]. The mean farm size cultivated is 0.79 acres for cassava and 0.98 acres for maize. Age and age-squared are used as indicators of farm work experience. The mean ages are 41.7 for maize farmers, and 43.2 for cassava farmers. Another way of estimating work experience was to subtract the number of years of schooling and the age when the farmer started kindergarten (5 years) from current age to indicate years of experience on the farm. The regression result did not change much when age squared was replaced with years of experience.

The education of the head and other adult members of the household, engaged in cassava and maize farming is generally very low. The average years of schooling for household heads are 5.83 for cassava farmers and 5.12 for maize farmers (see Table 4.1). This means that most of the farmers sampled had less than primary level education on the average. The average level of schooling years completed by other adult household members was 4.06 and 2.97 for households cultivating cassava and maize respectively. To account for the possibility that different levels of schooling have differing effects upon productivity, a set of dummy variables representing different levels of schooling is used as a measure of education in other specification of the estimated functions. According to Weir (1999) the coefficient on a 0-1 dummy variable represents the percentage increase in output due to having that level of schooling, as compared with that of no schooling and other levels completed.

[8] See appendix 1 for the conversion of poles and ropes to acres using standard conversion factors

A proxy variable was used for extension contact because of the absence of direct question in the survey questionnaire that required respondents to either indicate whether they had any extension contact or not. Farmers were to indicate the source of the physical inputs they use, whether from the Ministry of Food and Agriculture (MoFA), NGO or Cooperative Society. This might not be a good proxy but it is employed on the assumption that farmers who receive their inputs from the above named sources, rather than purchasing from the open market, are assisted, taught or given advice on how to use them.

Site dummy variables are included to capture site-specific fixed effects like location and ecological zone effects. Education and/or occupation of parents are good indicators of how well a particular individual is doing in his farm enterprise activity. The occupation of parents (as farmers) is expected to impact positively on farm productivity because children may have learnt a lot of farming skills from them especially if they spent a significant number of years on their parent's farm prior to having their own. Dummy variables of 0-1 were used to indicate the occupation of parents. Together, with the site dummies they serve as control variables to capture some of the unobserved effects on farm productivity.

4.3 Descriptive statistics and demographic profile of farmers

This section provides descriptive statistics on household heads in the two farm enterprise activities selected for the study. The section looks at the age-sex structure of farmers, their locality and ecological zone, whether they had attended school before or not, their educational attainment by sex and extension service contact.

4.3.1 Farmers' Locality and Ecological Zone

The GLSS 4 survey was carried out in all the three ecological zones of Ghana. There were four locality classifications but we focus on the first locality classification of whether farmers were in an urban[9] or rural[10] location. A cross tabulation is carried out to indicate the distribution of agricultural household heads into selected farm enterprise activities, their ecological zone and locality.

As shown in Table 4.2, cassava and maize production is a rural phenomenon with about 91% of farmers sampled found in the rural area (409). Only 9% of farm household heads were from the urban locality with more than half of them involved in maize cultivation. Most of the farmers were concentrated in the rural forest zone. The percentage of cassava and maize in the rural forest zone were 75.5 and 58.9 respectively.

Table 4.2: Classification of agricultural household heads into selected cassava and maize farmers by ecological zone and locality.

Activity	Cassava				Maize				Total	
	Urban		Rural		Urban		Rural		Urban	Rural
	No	%	No	%	No	%	No	%		
Coastal	3	12.5	16	10.6	2	6.3	27	10.5	**5**	**43**
Forest	17	70.8	114	75.5	13	40.6	152	58.9	**30**	**266**
Savanna	4	16.7	21	13.9	17	53.1	79	30.6	**21**	**100**
Total	**24**	**100.0**	**151**	**100.0**	**32**	**100.0**	**258**	**100.0**	**56**	**409**

Source: Author's calculation from GLSS4 data (2000).

The total number of household heads involved in cassava production was 175 with 151 found in rural area forming about 86.3%. The distribution of cassava farmers by ecological zone show that 10.8% of the farmers were found in the coastal zone, 74.9% in the forest zone and 14.3% in the savannah zone of Ghana. For maize farmers, 10.0% were in the coastal zone, 56.9% in the forest

[9] Urban indicates localities inhabited by more than 5000 people (Population size greater than 5000)

[10] Rural indicates localities inhabited by less or equal to 5000 people (Population size less than or equal to 5000)

zone and 33.1% in the savannah zone. The high percentage of farm household heads in the rural forest zone is not surprising as it supports the view that the production of major staple crops is mostly done in the forest zone[11].

4.3.2 Age-sex structure

As shown in table 4.3, male farmers outnumbered their female counterparts in the two different farm activities studied. This might be due to the fact that the sample dwelt mainly on household heads alone excluding their spouses. With the exception of farmers involved in cassava production, male heads were more than female heads when all age groups are considered. Female heads in cassava production whose ages were in the 41-45 category and between the ages of 56 and 60 were more than their male counterparts. Cassava farmers are concentrated in ages 36-40 and 46-50. The broad age bracket of 36-50 accounts for 46 per cent of cassava farmers. For maize farmers, their ages mostly fell in the 36-40 bracket.

Table 4.3: Age-Sex Distribution of Farmers by Farm activity

Age Group	Farm Activity					
	Cassava			Maize		
	Male	Female	Total	Male	Female	Total
15-20	1.1		**1.1**	1.0		**1.0**
21-25	1.7	1.7	**3.4**	6.9	0.3	**7.2**
26-30	6.9	5.7	**12.6**	12.1	1.7	**13.8**
31-35	6.9	4.6	**11.4**	10.7	2.4	**13.1**
36-40	11.4	4.6	**16.0**	12.8	4.1	**16.9**
41-45	5.1	9.7	**14.9**	9.3	2.8	**12.1**
46-50	8.0	8.0	**16.0**	7.6	3.4	**11.0**
51-55	5.1	4.0	**9.1**	5.2	2.1	**7.2**
56-60	4.0	5.7	**9.7**	7.6	2.8	**10.3**
61-65	3.4	2.3	**5.7**	4.5	2.8	**7.2**
Total	**53.7**	**46.3**	**100.0**	**77.6**	**22.4**	**100.0**

Source: Author's calculation from GLSS 4 data (2000).

We observe a lower concentration within the age groups of 15-30. The percentage of farmers in that age group was 17.1 for cassava and 22 for maize. The percentages of older farmers (51-65) in cassava and maize production were 24.5 and 24.7 respectively. This is not surprising since most

[11] See Sijm J. (1993)

studies[12] have reported this phenomenon and this should be a major concern for decision-makers. It is thus evident that farming or for that matter production of major staples crops like cassava and maize have been left to the older folks. It is believed that though they gain experience as they stay on the farms for long they however tend to be late adopters and are more likely to stick to their primitive ways of farming at the expense of increasing productivity.

4.3.3 Formal School Attendance

Information in Table 4.4 shows the number of farmers in each farm activity distributed over gender who had attended school before and those who had never attended school. The percentage of cassava and maize farmers who responded as having attended formal schooling was 73.7 percent and 63.8 percent respectively. Male household heads that reported as attending school before outnumbered their female counterparts.

Table 4.4: Frequency Distribution of Farmers Attending Formal Schooling by Farm Activity Percentages

	Farm Activity					
	Cassava			**Maize**		
	Male	Female	Total	Male	Female	Total
Been to school before	82	47	**129**	160	25	**185**
No schooling	12	34	**46**	65	40	**105**
Total	**94**	**81**	**175**	**225**	**65**	**290**

Source: Author's calculation based on GLSS 4 data.

Although the agricultural research system in Ghana has generated several improved technologies for food crop production (Obaatanpa, high resistant cassava mosaic virus varieties), the adoption rate of these innovations among smallholders has generally been slow. This situation has been partly blamed on the low education level or attainment of the average Ghanaian farmer.

[12] See Anrooy (1997) and Sijm (1993)

4.3.4 Educational Attainment

Table 4.5 shows the educational level completed by household heads by activity and sex. Males, who had been to school before, dominated all in the two-farm enterprise activities. Out of 129 cassava farmers who said they had attended school before, 63.6 percent were males and 36.4 percent were females. For maize farmers, 86.5 percent of the total (185) were males and 13.5 percent were females.

About 90.5 percent of household heads who had been to school before were males with the rest being females. In relative terms, females had less education than their male counterparts though female numbers in the sample were small. The disparity in educational attainment between male and female household heads for the two farm enterprises is more pronounced at higher levels of schooling completed with one male maize farmer completing at the university level. As shown in table 4.5, none of the female heads in the two farm enterprises had completed schooling beyond the senior secondary school level with more than 95 percent completing up to the middle school level. Generally, the educational level completed by cassava and maize farmers were low, with about 90 percent of them completing up to only basic education.

This supports the view that the agricultural workforce in the production of staple foods and cash crops are in the hands of mostly illiterate and semi-illiterate older farmers. This has resulted in the production of these crops suffering from the injection of innovations and increased productivity.

Table 4.5: Level of Education completed by Household heads by Sex and Farm Enterprise.

Highest level completed	CASSAVA			MAIZE		
	MALE	FEMALE	TOTAL %	MALE	FEMALE	TOTAL %
None[a]	4 (3.1)	4 (3.1)	**6.2**	13 (7.0)	3 (1.6)	**8.6**
Kindergarten	6 (4.7)	5 (3.9)	**8.6**	9 (4.9)	2 (1.1)	**6.0**
Primary	16 (12.4)	16 (12.4)	**24.8**	33 (17.8)	10 (5.4)	**23.2**
Middle	44 (34.1)	21 (16. 3)	**50.4**	81 (43.8)	9 (4.9)	**48.7**
JSS	2 (1.6)		**1.6**	12 (6.7)	1 (0.5)	**7.2**
SSS		1 (0.8)	**0.8**	4 (2.2)		**2.2**
Voc./Comm.	2 (1.6)		**1.6**			
Secondary'O'	5 (3.9)		**3.9**	5 (2.7)		**2.7**
Teacher's Training			-			
Technical	1 (0.8)	-	**0.8**	1 (0.5)		**0.5**
Nursing	2 (1.6)		**1.6**			
Polytechnic						
University				1 (0.5)		**0.5**
Koranic			-	1 (0.5)		**0.5**
Other			-			
Total	**82 (63.6)**	**47 (36.4)**	**100.0**	**160 (86.5)**	**25 (13.5)**	**100.0**

Source: Author's estimation from GLSS 4 data (Statistical Service 2000)
Figures in parentheses are percentages of the total.
a. No level completed though respondent reported of been to school before

The findings compare well with conclusions made by Anrooy (1997), Jollife (1998) and Sijm (1993).

4.3.5: Extension Service Contact

Table 4.6 shows the percentages of farmers who had come into contact with any form of extension service by farm activity. More than 90 percent of cassava and maize farmers said they had no form of assistance from MoFA, NGOs and co-operatives.

Table 4.6: Extension Service Contact Response

Farm Activity	Percentage Responding		
	No	Yes	Total
Cassava	90.12	9.88	100
Maize	91.03	8.97	100

Source: Author's computation from GLSS 4 Data (2000)

Only 9.9 percent of cassava farmers and about 8.97 percent of maize farmers had their input sources from the MoFA, NGOs and Co-operatives and therefore some form of extension service contact. Extension service contributes to improving farm productivity through informal education of farmers, but if we have just about 10 percent of major staple crop farmers having access to extension service through input acquisition then this calls for a careful look by policy makers.

4.4 Farm Productivity Regression Functions

4.4.1 Some Econometric issues

Careful consideration has been made to omit outliers from the data, in addition to the transformation of some of the variables to achieve normality and linearity. We nevertheless expect some of the variables used in the estimation, to violate some of the assumptions underlying least squares estimation. The principal one is the problem of non-constant variance (Heteroscedasticity). The two-stage design of the GLSS sample typically results in the rejection of the assumption of homoscedasticity because observations drawn from within a cluster are likely to have characteristics that are more similar than observations drawn from different clusters. The difference between intra-cluster correlations will most likely result in heteroscedasticity. The presence of heteroscedasticity causes OLS parameter estimates to be imprecise and their estimated standard deviation to be biased. Heteroscedasticity was tested in all regression estimations by performing the White and Goldfeld – Quandt test[13] to find out if the variance of the disturbance term varies systematically with one or more of explanatory variables. In all cases we found that heteroscedasticity was a problem. The dependent and other explanatory variables were transformed into logarithmic form and OLS was used to estimate the parameter coefficients. As stated by Jollife (1998) and Vijverberg (1995), the logarithmic transformation lacks flexibility as a method to deal with heteroscedasticity in addition to the skewed spread in farm enterprise size. The study reports the OLS estimates with t-ratios based on heteroscedasticity-consistent standard errors and covariance.

One way of dealing with heteroscedasticity is to use the variable that is causing the heteroscedasticity or has greater variability with the disturbance term as a weight variable in Weighted Least Square (WLS) estimation[14].

With the exception of the age and the square of ages of farmers, correlation coefficients[15] estimated were low and not significant. Multicollinearity was assumed not to be a problem in the estimation since the standard errors were also low in all the regression estimates.

[13] See Koutsoyiannis, A. (1996) – reprint; White, H. (1980); Maddala, G.S. (1988)
[14] See Koutsoyiannis, A. (1996) – reprint, pages 189 and 190; Norusis, M. J. (1988)

[15] See appendix 2 for estimated correlation coefficients

4.4.2 Basic production function results: Cassava

Results of Ordinary Least Squares (OLS) and Weighted Least Squares (WLS) are shown in Table 4.7. Equation A1 and A2 under both OLS and WLS are full estimation results with site and family background variables (see Liu *et al*, 1999) as control variables. Equations labelled B1 and B2 under both estimators are estimated coefficients when site dummies and highly insignificant explanatory variables are removed. Results shown in the table are estimations based on the production function equation 3.15.

Table 4.7: OLS and WLS estimate of the C-D Production Function: Cassava (Without Education)

	Coefficients Estimates			
	OLS		WLS	
Variable	A1	B1	A2	B2
Constant	1.155 (0.366)	4.160 (2.600)***	1.204 (0.748)	1.080 (0.739)
Ln_Lab	0.350 (0.945)	0.274 (1.745)*	0.624 (2.952)***	0.445 (2.174)**
Ln_Hlab	0.202 (1.730)*	0.129 (1.425)	0.259 (1.628)*	0.315 (2.013)**
Ln_Cfert	0.090 (0.734)		0.109 (0.930)	
Ln_Htool	-0.121 (-0.670)	-0.042 (-0.283)	-0.194 (-1.065)	-0.046(-0.243)
Ln_Capinpts	-0.049 (-0.496)		0.137 (1.248)	
Ln_Hhsize	-0.245 (-0.720)		-0.236 (-1.248)	
Agey	0.094 (1.251)	-0.002 (-0.191)	0.004 (0.357)	-0.002(-0.267)
Agesq	-0.001 (-1.223)		-0.001 (-1.143)	
Sex_1	0.172 (0.776)	0.148 (0.793)	0.118 (0.452)	
Rural	0.182 (0.613)		-0.154 (-0.429)	
Forest	0.194 (0.571)		-0.403 (0.760)	
Coastal	-0.009 (-0.023)			
Pwork	0.408 (1.498)	0.426 (1.862)*	0.476 (1.656)*	0.452 (1.478)
R^2	0.26	0.24	0.95	0.95
Adj.R^2	0.14	0.20	0.94	0.94
F-stats (Prob)	2.25 (0.01)	5.67 (0.000)	184.40 (0.000)	406.79 (0.000)
N	107	135	107	135

Source: Author's computation from GLSS 4 data, 2000
Dependent variable is natural logarithm of cassava output per acre. Figures in parentheses are t-ratios. Stars indicate significance using a two tailed t-test as follows: *** = 0.01; ** = 0.05; * = 0.10.
Natural log of farm size was used as weighted variable (Principal cause of heteroscedasticity)

Most coefficients of the direct inputs into the production of cassava were found to be insignificant. Likewise, household composition variables like household size age of household, age-square and gender were found to be insignificant. With the removal of the site dummy variables and highly insignificant variables, the OLS estimates show a 10% level of significance for family labour, and father's occupation variable. Output elasticity reduces in the case of family labour but the dummy variable indicating the main occupation of the household heads' father had a positive effect on output per acre, all other inputs held constant compared to the case where the father is not a farmer. Output elasticity of hired labour reduces from 0.20 to 0.13 and becomes insignificant. In equation A1 under OLS, the explanatory variables explain only 20% of the variation in output per acre of cassava. The R^2 reduces to 24% in equation B1.

A test of heteroscedasticity using White and Goldfeld - Quandts test indicated that land size[16] was the principal cause, in addition to it having a non-zero covariance with the estimated residuals. As a form of correction, land size was used as a weighted variable in WLS estimation. The results from the WLS estimate show a better F-statistic and R^2, with the explanatory variables explaining 95% of the variation in cassava output per acre. The full estimation results of WLS in equation A2 indicate a positive high output elasticity of family labour (0.62), which is statistically significant at the 1% level when all other inputs are held constant. Output elasticity of hired labour cost is statistically significant at 10% level meaning that cassava productivity is very dependent on labour input from the family and amount spent on hired labour of farmers.

Aggregated value of fertiliser and agro-chemicals and the cost of capital inputs have a positive but insignificant effect on cassava output per acre. Apart from the dummy coefficient of father's occupation, which remains positive and significant at 10% level, the remaining variables included were found to be not significant with a change in sign for site dummies. With the exclusion of site

[16] Total land size used as a scale variable

dummy variables and highly insignificant coefficients, we observe that labour input from the family and cost of hired labour remains as the most important factors explaining the variations in cassava farm productivity. In addition to hand tools cost, age of farmer and the dummy signifying the fathers' occupation, they explain about 95% of the variation in farm productivity (see equation B1 and B2). Low R^2 obtained in OLS estimation is explained by the fact that cassava production at the traditional level is influenced by a number of unobserved variables such as access to credit, farm motivation, soil quality, (which are not dealt with in this study).

4.4.3. Basic Production Function Results: Maize

Table 4.8 shows the production function estimates obtained by using the OLS and WLS estimators. The dependent variable is the natural log of maize output divided by the acres of land farmed. Equation A1 incorporates all the basic explanatory variables, including household composition and site dummy variables. Surprisingly, family labour results in less maize output per acre obtained, though the effect is not significant. Among the household composition variables, only household size significantly affects the output of maize per acre. Output per acre of maize increases by 0.42% as household size goes up by 1% when all other inputs are held constant.

The negative coefficient on age of farmer suggests that older farmers are less productive and that productivity declines at a falling rate as the head gets older. This is only true if the head provides the main farm labour. Households headed by males produced more maize per acre (0.41) than female headed households. This may be because males spent more quality time on the farm and do most of the hard labour intensive activities on the farm. The dummy variables, indicating the locality of farmer and the ecological zone he/she resides had a positive effect upon farm productivity. However, the forest dummy is not significant. As compared with those in savannah areas (omitted variable category), coastal farmers had a reduction in output by 0.41%.

Table 4.8: OLS and WLS estimate of the C-D Production Function: Maize (Without Education)

	Coefficients Estimates			
	OLS		WLS	
Variable	A1	B1	A2	B2
Constant	2.566 (1.392)	0.462 (0.430)	-0.700(-0.491)	0.538 (0.409)
Ln_Lab	-0.158 (-1.388)	0.101 (0.930)	0.166 (1.312)	0.216 (1.814)*
Ln_Hlab	0.322 (4.970)***	0.368 (5.254)***	0.287 (4.137)***	0.344 (4.483)***
Ln_Cfert	0.115 (1.941)*	0.054 (0.867)	0.108 (1.459)	
Ln_Htool	-0.085 (-0.790)		-0.009 (-0.098)	
Ln_Inputs	0.161 (2.831)***	0.086 (1.583)	0.207 (2.995)***	0.132 (1.950)*
Ln_Hhsize	0.420 (3.074)***		0.021 (0.154)	0.045 (0.359)
Agey	-0.076 (-1.540)	-0.033 (-0.845)	-0.041 (-0.769)	-0.036 (-0.775)
Agesq	0.001 (1.403)	0.000 (0.530)	0.000 (0.565)	0.443 (2.055)**
Sex_1	0.413 (2.021)**	0.322 (4.970)***	0.389 (1.600)	0.000 (0.419)
RuralDum	0.472 (2.365)**		0.442 (1.342)	
ForeDum	0.211 (1.551)		0.399 (2.718)**	
CoastDum	-0.412 (-2.253)**		-0.424 (-1.265)	
Pwork	0.181 (0.904)	0.319 (1.662)	0.139 (0.535)	
R^2	0.46	0.41	0.95	0.95
Adj.R^2	0.40	0.38	0.94	0.94
F-stats (Prob)	8.814 (0.000)	11.008 (0.000)	218.87 (0.000)	396.60 (0.000)
N	151	151	151	151

Source: Author's computation from GLSS 4 data, 2000

Dependent variable is natural logarithm of maize output per acre. Figures in parentheses are t-ratios. Stars indicate significance using a two tailed t-test as follows: *** = 0.01; ** = 0.05; * = 0.10.

Natural log of farm size was used as weighted variable (Principal cause of heteroscedasticity)

Overall, the included regressors explain 46 percent of variations in maize output per acre. When site dummies and other highly significant variables are omitted, only hired labour, sex dummy variable and fathers occupation were the only significant variables that affects maize output per acre. While output per acre elasticity of hired labour was 0.37, male heads were likely to increase output by 0.32% compared to their female counterparts holding all other inputs.

With the removal of household size variable the coefficient on natural logarithm of family labour family turn positive (but insignificant) suggesting that household size may be correlated with farmily labour. When family labour was instrumented with household size and other variables the coefficient was not significant in all cases with a low coefficient of determination (R^2).

To correct for heteroscedasticity, land holdings in acres was used to weight the regressors and the estimated coefficient are presented under WLS in table 4.8. The test for heteroscedasticity under OLS rejected the null hypothesis of homoscedasticity. Output elasticities of hired labour cost and value of other capital inputs were low (0.28 and 0.21 respectively) but statistically significant at 1% level. Male farmers in the forest zone of Ghana were found to be more productive (0.4% more output on one acre) than those residing in the savannah. The Cobb-Douglas production function estimated by employing WLS are able to explain 95 percent of the variation in maize output produced per unit land area cultivated.

When site dummies and highly insignificant regressors were omitted from equation A2, the coefficient on family labour becomes significant at 10% level with an output elasticity of 0.22. This compare well with elasticities estimated by Croppenstedt and Muller (2000), Weir (1999) and Chinn (1979). The coefficient for hired labour cost is positive and statistically significant at 1% level. This means that both family labour and hired labour costs are most important factors in increasing productivity of maize farmers. The value of other capital inputs has a positive significant effect at least at the 10% level with an output elasticity of 0.13. Male farmers are found to be more efficient than their female counterparts as they produce 0.4% more output on an acre of farm size compared to female heads.

The study tried to correct endogeneity problems by using instrumental variables in place of potentially endogenous variables. The predicted values of variables such as family labour and age-squared are used in a second stage of the two-stage least squares (2SLS), but the results yielded insignificant coefficients.

4.4.4 Effect of Formal Education on Farm Productivity: Cassava

The estimated coefficient under WLS estimated for cassava is presented in Table 4.9. Equation 1 in Table 4.9 includes the years of formal schooling completed by the household head farmer as an input into production and also extension service contact dummy of 1-0, which represents non-formal education. In equation 2 of Table 4.9, the years of formal schooling is replaced with dummy variable indicators signifying the level of schooling completed by the cassava farmer. Both equations are based on equation 3.17 developed earlier with a different variant of education measure used in each case.

Output elasticity of family labour is positive and statistically significant at the 5% level when the specified equation includes the years of schooling completed. The significance level decreases when dummy indicators are introduced in equation 2. A 1 percent increase (decrease) in family labour input induces an increase (decrease) in cassava farm productivity by 0.5% as in equation 1 or only 0.3% in equation 2 with all other inputs held constant. The cost of hired labour is positively associated with farm productivity and the effect is highly significant. The only possible explanation is that cassava farmers who spent more on hired workers tend to be efficient in production. This assertion may not hold if the hired workers were only recruited during the harvesting period and not at the early stages of land preparation, planting and weeding.

Table 4.9: WLS estimates of the C-D Production Function: Cassava (With Education)

Variable	Coefficients Estimates			
	Equ. 1		Equ. 2	
	Estimated Coefficient	t-ratios	Estimated Coefficient	t-ratios
Constant	0.508	0.313	4.555**	2.000
Ln_Lab	0.501**	2.353	0.344*	1.683
Ln_Hlab	0.379**	2.495	0.270***	2.661
Ln_Htool	-0.135	-0.652	-0.098	-0.578
Agey	0.004	1.480	-0.108	-1.346
Agesq			0.001	1.451
Sex_1	-		-0.153	-0.584
Schyrs	0.036	1.079		
Eduprim			0.585*	1.957
Edumid			-0.239	-0.964
Edujss			-0.804	-1.710
Edusec			1.433***	3.348
Edupsec			-2.114**	-2.026
Aveschyrs			0.010	0.737
Extserv	-0.200	-0.768	-0.338*	-1.768
Rural	Yes	(insig)	Yes	(insig)
Forest	Yes	(insig)	Yes	(insig)
Coastal	Yes	(insig)	Yes	(insig)
Pwork	0.556*	(1.700)	0.454	(1.570)
R^2	0.94			0.98
Adj.R^2	0.93			0.97
F-stats (Prob)	223.740 (0.000)			140 (0.000)
N	103			103

Source: Author's computation from GLSS 4 survey data (2000)
Dependent variable is natural logarithm of cassava output per acre. Figures in parentheses are t-ratios.
Stars indicate significance using a two tailed t-test as follows: *** = 0.01; ** = 0.05; * = 0.10.
Natural log of farm size was used as weighted variable (Principal cause of heteroscedasticity)
Yes – variable included in equation; insig -not significant.

All the other regressors were not significant and therefore do not seem to improve farm productivity. The value of aggregated fertiliser and agro-chemical input, and the value of other capital inputs were found to be always insignificant with wrong signs and were therefore dropped from the final analysis because they did not contribute to the overall goodness of fit of the regression estimates.

Household composition variables all had insignificant effects on farm productivity. Estimated coefficient of formal years of schooling completed by the household head farmer is positive (0.036) meaning that returns to schooling is positive but insignificant. Additional year of education has very minimal and insignificant effect in cassava farm productivity. OLS estimates[17], which are reported with t-statistics based on heteroscedasticity-consistent standard errors, had a much lower coefficient of years of schooling completed (0.002). The results support the view that farmers who employ traditional technology are most likely to be deficient in skills, knowledge and ability to be more efficient. As discussed under section 4.3 and 4.4 many of the cassava farmers sampled had no or very minimal education and this explains the insignificant effect of the education variable or captured by the years of schooling completed by the farmer.

In equation specification 2, we find that cassava farm productivity increases by 0.6% when household head farmer has completed primary education as compared to the one who had not received any schooling with all other inputs held constant. The effect of education dummy variable for cassava farmers with secondary education is positive and statistically significant at the 1% level. We find that cassava farmers who had completed secondary education were more productive and output per acre increase by 1.4% compared to the base case. The generally held view is that those with higher education have negative attitude towards farming and are likely to move into off-farm activities. The results from Table 4.10 however show that farmers with high education up to secondary school level are associated with very high outputs per acre. The negative coefficient on the indicator dummy variable signifying middle school completion is unexpected. It is expected that the completion of middle school by farmers will greatly enhance the farmers' ability and skill to perceive things differently from those with no schooling. The result is therefore difficult to explain. The OLS estimates however show a positive but insignificant effect. Cassava farmers with junior

[17] See appendix 3 for estimated results

secondary completion and post secondary were found to be less productive though the negative effects were found to be insignificant.

Extension service coefficient is negative and significant at the 10% level. Farm productivity in cassava production decreases by –0.3% when farmer has extension service contact than where there is no contact through agricultural input acquisition. This is quite in sharp contrast with the generally held view that technical efficiency increase when farmers are introduced to new and modern inputs and technology and they adopt them. The result may be due to the fact that most of the farmers sampled obtained their input themselves and therefore responded in the negative when interviewed.

Average schooling years completed by other adult household members apart from the head had positive but insignificant effect on productivity of cassava farms. Fathers' background occupation dummy was only positive and significant in equation specification 1, but insignificant in specification 2. Productivity increases by 0.45 to 0.56 percent when the heads father had farming as his main occupation, holding all other inputs constant. Overall, the explanatory variables explain 94% of the variation in productivity of cassava farms in equation 1 and 98 percent in equation 2. Percentage increase in farm productivity or output per acre due to the addition of one extra year of schooling is provided in appendix 5. Percentage increase in the case of equation specification 2 of Table 4.9 is calculated for only primary and secondary education completion. The results are compared with studies reviewed by Lockheed et al (1980); Phillips (1994) and Weir (1999). The effect of an additional year of schooling for the household head who is a cassava farmer is to increase output of cassava per acre by 3.7%. In general, the results compare quite favourably with studies reviewed by Lockheed et al (1980), which range from –3.3% to 6.5% and those of Phillip (1994), which ranged from - 3.1% to 8.4%. Weir (1999) however obtained lower response rates of between 1.0% and 2.0% for farmers. For farmers who had completed primary education, the estimated increase in cassava output per acre for one additional year of education is 13.25% and for secondary education productivity increases by 21.2%.

4.4.5 Effect of Formal Education on Farm Productivity: Maize

In the following discussion of the estimation results, the study focuses primarily on the effect of schooling and extension contact obtained from the Weighted Least Square (WLS) regression and comparison with results obtained by using the Ordinary Least Squares (OLS) estimator. The WLS estimation in table 4.10, show better results with respect to the significant levels of the estimated coefficients, the R^2 values and the F-statistics as compared to the OLS results[18]

Family labour was found to be insignificant but positive in both equations. Low output elasticities were associated with family labour (0.08 and 0.09). Output elasticities of hired labour cost, the value of fertiliser and other agro-chemicals and all other capital inputs were significant (at the 5% level) and were positively associated with maize productivity.

Household composition variables were found to affect maize output per acre significantly except in the second specification where the significance of household size is lost when completed years of formal schooling is replaced by dummy indicators for each level of schooling completed. While household size is positively associated with maize productivity, we found a negative coefficient on age, which suggests that maize farmers become less productive as they get older. Experience of the farmer as captured by the square of their ages has an estimated coefficient of near zero meaning that experience of the farmer as captured in this way does not impact on maize farm productivity.

Male farmers in maize production were found to be more productive than their female counterparts.

[18] See appendix 3 for OLS estimated results for maize

Table 4.10: WLS estimates of the C-D Production Function: Maize (With Education)

Variable	Coefficients Estimates			
	Equ.1		Equ.2	
	Estimated Coefficient	T-ratios	Estimated Coefficient	T-ratios
Constant	0.302	0.180	1.445	1.186
Ln_Lab	0.056	0.543	0.088	1.000
Ln_Hlab	0.371***	4.792	0.226**	2.602
Ln_Cfert	0.128*	1.928	0.157**	2.472
Ln_Capinpts	0.172**	2.615	0.226***	3.253
Ln_Hhsize	0.387***	2.788	0.151	0.941
Agey	-0.096*	-1.893	-0.092**	-1.984**
Agesq	0.000*	1.728	0.001	1.635
Sex_1	0.420**	2.210	0.398**	2.201**
Schyrs	0.030	1.194		
Eduprim			0.015	0.605
Edumid			0.206	1.573
Edujss			-0.427	-0.937
Edusec			0.115	0.346
Edupsec			0.346	0.878
Aveschyrs	0.010	0.493	0.017	0.734
Extserv	-0.356	-1.376	-0.514**	-2.007**
Rural	Yes	insig	Yes	(sig)
Forest	Yes	insig	Yes	(insig)
Coastal	Yes	insig	Yes	(insig)
Pwork	0.402	1.810*	0.414	(1.917)*
R^2	0.50	0.47	0.96	0.96
Adj.R^2	0.43	0.39	0.95	0.95
F-stats (Prob)	6.880 (0.000)	6.164 (0.000)	180.680 (0.000)	170.890 (0.000)
N	110	150	110	150

Source: Author's computation from GLSS 4 survey data (2000)
Dependent variable is natural logarithm of maize output per acre. Figures in parentheses are t-ratios. Stars indicate significance using a two tailed t-test as follows: *** = 0.01; ** = 0.05; * = 0.10.
Natural log of farm size was used as weighted variable (Principal cause of heteroscedasticity)

Maize productivity was found to increase by about 0.4 percent, *ceteris paribus* among male-headed households than female headed households. The value of hand tools and dummy variables used to represent the locality and ecological zone of maize farmers all had insignificant coefficients and were therefore omitted from the final estimation.

Under the WLS estimation we find that an additional year of schooling for household heads that are maize farmers induce an increase in maize productivity by 0.03 percent but this was found not to be significant. The return to formal schooling among maize farmers in Ghana is found to be near zero. The result compares well with several other results that employ data on farmers who are primarily involved in traditional agriculture (Lockheed *et al,* 1980). The coefficient of formal education on maize farm productivity does not differ much from that obtained under OLS. Huffman (1974) has attributed small estimated effects of schooling on crop yields or gross farm output to limited technical-efficiency gains from skills provided by farmers' education. Taylor and Yunez-Naude (2000) have argued that such studies do not take into account the technological changes and sectoral diversification characterising agricultural transformations in less developed countries (LDCs). Due to the traditional nature of maize farming in Ghana and the fact that most of the farmers sampled for the study had only basic education, it is believed that the positive "worker effect" of formal years of schooling completed will be more significant if the choice of or selection into activities is closely studied by looking at the allocative effects.

Indicator dummy variables representing different categories or levels of schooling completed had insignificant coefficients in equation specification 2 of Table 4.10. While dummy indicators signifying completion of primary education and middle school had positive coefficients both in the OLS and WLS estimation, that for secondary and post secondary had negative coefficients in the OLS estimation but turned positive except for JSS category in the WLS estimation. The results are characterised by low returns to schooling for the levels though none was significant. Only the coefficient of middle school completed was significant at the 12% level (not a conventional practice). The percentage increase in productivity of maize farm is 0.20 percent, *ceteris paribus* for a farmer who had completed middle school as compared with the farmer who had received no education.

Extension service contact dummy had a significant negative coefficient at the 5% level. This suggest a reduction in maize productivity levels by 0.5% for a farmers who had extension service contact compared to those who had no contact by the way of inputs, training or advice from NGOs, MOFA extension agents or any co-operative society. This is surprising and in contrast with the generally held view that farmers who have come into contact with extension agents are expected to be more productive than those whose input sources are private. The only explanation is that most of the farmers sampled reported “no” to having any links with MOFA extension agents, NGOs or co-operatives by way of acquisition of relevant inputs. Probably, farmers were not probed enough during the interview as they are likely to report “no” extension contact so they will be included in any list of names of farmers they erroneously think may be targeted for help. Other studies such as Jamison and Lau (1978), Hopcraft, (1974), Pachico and Ashby (1976) have also reported negative coefficients of extension on productivity. Evidence of extension contact and formal education interaction however gave mixed results in most of the studies reviewed by Lockheed et al (1980) and Philip (1994). We therefore interact extension contact and formal schooling dummies in another specification (see Table A.4b in appendix 4), which is estimated using only the WLS method. The coefficient on the interaction effect is positive but insignificant and turns negative when years of schooling completed by the head and dummy variable signifying extension service contact are excluded from the production function. The independent effect of completed years of schooling improves and becomes significant (at the 10% level). We found a significant influence of maize farmers’ family background dummy variable (fathers occupational background was used as a proxy) on farm productivity. This means that all other things being equal, farmers whose fathers’ main occupation was farming are likely to have an increase in productivity of 0.4% compared to those whose fathers’ were not farmers. Farmers who are more productive may have spent a greater part of their formative years on the farm and have at least learnt a lot of skills (at least in traditional way) in making good use of available inputs at their disposal. The estimated coefficient on average years of formal schooling completed by adult household members is positive but does not play any significant role in raising the productivity of maize farm enterprise of the household head.

Results of percentage increase in maize output are shown in appendix 5. The estimated increase due to one extra year of schooling at the mean educational level of the sample is 3.0%. We estimate the percentage increase only for farmers who have completed middle school. The result show that farmers with one extra year of schooling above middle school are likely to have increases in maize output per acre by 2.34%.

In summary, the WLS estimates provide a better goodness of fit of the estimated regression equation model and significance of estimated coefficients. Education as captured by years of formal schooling completed had no significant effect on farm productivity but there is strong evidence of threshold effect for schooling. Productivity increases are associated with farmers with primary and secondary education. Extension service contact however was negatively associated with farm productivity. In theory, there is a complementary relation between extension and educational attainment in a production function. As stated by Moock (1981), farmers with a higher educational attainment would have an expanded capacity to understand, interpret in light of specific conditions, and apply on their own farms the lessons offered by the extension agent(s). WLS Estimation results of interaction effects are provided in Table A.4a under appendix 4. In equation 1 of Table A.4a, we allow educational attainment to interact with extension service contact without removing their individual effects. The estimated coefficient is positive (0.470) but insignificant. There is no significant improvement in the independent effects of head's completed years of schooling (schyrs) and extension service contact. In equation 2 of Table A.4a, the independent effects of schooling years completed by the head and extension dummy variables were not significant. There is a negative (-0.646) and significant interaction effect on farm productivity, which is not predicted from theory and therefore difficult to explain. The education (years of schooling completed) of household heads who are maize farmers have no significant effect on productivity in their farms so far as output per land area cultivated is concerned. Only those who have completed middle school were found to have an effect on farm productivity compared with the base case of no schooling (only at 12% level of significance).

4.5 Full Estimation Results for Farm Net Income

Ordinary Least Square (OLS) and Weighted Least Square (WLS) estimation results for maize farm net income are presented in Table 4.11. The estimates are based on equation model 3.20. Due to insufficient information on cassava input price data, farm income regression was only possible for maize.

Table 4.11: Results of farm income function estimation: Maize

	Coefficients Estimates							
	OLS				WLS			
Variable	A1		B1		A2		B2	
Constant	5.883	(2.589)**	4.789	(2.697)***	5.906	(2.676)***	4.259	(2.392)**
Ln_Mprice	0.058	(0.556)	0.052	(0.590)	0.098	(0.864)	0.035	(0.349)
Ln_Fprice	-0.052	(-0.265)	-0.039	(-0.254)	-0.019	(-0.092)	-0.049	(-0.303)
Ln_Tprice	-0.153	(-0.521)	-0.018	(-0.081)	-0.268	(-0.782)	0.046	(0.192)
Ln_Lab[a]	0.097	(1.462)	0.051	(0.937)	0.135	(1.591)	0.085	(1.223)
Ln_Land[a]	0.394	(4.256)***	0.309	(4.181)***	0.471	(3.396)***	0.338	(3.335)***
Sex_1	0.111	(0.945)	0.112	(1.385)	0.040	(0.275)	0.024	(0.249)
Schyrs	0.017	(1.548)	-		0.014	(1.212)		
Educprim	-		0.127	(1.338)			0.075	(0.569)
Educmid	-		0.155	(2.070)**			0.161	(1.965)**
Educjss	-		0.030	(0.202)	-		0.059	(0.361)
Educsec			0.241	(1.336)			0.229	(1.169)
Educpsec	-		0.235	(0.683)			0.279	(2.167)**
Aveschyrs			0.003	(0.365)				
Extserv	0.066	(0.421)	0.068	(0.602)	0.169	(1.408)	0.093	(1.142)
R^2	0.22		0.20		0.91		0.92	
Adj. R^2	0.17		0.15		0.90		0.91	
F-statistic	4.624		3.829		178.764		182.232	
(Prob)	(0.000)		(0.000)		(0.000)		(0.000)	
N	154		213		154		213	

Source: Author's computation based on GLSS 4 (2000) Survey data.

Figures in parentheses are t-ratios. Stars indicate significance using a two tailed t-test as follows: *** = 0.01; ** = 0.05; * = 0.10.

Age of farmer was used as a weight variable in WLS estimation. It was the principal cause of heteroscedasticity and therefore omitted from the results shown in the table.

a. Fixed inputs included in the function

Variable definitions are given in Table 4.1. The estimated farm income equation is specified in two ways. First, the education of the household head is specified as the years of schooling completed and the results of OLS and WLS estimation are provided under equation A1 and A2 respectively. Second, dummy variable indicators signifying different levels of schooling completed by the household head are specified in equation B1 and B2 in Table 4.11.

The estimated coefficients of output price of maize and input prices were statistically insignificant but had the expected signs in all cases except the coefficient of hand tool price in equation B2 under WLS. This means that though maize price is positively associated with farm income and input prices have an inverse relationship with farm income, they do not play any significant role in determining the net farm income for maize farmers among the sample. There are two fixed input variables included in the equation specification. Family labour coefficient is positive in all cases but was found not to be statistically significant. However the estimated coefficients and their levels of significance were better under the WLS estimation. The effect of land area cultivated under maize was positive and significant at the 1% level. Under the WLS estimation, a 1 percent increase (decrease) in land area cultivated, all other things being equal induces an increase (decrease) in maize farm income between 0.34 to 0.47 percent.

Education of the household head measured as the years of formal schooling completed by the household head does not significantly affect maize farm income under the WLS estimation but was found to be significant only at the 13% level (not a conventional practice). Even then the estimated coefficient of formal education was found to be low and almost approaching zero. In equation B1 and B2, where, formal education of the head is captured by employing dummy variable indicators, we found that all the estimated coefficients for all the indicators are positive. All the coefficients were not statistically significant under OLS estimation except the indicator signifying completion of middle school. When all other inputs are held constant, maize farm net income goes up by 0.2

percent when the household head has completed middle school compared with those who have not received any education. This means that return to middle school education is better than not receiving any formal education. When the equation is estimated by weighting variables which show much variability, the percentage increase in maize farm income *ceteris paribus* for the farmer who has completed post secondary education is 0.28 (significant at the 5% level). Also the percentage increase in maize farm income is 0.16, all things being equal for farmers that have completed middle school. The coefficient of average years of schooling of other household members was insignificant and therefore dropped from the final analysis. The coefficient of dummy variable indicator signifying whether the farmer has received any extension service contact or not was positive but insignificant in all specified equations estimated. WLS estimation provides better goodness of fit for the model specified. The F-Statistic is highly significant meaning that the explanatory variables jointly influence the changes observed in the dependent variable. Overall, 92 percent of the variation observed in maize farm net income is explained by the explanatory variables included in the model.

In summary, we find that the coefficient for middle school completion is significant (OLS and WLS), together with dummy indicator for post secondary education. The evidence thus suggests that middle school and post secondary completion is positively related to farm income. Maize farm income also increases (decreases) as land area cultivated under maize increase (decrease).

4.6 Education, Productivity, and Food security issues

Food security is achieved when all people at all times have access to sufficient food for a healthy and productive life (Haddad, 1997). Siamwalla and Valdes (1984), however define food security as the ability of countries, regions or households to meet their required levels of food consumption at all times. Food security has three main components: food availability, food access, and food utilisation.

Food availability refers to the need to produce sufficient food in a way that generates income for small-scale producers while not depleting the natural resource base, and to the need to get this food into markets for sale at prices that consumers can afford. The second component relates to people's ability to get economic access to food. Economic access is typically constrained by income: If households cannot generate sufficient income to purchase food, they lack and entitlements to that food. The final component concerns an individual's ability to use food consumed for growth, nutrition, and health: in an environment lacking clean water, sanitation, child care, and health facilities, the ability to use food to promote health and nutrition will be impaired, particularly for young infants.

Many countries aspire to achieve food security, which is not synonymous with food self-sufficiency. Self-sufficiency in food supply refers to the internal capacity of a country or household to supply all the food it requires, whereas food security does not require self-sufficiency in food supply. Food security can be achieved by importing food or buying food, as long as one has the capacity to import additional food or buying it from others without involving undue supply risks.

We have supply-side and demand-side factors determining food security in the country. Supply of food is affected by the national resource endowment, availability of technology and its dissemination (for food production, storage and preservation), prices, market opportunities and ability to augment own production with external supplies when the need arises. On the demand-side, food security is affected by household incomes and economic assets (including stock of animals), prices, demographic factors such as number, gender and age composition of households, and socio-cultural factors like health and sanitation status, educational level, cultural norms and food composition habits.

Food Security can be achieved through increased agricultural productivity. But agricultural productivity is low among traditional peasant Ghanaian farmers who apply low productivity-enhancing inputs such as fertilisers and agro-chemicals. Though growth in agricultural production and increases in agricultural productivity have been the main objectives of the agricultural policies of the past and present governments, sustained success has eluded policy-makers on both counts (Nyanteng and Seini, 2000). Achieving food security would ultimately lead to adequate food consumption and export of surpluses. Food security in its entire dimension cannot be achieved in a vacuum. It can only be achieved if food crop producers and livestock farmers are technically efficient in their production. But high cost of inputs, low application of these inputs and slow rate of adoption among others, constrain productivity. Education has long been an investment good in the economy of many nations. In several developed countries less than 5% of the Economically Active Population (EAP) are involved in agriculture but they are able to produce more for home consumption and for export. The level of education of farmers in these countries plays a major role in agricultural production. The situation is quite different in Ghana, where more than 50% of the EAP are into agriculture and its related activities but food security attainment is a problem with occasional shortages of food mostly in the northern savannah areas of the country. This can lead to transitory food insecurity, which could be temporary or transient, arising from temporary shortfalls in food supply relative to requirements, or because of a temporary loss of adequate effective purchasing power for food. The factors that lead to temporary food insecurity include seasonal and annual fluctuation in food production, natural catastrophes, temporary loss of employment etc. It is believed that the more educated the producer is, the more he or she is likely to move into the production of high income earning crops or animals whenever any of these causes are prevalent in an area (Philips *et al*, 1990). According to Okai (1997) a positive technological intervention is needed to improve the performance of the agricultural sector through recombination of resources. The ability to do this can only come from farmers who have more knowledge in modern farming and can shift resources from the production of one crop to the other.

In Ghana, agriculture accounts for about 60-70% of the labour force as stated earlier in the study and contributes about 40 percent of GDP but budgetary outlays are inadequate. Smallholder agriculture dominates with most of the farming population in the rural area. Although technological research has come out with improved modern methods of farming, adoption rates are low among farm households in Ghana. Even those who have adopted these modern farm methods are unable to expand their holdings due to a number of reasons.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary and Conclusion

Education is a key point of entry for inducing a sequence of changes, which benefits the rural farmer. A major effect of education on production is that it enhances the ability of a producer to acquire or decode information about the productive characteristics of new inputs. Therefore, the more rapid the flow of new inputs, the greater will be the productivity differential associated with additional education. Low productivity in agriculture in Ghana has been attributed partly to low-skilled labour force, illiterate and semi-illiterate farmers who have persisted in the use of traditional farm implements and methods in farming.

To fully understand the influence that education of an individual farmer has on productivity on his or her farm we have estimated and quantified the contributions of improved education and exposure to extension training on cassava and maize farm productivity and net farm income from these enterprises. A Cobb-Douglas production function has been specified with education variables as inputs. Due to the problem of heteroscedasticity, which makes the OLS estimator inefficient, we apply Weighted Least Squares (WLS) method in the estimation. However, OLS estimation results are reported after transformation.

For household heads that are cassava farmers, education, as measured by years of formal schooling completed had no significant effect on farm productivity, though the effect is positive. Increase in productivity is however associated with farmers who have obtained primary or secondary education. Primary and secondary schooling tends to enhance efficiency in cassava production by providing skills, which are useful in terms of using available inputs at their disposal. Extension service contact, however was negatively associated with farm productivity. This may be due to the fact that most of the farmers sampled did acquire their own inputs. It must be stated here that the proxy used for extension contact was only used because of the absence of a direct question in the survey questionnaire that required respondents to either indicate whether they had any extension contact or not. However, percentage increase in cassava output is as much as 3.7 for one year increase in schooling above the mean education level of the sample. The effect of an additional year of schooling for the household head who has completed schooling at the primary level is to increase cassava output by 13.3 percent. For secondary schooling, output increases by as much as 21.2 percent.

Schooling years completed by maize farmers who are household heads does not significantly improve productivity. Only the coefficient of middle school completed was significant at the 12% level (not a conventional practice). For these farmers, at least some middle school education is necessary for there to be positive and significant benefits of schooling. Extension service was found not to enhance productivity in any way. The percentage increase in maize output for one additional year of education at the mean educational level of the sample is to increase output by 3.1 percent. For additional year of schooling above the middle school level with 10 years of education, maize output is estimated to increase by 2.3 percent. Given the traditional nature of maize farm technology in Ghana and the fact that most of the farmers sampled had completed education only up to the basic level, it is not surprising that formal education's contribution to farm productivity is insignificant.

The estimated farm income function indicated that returns to schooling are highest for farmers with middle and post secondary education. Having access to extension service does not significantly result in an increase in maize farm income.

5.2 Policy Recommendation

Based on the findings from the study, the following recommendations are made for policymakers in the education and agriculture sector and further research into education and productivity relationships.

First, the transient food security problem facing the Sub-Saharan Africa region and especially the northern part of Ghana demonstrates the need for informed policymaking. The government should pursue macroeconomic policies that do not tax agriculture but provide special incentives for the educated youth. Their attraction into the production of staple food crops that the nation has comparative advantage in could help the nation in our quest to achieve food security. Second, a strong case is made for government or donor intervention to encourage higher levels of investment in basic and secondary education in rural Ghana. Increases in budgetary allocation to the education sector would be in the right direction as the rate of return to investment in education is high compared with other investments.

Third, smallholder staple crop farmers should be targeted for special assistance in the area of informal or non-formal education to enable them improve on their efficiency on the farm. Finally, since different levels of education have different impacts on farm productivity, it is convenient to conclude that the nation can achieve food security if farmers with certain levels of education are assisted or supported to increase their efficiency in production. Given effective demand of households and their endowments, production decisions need to be taken by knowledgeable heads in the family in order to increase productivity and to acquire income so as to increase their purchasing power. It is said that the key to food security is sustainability therefore there is the need to ensure that, available resource at the disposal of the farmer is utilised efficiently. To attain food security through increased farm productivity, Ghanaian farmers should have the required skills and knowledge in modern farming methods and be able to comprehend simple instructions on the use of modern farm inputs.

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APPENDICES

Appendix 1

Conversion Factors

The GLSS 4 survey data recorded the units of land area cultivated (farm size) and weight of farm products in local units. Following Anrooy (1997), the different units are converted into international units of measurement.

Variation in the recorded local units of area in the data is converted into acres
The conversion factors used are as follows:

1 Rope = 0.125 acre
1 Pole = 0.225 acre

Variation in recorded units of weight in the data is converted into kilograms.

Cassava has the following conversion factors:

1 Minibag	=	91.00 kg
1 Maxibag	=	182.00 kg
1 Basket	=	22.75 kg
1 Bowl	=	2.00 kg
1 Stick	=	0.50 kg

Maize has the following conversion factors:

1 Minibag	=	50.00 kg
1 Maxibag	=	100.00 kg
1 Basket	=	12.50 kg
1 Bowl	=	2.70 kg
1 American Tin	=	0.50 kg

Appendix 2

Table A2a: Correlation Coefficients between Variables: Cassava

	OTP	LAB	HLB	INP	HTO	CF	LND	HSIZ	AGE	AGSQ	SEX	SCH	ASCH	PRIM	JSS	MID	SEC	PSEC	EXT	FB
	1.00	0.03	0.02	0.03	0.06	0.17	-0.15	0.01	0.17	0.14	0.01	0.03	0.02	0.08	-0.16	0.15	0.23	-0.42	-0.18	-0.04
	0.03	1.00	0.15	0.25	0.65	0.39	-0.61	0.49	-0.02	-0.03	0.08	0.20	0.09	-0.23	0.11	0.30	-0.13	0.08	-0.06	-0.07
	0.02	0.15	1.00	0.46	0.51	0.53	-0.10	0.21	0.25	0.25	0.41	0.14	-0.13	0.00	-0.03	-0.04	0.13	0.12	0.30	-0.12
	0.03	0.25	0.46	1.00	0.52	0.47	-0.41	0.06	0.16	0.14	0.08	-0.07	0.17	0.18	-0.08	0.01	-0.23	0.03	0.15	-0.04
	0.06	0.65	0.51	0.52	1.00	0.63	-0.53	0.23	0.14	0.12	0.18	0.09	0.00	-0.02	0.03	0.13	-0.19	0.13	0.07	0.01
	0.17	0.39	0.53	0.47	0.63	1.00	-0.32	0.31	0.18	0.17	0.19	0.29	0.22	-0.02	-0.03	0.19	-0.07	0.21	0.30	-0.16
LND	-0.15	-0.61	-0.10	-0.41	-0.53	-0.32	1.00	0.07	-0.01	-0.01	-0.01	0.00	-0.05	0.18	0.08	-0.33	0.30	0.02	0.15	0.07
HSIZ	0.01	0.49	0.21	0.06	0.23	0.31	0.07	1.00	0.03	0.01	0.04	0.31	0.20	0.03	0.21	0.04	0.12	0.12	0.03	-0.20
AGE	0.17	-0.02	0.25	0.16	0.14	0.18	-0.01	0.03	1.00	0.99	-0.02	0.11	-0.01	-0.13	-0.27	-0.05	0.13	0.29	-0.11	0.13
AGSQ	0.14	-0.03	0.25	0.14	0.12	0.17	-0.01	0.01	0.99	1.00	-0.01	0.12	-0.01	-0.16	-0.22	-0.04	0.12	0.31	-0.12	0.12
SEX	0.01	0.08	0.41	0.08	0.18	0.19	-0.01	0.04	-0.02	-0.01	1.00	0.21	-0.19	-0.04	0.08	0.00	0.15	0.12	0.22	-0.02
SCH	0.03	0.20	0.14	-0.07	0.09	0.29	0.00	0.31	0.11	0.12	0.21	1.00	0.15	-0.23	0.04	0.46	0.38	0.40	-0.01	-0.11
ASCH	0.02	0.09	-0.13	0.17	0.00	0.22	-0.05	0.20	-0.01	-0.01	-0.19	0.15	1.00	-0.05	-0.01	0.21	-0.03	-0.04	-0.08	-0.22
PRIM	0.08	-0.23	0.00	0.18	-0.02	-0.02	0.18	0.03	-0.13	-0.16	-0.04	-0.23	-0.05	1.00	-0.08	-0.51	-0.15	-0.12	0.09	0.15
JSS	-0.16	0.11	-0.03	-0.08	0.03	-0.03	0.08	0.21	-0.27	-0.22	0.08	0.04	-0.01	-0.08	1.00	-0.14	-0.04	-0.03	-0.06	-0.30
MID	0.15	0.30	-0.04	0.01	0.13	0.19	-0.33	0.04	-0.05	-0.04	0.00	0.46	0.21	-0.51	-0.14	1.00	-0.24	-0.20	-0.10	-0.10
SEC	0.23	-0.13	0.13	-0.23	-0.19	-0.07	0.30	0.12	0.13	0.12	0.15	0.38	-0.03	-0.15	-0.04	-0.24	1.00	-0.06	0.16	-0.09
PSEC	-0.42	0.08	0.12	0.03	0.13	0.21	0.02	0.12	0.29	0.31	0.12	0.40	-0.04	-0.12	-0.03	-0.20	-0.06	1.00	-0.08	0.11
EXT	-0.18	-0.06	0.30	0.15	0.07	0.30	0.15	0.03	-0.11	-0.12	0.22	-0.01	-0.08	0.09	-0.06	-0.10	0.16	-0.08	1.00	0.03
FB	-0.04	-0.07	-0.12	-0.04	0.01	-0.16	-0.07	-0.20	0.13	0.12	-0.02	-0.11	-0.22	0.15	-0.30	-0.10	-0.09	0.11	0.03	1.00

Table A2b: Correlation Coefficients between Variables: Maize

	OTP	LAB	HLB	INP	HTO	CF	LND	HSIZ	AGE	AGSQ	SEX	SCH	ASCH	PRIM	JSS	MID	SEC	PSEC	EXT	FB
OTP	1.00	0.23	0.58	0.39	0.31	0.41	-0.19	0.24	-0.14	-0.14	0.26	0.06	0.05	-0.02	-0.10	0.06	0.07	-0.06	-0.05	0.00
LAB	0.23	1.00	0.31	0.22	0.50	0.39	-0.65	0.45	0.24	0.22	-0.02	-0.04	0.14	-0.08	-0.09	0.13	-0.13	-0.04	-0.07	-0.10
HLB	0.58	0.31	1.00	0.48	0.43	0.54	-0.33	0.07	0.03	0.02	0.05	-0.07	0.06	0.06	-0.06	0.00	0.02	-0.13	-0.07	-0.08
INP	0.39	0.22	0.48	1.00	0.46	0.45	-0.27	0.08	0.01	0.01	0.12	0.14	-0.17	-0.09	-0.03	0.09	0.07	0.05	0.10	-0.10
HTO	0.31	0.50	0.43	0.46	1.00	0.46	-0.68	0.01	-0.09	-0.08	0.06	-0.01	-0.01	-0.01	-0.01	0.04	-0.09	-0.05	0.14	-0.20
CF	0.41	0.39	0.54	0.45	0.46	1.00	-0.50	0.05	-0.04	-0.04	0.07	-0.01	-0.14	-0.15	0.04	-0.06	0.09	0.08	0.10	-0.16
LND	-0.19	-0.65	-0.33	-0.27	-0.68	-0.50	1.00	0.17	0.03	0.00	0.16	0.02	-0.04	-0.01	-0.11	0.04	-0.09	0.21	0.12	0.22
HSIZ	0.24	0.45	0.07	0.08	0.01	0.05	0.17	1.00	0.35	0.29	0.20	0.11	0.21	-0.22	-0.27	0.38	-0.23	0.11	0.02	0.14
AGE	-0.14	0.24	0.03	0.01	-0.09	-0.04	0.03	0.35	1.00	0.99	0.00	0.05	0.02	-0.02	-0.34	0.27	-0.20	0.12	-0.04	0.15
AGSQ	-0.14	0.22	0.02	0.01	-0.08	-0.04	0.00	0.29	0.99	1.00	0.01	0.04	0.00	-0.01	-0.29	0.22	-0.18	0.12	-0.04	0.13
SEX	0.26	-0.02	0.05	0.12	0.06	0.07	0.16	0.20	0.00	0.01	1.00	0.10	0.13	-0.28	-0.01	0.13	0.09	0.05	0.12	-0.16
SCH	0.06	-0.04	-0.07	0.14	-0.01	-0.01	0.02	0.11	0.05	0.04	0.10	1.00	0.17	-0.29	0.05	0.51	0.31	0.30	0.14	-0.17
ASCH	0.05	0.14	0.06	-0.17	-0.01	-0.14	-0.04	0.21	0.02	0.00	0.13	0.17	1.00	-0.03	-0.03	0.06	0.20	-0.01	0.06	-0.12
PRIM	-0.02	-0.08	0.06	-0.09	-0.01	-0.15	-0.01	-0.22	-0.02	-0.01	-0.28	-0.29	-0.03	1.00	-0.13	-0.51	-0.11	-0.06	-0.07	-0.06
JSS	-0.10	-0.09	-0.06	-0.03	-0.01	0.04	-0.11	-0.27	-0.34	-0.29	-0.01	0.05	-0.03	-0.13	1.00	-0.31	-0.07	-0.04	0.02	-0.16
MID	0.06	0.13	0.00	0.09	0.04	-0.06	0.04	0.38	0.27	0.22	0.13	0.51	0.06	-0.51	-0.31	1.00	-0.27	-0.15	-0.01	0.10
SEC	0.07	-0.13	0.02	0.07	-0.09	0.09	-0.09	-0.23	-0.20	-0.18	0.09	0.31	0.20	-0.11	-0.07	-0.27	1.00	-0.03	-0.08	-0.11
PSEC	-0.06	-0.04	-0.13	0.05	-0.05	0.08	0.21	0.11	0.12	0.12	0.05	0.30	-0.01	-0.06	-0.04	-0.15	-0.03	1.00	0.41	-0.12
EXT	-0.05	-0.07	-0.07	0.10	0.14	0.10	0.12	0.02	-0.04	-0.04	0.12	0.14	0.06	-0.07	0.02	-0.01	-0.08	0.41	1.00	-0.10
FB	0.00	-0.10	-0.08	-0.10	-0.20	-0.16	0.22	-0.14	0.15	0.13	-0.16	-0.17	-0.12	-0.06	-0.16	0.10	-0.11	-0.12	-0.10	1.00

Where:

OTP .... Output
LAB .... Labour
HLB .... Hired labour
INP .... .Other inputs
HTO ....Hand Tools
CF ....Chemical Fertilizer
LND .... Land
HSIZ ....Household size
AGE.. Age of household head
AGSQ ....Square of the age of household head
SEX ....Sex of household head
SCH.. Years of schooling
ASCH.. Average school years of other family members
PRIM... Primary education
JSS .... Junior Secondary School education
MID .... Middle School education
SEC ....Secondary education
PSEC .... Post- Secondary education
EXT ....Extension education
FB ....Family Background

Appendix 3

Table A3a: OLS regression results: Cassava

	OLS Coefficients Estimates			
	Equ.1		Equ.2	
Variable	Est. Coefficients	T-ratios	Est. Coefficients	T-ratios
Constant	3.164	(1.156)	1.482	(0.670)
Ln_Lab	0.035	(0.190)	0.452	(2.178)**
Ln_Hlab	0.171	(1.330)	0.142	(1.234)
Ln_Cfert	0.238	(1.865)*	0.269	(1.761)*
Ln_Htool	-0.283	(-1.581)		
Agey	0.086	(1.467)	0.028	(0.312)
Agesq	-0.001	(-1.327)	- 0.000	(-0.125)
Sex_1	0.092	(0.281)	0.096	(0.372)
Schyrs	0.002	(0.054)		
Educprim			0.289	(0.878)
Educmid			0.024	(0.863)
Educjss			-0.651	(-1.067)
Educsec			1.313	(2.052)**
Educpsec			-2.525	(-2.222)**
Aveschyrs			-0.007	(-0.253)
Extserv	-0.443	(-1.641)	-0.680	(-2.713)***
RuralDum	Yes	(insig)	Yes	(insig)
ForeDum	Yes	(insig)	Yes	(insig)
CoastDum	Yes	(insig)	Yes	(insig)
Pwork	0.496	(1.800)*	0.332	(1.164)
$R^{2\cdot}$	0.26		0.39	
Adj.R^2	0.14		0.26	
F-stats (Prob)	2.158 (0.000)		3.010 (0.000)	
N	86		86	

Source: Author's computation from GLSS 4 data, 2000
Dependent variable is natural logarithm of cassava output per acre. Figures in parentheses are t-ratios. Stars indicate significance using a two tailed t-test as follows: *** = 0.01; ** = 0.05; * = 0.10.
a. Included as a scale variable
Yes- included in the model; insig- estimated coefficient not significant
Equations labelled 1 and 2 are based on equation 3.17 using different variants of education measure.

Table A 3b: OLS regression results: Maize

Variable	OLS Coefficients Estimates			
	Equ. 1		Equ. 2	
	Est. Coefficients	T-ratios	Est. Coefficients	T-ratios
Constant	-1.935	(-1.542)	0.106	(0.083)
Ln_Lab	0.201	(1.527)	0.078	(0.699)
Ln_Hlab	0.385	(4.536)***	0.288	(3.842)***
Ln_Cfert	0.107	(1.318)	0.147	(2.119)**
Ln_Inputs	0.136	(1.803)*	0.147	(2.352)**
Agey	-0.045	(-1.021)	-0.057	(-1.321)
Agesq	0.000	(0.724)	0.000	(1.096)
Sex_1	0.580	(2.270)**	0.453	(2.651)***
Schyrs	0.025	(1.139)		
Educprim			0.088	(0.415)
Educmid	-		0.031	(0.210)
Educjss			-0.446	(-1.346)
Educsec			-0.052	(-0.160)
Educpsec			-0.172	(-0.285)
Aveschyrs	0.004	(0.171)	0.022	(1.160)
Extserv	-0.568	(-2.630)***	-0.158	(-0.804)
RuralDum	Yes	(insig)	Yes	(sig)
ForeDum	Yes	(insig)	Yes	(insig)
CoastDum	Yes	(insig)	Yes	(insig)
Pwork	0.436	(1.954)*	0.312	(1.571)
R^2	0.50		0.47	
Adj.R^2	0.43		0.39	
F-stats (Prob)	6.880 (0.000)		6.164	
N	150		150	

Source: Author's computation from GLSS 4 data, 2000
Dependent variable is natural logarithm of maize output per acre. Figures in parentheses are t-ratios. Stars indicate significance using a two tailed t-test as follows: *** = 0.01; ** = 0.05; * = 0.10.
a. Included as a scale variable
Yes- Variable included in the model; insig- estimated coefficient is not significant; sig- coefficient is significant
Equations labelled 1 and 2 are based on equation 3.17 using different variants of education measure.

Appendix 4

Table A 4a: WLS estimation results showing interaction effect for Extension Service and Years of schooling completed : Cassava

Variable	WLS Coefficients Estimates			
	Equ. 1		Equ. 2	
	Est. Coefficients	T-ratios	Est. Coefficients	T-ratios
Constant	0.540	0.172	0.586	0.026
Ln_Lab	0.357	1.113	0.486*	1.953
Ln_Hlab	0.300	1.276	0.243	1.460
Ln_Cfert	0.116	0.616	0.086	0.788
Ln_Htool	-0.193	-0.871	-0.210	-1.112
Ln_Inputs	0.060	0.376	0.135	1.012
Agey	0.062	0.618	0.044	0.532
Agesq	-0.000	-0.654	-0.000	-0.544
Sex_1	-0.128	-0.288	0.001	0.004
Schyrs	0.012	0.213		
Extserv*Schyrs	0.470	0.685	-0.646**	-2.201
Extserv	-1.009	-1.519		
RuralDum	-0.394	-0.644	-0.277	-0.767
ForeDum	-0.411	-0.689	-0.533	-1.082
CoastDum	0.012	0.018	-0.333	-0.577
Pwork	0.696*	1.781	0.582**	1.856
R^2	0.93		0.95	
Adj.R^2	0.92		0.94	
F-stats (Prob)	69.476 (0.000)		137.009 (0.000)	
N	107		107	

Source: Author's computation from GLSS 4 data, 2000
Dependent variable is natural logarithm of cassava output per acre. Figures in parentheses are t-ratios. Stars indicate significance using a two tailed t-test as follows: *** = 0.01; ** = 0.05; * = 0.10.
Land area cultivated was used as a scale or weighted variable
Equations labelled 1 and 2 are based on equation 3.17 using different variants of education measure.

Table A 4b: WLS estimation results showing interaction effect for Extension Service and Years of schooling completed : Maize

	WLS Coefficients Estimates			
	Equ. 1		Equ. 2	
Variable	Est. Coefficients	T-ratios	Est. Coefficients	T-ratios
Constant	-1.656	-0.993	-0.678	-0.503
Ln_Lab	0.198	1.292	0.162	1.343
Ln_Hlab	0.368***	4.244	0.262***	3.355
Ln_Cfert	0.119*	1.724	0.116	1.484
Ln_Htool	0.026	0.241	-0.010	-0.010
Ln_Inputs	0.155**	2.031	0.216***	3.056
Agey	-0.049	-0.928	-0.034	-0.717
Agesq	0.000	0.711	0.000	0.489
Sex_1	0.447	1.497	0.395	1.634
Schyrs	0.040*	1.710	-	
Extserv*Schyrs	0.296	0.547	-0.191	-0.918
Extserv	-0.374	-0.795		
RuralDum	0.299	0.778	0.473	1.522
ForeDum	0.303*	1.682	0.417***	2.774
CoastDum	-0.507	-1.390	-0.437	-1.292
Pwork	0.292	0.917	0.107	0.400
R^2	0.96		0.95	
Adj.R^2	0.95		0.94	
F-stats (Prob)	147.364 (0.000)		219.779 (0.000)	
N	151		151	

Source: Author's computation from GLSS 4 data, 2000

Dependent variable is natural logarithm of maize output per acre. Figures in parentheses are t-ratios. Stars indicate significance using a two tailed t-test as follows: *** = 0.01; ** = 0.05; * = 0.10.

Natural log of farm size was used as a weighted variable (Principal cause of heteroscedasticity)

Equations labelled 1 and 2 are based on equation 3.17 using different variants of education measure.

Appendix 5

Table A 5: Percentage increase in output associated with an extra year of schooling of head farmer*

Farm Enterprise Activity	Education Variable	Percentage increase in output
Cassava	Years of Schooling	3.66
	Dummy Indicator	
	Primary	13.25
	Secondary	21.19
Maize	Years of Schooling	3.05
	Dummy Indicator	
	Primary	0.25
	Middle	2.34
	Secondary	0.81
	Post Secondary	2.29

Source: Author's computation from GLSS 4 data (2000), using the formula developed by Lockheed, Jamison and Lau (1980)

* Results based on equations 3.18a and 3.18b