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Research on Poverty Alleviation

17th ANNUAL RESEARCH WORKSHOP

Education and Farm Productivity in Rural Tanzania

Lucas Katera

Draft Report ***GD3***

Presented at REPOA's 17th Annual Research Workshop
held at the Whitesands Hotel, Dar es Salaam, Tanzania;
March 28-29, 2012

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1.0 INTRODUCTION

It is widely accepted that growth of many countries particularly those in Sub Saharan Africa, will only be realized with a well-developed Agriculture Sector. This is because agriculture growth has powerful leverage effects on the rest of the economy, especially in the early stages of development and economic transformation, when agriculture accounts for large shares of national income, employment and foreign trade. Tanzania is no exception in this aspect. Recent statistics show that 80% of its population depends on agriculture for livelihood; and agriculture contributes to 95% of food consumption. Furthermore, agriculture contributes more than 25% of GDP, 30% of total exports and 65% of raw materials for Tanzanian industries. Development of the Tanzanian economy cannot be isolated from development of the agriculture sector. Within this context, researching agriculture remains to be an important aspect of development.

In his Nobel Prize Lecture Schultz (1979) summarized the motivation for his research as: "Most of the people in the world are poor, so if we knew the economics of being poor, we would know much of the economics that really matters. Most of the world's poor people earn their living from agriculture, so if we knew the economics of agriculture, we would know much of the economics of being poor."

Public investment in agriculture is an important driver of agricultural growth and has a significant bearing on poverty outcomes. Because of the budget constraints, however, countries find themselves in an increasingly difficult situation of having to meet the rising costs of social services to mitigate the immediate impact of poverty and, at the same time, raise investments to boost and broaden growth in the agriculture sector in order to reduce the prevalence of poverty especially in rural areas in the future. Under such condition of trade-off between social and growth sectors, it is important to understand, acknowledge and take advantage of synergies existing between them. Education is one of the social sectors that have a bearing on productivity. Specifically, education may enhance farm productivity directly by improving the quality of labour, by increasing the ability to adjust to disequilibria, and through its effect upon the propensity to successfully adopt innovations. Education is thought to be most important to farm production in a rapidly changing technological or economic environment (Alene and Manyong, 2007). Since farming methods in Tanzania are largely traditional, there appears to be little economic justification for Tanzania farm households to invest in education. However, with the new initiative called *Kilimo Kwanza* the government focuses attention to a modernized agriculture (URT-TNBC, 2009).[1] As technological innovations spread more widely within the country, the importance of formal schooling to farm production ought to become more apparent.

[1] *Kilimo Kwanza* are Kiswahili words meaning Agriculture First. Under this initiative, the Government of Tanzania intends to modernize agriculture though increased financing and creating environment for private sector participation. Detailed discussion on Kilimo Kwanza comes shortly in this paper. The acronym URT means United Republic of Tanzania and TNBC is Tanzania National Business Council.

In Tanzania, however, primary education seems to have not been viewed as an input to agricultural productivity, but rather as a conduit to secondary and higher leaning institutions to prepare a student for formal employment. Consequently, parents see importance of primary schooling only if they perceive that it will provide an opportunity for formal employment as a student moves to higher education. The "Primary school (compulsory enrolment and attendance) Rule 2002" issued in June 2002 make it a criminal offence for parents/guardians to fail to enrol seven year olds into standard one and to allow a pupil to drop out before completion of the full primary cycle (URT, 2003d). Despite imposed penalties, including cash payment and jail sentences for a victim, efficiency of primary education measured in terms of cohort wastage raises a number of concerns. The average survival rate to standard seven between 2005 and 2010 is 69% (URT, 2011). This suggests a low level of acknowledging importance of primary education, especially if parents see limited chances for their children to excel to secondary and higher education for formal employment in urban areas.

The purpose of this paper is two-fold: first, to challenge the hypothesis that demand for schooling in rural Tanzania is constrained by lack of visible benefits of schooling in terms of farmer productivity; and second, to understand better the potential consequences of low levels of demand of schooling in terms of missed opportunities to improve agricultural output in rural Tanzania by raising farmer efficiency and by increasing the propensity successfully to adopt innovations. The first objective is to work out the benefits (or lack thereof) of schooling to the rural economy. Parents may see the benefits of secondary schooling for their children in terms of the possibility for urban employment, and view primary education as a necessary input into secondary schooling. Thus, demand for both levels of schooling may be constrained by a perceived lack of job opportunities for secondary school graduates. However, farm households may still value schooling for their children if there is a perception that primary education generates cognitive skills (e.g., basic literacy and numeracy) which are useful in agriculture. If this is not the case in Tanzania, it may explain why there is such a high level of drop-outs before completing standard seven. The second objective is important for policy-makers concerned about high drop rates despite free provision of education. Apparently, agriculture policies focus of mechanizing agriculture with emphasis on inputs like machinery, chemical fertilizers, improved seeds, etc. If education is found to have a significant impact upon agricultural productivity, this will provide a rationale for agriculture policies to integrate issues of formal education.

There are several avenues by which schooling may create economic benefits in rural areas. Households receive income in cash and in kind from farming and off-farm activities, wage employment, and remittances from migrants. Education may increase the probability of success in each of these endeavours and, in so doing, diversify household income sources to reduce risk and improve economic security. Since farming is the primary activity of most households in rural Tanzania, this paper will focus on the part played by schooling in agricultural production.

2.0 OVERVIEW OF AGRICULTURE IN TANZANIA

2.1 Structure

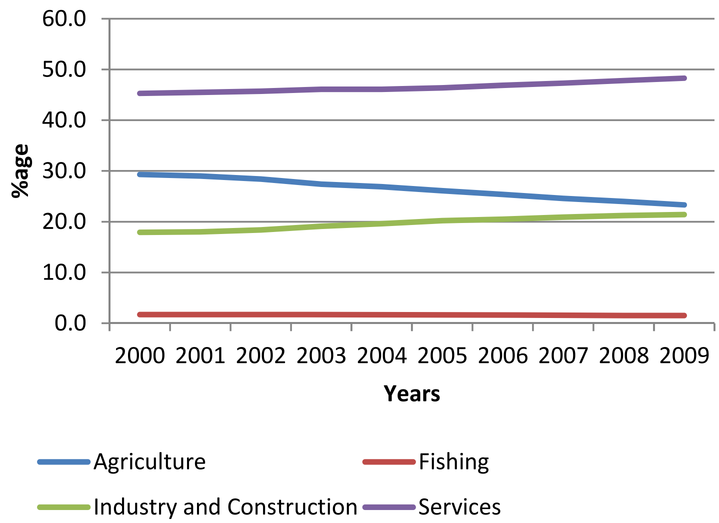
Tanzania is estimated to have 44 million hectares of land suitable for crop production. Out of this, only 10.8 million hectares are under cultivation, being only 25% of the potential land. In addition, the country has60 million hectares of grazing land suitable for livestock keeping. Generally, there is ample land suitable for crops and animal production which is not or is underutilised. Land holdings average 0.2 to 2 hectares per household. Main crops produced in Tanzania include both food and cash crops. The main food crops are maize, paddy, banana, potatoes and cassava. On the other hand, main cash crops are coffee, tobacco, sisal, cotton, sugarcane, cashew-nuts and tea. Lately, horticultural crops are fast emerging as a major component in the sub-sector. There is great product range of fruit, vegetables and flowers in Tanzania. The most important fruits include pineapples, passion fruits, citrus fruits, mangoes, peaches, pears and sweet bananas. Vegetables include tomatoes, spinach cabbages, okra etc. Flowers include many tropical varieties and some temperate types. Limitation in availability and access to modern technology is a major obstacle to expansion of land under cultivation. The agriculture sector review and public expenditure review 2008/09 shows that 70% of farmers still use a hand hoe for tilling land, 20% use animal draught ploughs and only 10% use tractors. While Kilimo Kwanza is expected to have positive results in terms of modernizing agriculture, more effort is needed to reach potential level of outputs. The agriculture sector review further shows that farmers in Tanzania are realizing low levels of their potential output due to impediments in adopting innovations (URT, 2008).

2.2 Trend

The agriculture sector in Tanzania remains one of the largest sectors in the economy. In 2009, the sector contributed nearly 25 % to national gross domestic product (GDP) (See Figure 1). In terms of foreign exchange, in the same year the sector contributed about 34 % of the country's export earnings (URT, 2010). While the share of agriculture sector to GDP is higher, the last decade has witnessed consistent decline in that share. Gradual decrease of the share of agriculture sector in GDP is the result of investments and growth in other sectors of economy such as services and manufacturing. The structural change in the GDP is a good sign in the economic development of any country. The decline in agriculture share to GDP implies that services and manufacturing sectors are gaining share and that may imply some success towards moving away from a subsistence economy. For the Tanzanian economy to develop through diversification, its share of the agriculture sector in GDP has to decline rapidly with an increase in the absolute size of the sector (production and values). The Global Forum of Food and Nutrition of the UN shows that a declining trend of agriculture sector share of GDP due to fast growth of other sectors is found in other developing countries such as India, China and Turkey. In 1990, the shares were 31% (India) and 27% (China). Recent data shows that the shares of agriculture sector to GDP for the two countries dropped to 25%

(India, 2007) and 11.9% (China, 2008). However, India, China and Turkey have increased agriculture production more than double in absolute and values, and have significantly increased exports of products from other sectors (FAO, 2011).

Figure 1: Sectoral share of GDP



Source: URT, 2010

The absolute growth of agriculture sector is an important input for Tanzania to reach the Millennium Development Goals (MGD). The second National Development Framework, MKUKUTA II, requires agricultural growth rate to increase from 3.2 % in 2009 to 6.0 % by 2015, with corresponding sub-sectors growing correspondingly to have an impact on poverty reduction.[2] However, this seems to be a serious challenge given observed recent trends. Over the last decade, the overall growth rate of the agriculture sector fluctuated, between 3.1 (2003) and 5.9 % (2004); the growth rate of GDP during the same period fluctuated between 4.9 (2000) and 7.8 % (2004). Agriculture has persistently registered a lower growth rate compared with industry and services: while agriculture grew at an average of 4.3% between 2000 and 2009, industry and services grew at an average of 8.6 and 7.5%, respectively, during the same period. Average growth of GDP between 2000 and 2009 was 6.7%. The faster growth rate of other sectors should imply that the agriculture sector efficiency is increasing to feed the manufacturing and service sectors and at the same time to release labour to those sectors. If such linkages do not exist, then growth will have limited impact on poverty reduction. One option of improving this linkage is to have an efficient labour in the agriculture sector, which increases production and is flexible enough to shift to other sectors. Within this context the importance of formal education among farmers cannot be over-emphasized.

[2] MKUKUTA is a Kiswahili acronym, whose long form is *Mkakati wa Kukuza Uchumi na Kupunguza Umasikini Tanzania*, which is the National Strategy for Growth and Reduction of Poverty (NSGRP). This is a national framework guiding strategies for Growth and Poverty reduction in the country.

2.3 Agriculture Sector Development Efforts in Brief

Past Efforts

Tanzania has historically treated agriculture as the backbone of its economy. The country's majority of its population (about 80%) and its leadership, at all levels, has throughout the country's history directed much of its energies as well as public and private sector resources towards the transformation of agriculture. This is manifested in a range of policy instruments and programs that were initiated and carried out in the past in an effort to improve the country's agriculture. These included: the Iringa Declaration of "Siasa ni Kilimo – politics is agriculture"; followed by "Kilimo cha Kufa na Kupona – life and death effort to improve agriculture"; The Arusha Declaration which had anchored largely in agricultural transformation. Vision 2025 which has already been in operation for over 10 years aiming at transforming Tanzania to semi industrialized country by 2025,has considerable focus on agriculture. All these were earlier efforts by the government to give a special emphasis on development of agriculture sector. The success of earlier policies faced a number of challenges, the major one being lack of popularity, especially because they lacked ownership because of being centrally planned with little or even no involvement of citizens in their formulation.

Recent Efforts

Recent strategies to promote the agriculture sector have been built within the National Framework for growth and poverty reduction, MKUKUTA, taking into account challenges experienced in earlier efforts. Through MKUKUTA, these strategies provide guidance on the type of intervention needed, who should be key actors and how to finance the action.

Agriculture Sector Development Strategy

In response to economic challenges including stagnant growth in the agriculture sector, resulted from failure of previous sectoral policies, the Government of Tanzania developed and approved the Agriculture Sector Development Strategy in 2001. The objective of ASDS is to achieve a sustainable agricultural growth rate of 5% per annum, primarily through the transformation from subsistence to commercial agriculture. The transformation is to be private sector led through an improved enabling policy environment and public expenditure. Among the core features of the ASDS is the use of district-level demand identification, project management and implementation through preparation of the District Agriculture Development Plans (DADPs).The use of district level management is aimed at addressing challenges of previous perceived top down management.

The Agriculture Sector Development Programme (ASDP) is the Government's operational response to the ASDS and the main mechanism for its implementation. The key methodology underlying the ASDP is based on a participatory and iterative approach in its design, beneficiary demand-driven approach in its need assessment, decentralised and result-based in its implementation. The Government is implementing a seven year Agriculture Sector

Development Programme (ASDP). Through ASDP basket fund, the Government in collaboration with development partners is financing the implementation of the Programme. The Programme has two components namely, the local level support which uses 75% of the total resources from the basket and the national level component which uses 25% from the basket.

Kilimo Kwanza

The totality of the effort Tanzania has directed in agriculture had aimed at achieving a significant measure of agricultural productivity or more commonly known as a “green revolution”. A substantial amount of the budget was required to achieve this. Indeed, the government of Tanzania had, at both the AU and SADC level committed that it would allocate 10% of the national budget to agricultural development. Considerable progress had been made from the low of 2.9% of the national budget that some years ago were allocated to agriculture to the present level of 6.2% in 2007, which seemed still too low to realize tangible agricultural transformation. Consequently, the sector suffered lower investment in mechanized farming, characterised with low usage of improved seeds and fertilizers and limited use of machinery. Furthermore, while the country is second in Africa, after DRC, for large volume of water resources and numerous water basins, is only able to irrigate 1% of its potential irrigable land of 29.4 million hectares (URT, TNBC 2009). Because of these problems, the sector has suffered lower investment and is unattractive to the private sector.

To address those challenges, the government felt that the time has come to have a defined trajectory for the transformation of Tanzania’s agriculture, which will be commonly understood and shared by all the stakeholders, and capable of generating the impetus for high and sustained growth rate of the economy as a whole, for many years to come. The way forward for Tanzania is a national vision for a green revolution, popularly known by the name ***Kilimo Kwanza,*** officially launched by President on 3rd August 2009. Under Kilimo Kwanza, emphasis starts in small scale agriculture, with gradual shift to medium to large scale farming. The shift away from small scale farming thus releasing agricultural labour to non-farm sectors is one of the outcomes of increases in agricultural productivity (due to use of modern inputs– fertilizers and improved seeds and breeds; mechanization - thus reduction in labour time- reliable water for irrigation, etc.). Strategies to ensure the economy absorbs labour released from farming, especially the rural non-farm activities, become an integral part of rural development strategies. Agriculture sector-specific growth issues revolve around productivity, with particular concerns for the smallholder farmers who are the majority. The government and private sector investment efforts focus on the identified drivers of growth in agriculture. The “drivers” are prioritized according to impact in raising productivity and creation of decent employment (with variations per region/district depending on existing relative advantages).

3.0 LITERATURE REVIEW

3.1 General Overview

Improvements in human capita are largely seen as influencing how an individual acquires, assimilates, and applies information and technology. Returns to investment in education based on human capital theory have been estimated since the late 1950s. Education, particularly formal education acquired during primary and secondary schooling, has been shown to result in higher incomes and improve overall economic development and growth (Becker, 1964).

Wage data is rarely available within the context of agriculture sector in developing countries, hence, most of the recent studies that relate agriculture sector productivity and human capita have been using production function (See Griliches, Z., 1964; Lockheed, M. E.et, all, 1980; Phillips, J. M. 1994; Appleton and Balihuta, 1996; Weir 1999; Alene and Manyong, 2007; and Ajani and Ugwu, 2008). Advantage of using a production function is that it gives the marginal product of a farmer in terms of real output per unit of improvement in human capital.

3.2 Studies Outside Africa

Griliche, (1964) made one of the earliest attempt to study the relationship between farm productivity and farmer education. Using Cob-Douglas production function, the study covered 39 states in America and used three cross sectional data sets covering 1949, 1954 and 1959. Education of the farm labour force was associated with 41% increase in average farm productivity and it had substantial economies of scale in agriculture. Subsequent studies found a positive relationship between education and farm labour productivity, but with lower magnitudes.

Lockheed et al, (1980) reviewed previous studies, aiming at examining the information they contained concerning the correctness of three hypotheses: (1) higher levels of formal education increase farmers' efficiency; (2) education has a higher payoff for farmers in a changing, modernizing environment than in a static, traditional one and (3) exposure to extension services improves farmers' productivity. The results of this review showed average increase in farm productivity by 7.4% as a result of a farmer's completing 4 years of elementary education rather than none, with some studies showing the effect to be more pronounced at the threshold number of years of education of 4-6. 3The review further found that the effects of education were much more likely to be positive in modernizing agricultural environments than in traditional ones.

[3] The 7.4% is a weighted average of values from those studies for which an estimate could be computed.

While these studies point to the importance of human capital in the form of formal education in farm productivity, they are criticized for using different data sets or comparing different studies, whose data collection and methodology of analysis may be different. Furthermore, same variables had definitions to different countries or states. For example, some studies used quantity produced others value of outputs as dependent variable, though the latter may be affecting by price changes. Consequently, Phillips, J. M. (1994)extended the work of Lockheed et al (1980) by performing a meta-analysis for the relationship between farmer education and farm productivity. Under this approach, the data points were the individual studies as opposed to individual subjects or observations. Their results confirmed and strengthened Lockheed et al.'s results in terms of estimating the average percentage gain in productivity from 4 years of schooling. They further support the hypothesis of stronger influence of education on productivity in a modernizing environment. Regarding cross-regional comparison, the study found out that the effect of education on farm productivity was stronger in Asia than in Latin America.

What we see in common for all these studies is that farmer education is positively related to farm productivity. However, the intensity of relationship as well as the threshold of education level differs between a country and another. Furthermore, their conclusions based on comparative studies which use different data sources and different definition of variables raise questions on the validity of their generalized findings, hence, calling for specific country studies for this relationship.

3.3 African Studies

In Africa, studies that relate education and agriculture sector productivity started with the earlier work by Appleton and Balihuta (1996) in Uganda. This study found a positive return to schooling on agriculture productivity. However, the social (external) return to schooling was higher than the private (internal) return. Indeed, one year rise in primary schooling of a neighbouring farmer primary education was associated with a 4.3% rise in output compared to a 2.8% of own farmer primary education. A similar study in Ethiopia is giving even more surprising results, where external returns to education is associated with 56% of farmer productivity compared to only 2% for private returns (weir, 1999). Further reviews of other studies (see Appleton and Balihuta, 1996; and Appleton 2000) concluded that the effect of education on agricultural productivity was at best mixed; This review found out that the effect of schooling on agricultural output is usually not significant, though in some cases it can be large, indicating that there is substantial variation in returns to schooling both within and between the areas surveyed. The authors suggest several possible reasons for the lack of significance of education in the African studies. Apart from challenges of establishing causality, the lack of significance of education in some of the studies in Africa has been attributed to small sample sizes and measurement errors in agricultural production.

Inconclusive results of studies that have looked at the relationships between education and farmer productivity have been challenged by other scholars, who argue that the lack of significance is due more to assuming homogeneous technology use by farmers. Consequently, such studies have failed to account for the fact that education plays a greater role in modern environments than traditional environments. This is because more educated farmers are more likely to respond and adjust to technological disequilibria than those who are less educated. Therefore, Alene and Manyong (2007) examined the effects of schooling and extension on cowpea production under both traditional and modern/improved technology in northern Nigeria. Their study established that farmer education had a positive and significant effect on adopters of improved cowpea varieties as opposed to non-adopters or traditional cowpea farmers.

While there have been variations in conclusions of such relationships, there appears to be some consensus that the relationship is positive, particularly where differences between traditional and modern agriculture are taken into account. In summary, literature shows that there is a wide variation in the actual effects of education on agricultural output in different areas and under different farming systems and with different technology. These results further suggest the need for further investigation of the effects of education on farm productivity in Africa.

3.4 Other Important Issues within the Literature

Where is the formal education threshold?

As we have seen, most of the studies have one consensus that education of farmer is positively related to farm productivity. However, there is not yet a consensus on the threshold on the desired formal education level to have an impact. Some studies have indicated that at least four years of schooling are needed for education to affect farm output (See Appleton and Balihuta, 1996, Lockheed *et al*, 1980; Phillips, 1994; Weir, 1999; Arega, D. *et al*, 2007). Such studies note that this level of formal schooling is commonly thought to be approximately the amount of schooling needed for literacy and numeracy to be functionally attained. Lockheed *et al*, (1980) support the threshold of four years of education to only some countries but in others a threshold of 4 to 6 years of schooling became more pronounced in increasing farm productivity.

An important thing to note within the literature on thresholds for education level to make impact to agriculture productivity is that of external benefits. Some studies have indicated that, while education of some members of the household is important to raise labour productivity, there are benefits that a household can gain from neighbouring education. Appleton and Balihuta (1996) finds out that education of the household increases farm productivity of a neighbouring household by 4.3% compared to 2.8% of own household productivity. In Ethiopia, the social (external) returns to education are even bigger than private returns (Weir, 1999). Evidence of strong external (social) benefits of schooling suggests that there may be considerable opportunities to take advantage of external benefits of schooling in terms of increased farm productivity if school enrolments in rural areas are increased.

Within the context of years of schooling threshold is on the impact of formal education on different farming technologies. Literature shows that usually, formal schooling is most useful in an innovative environment where farmers face rapid technology changes and hence, can catch up faster with the new technology than their counterpart (see Schultz, 1964; and Arega, D. et al, 2007). If this is true, more schooling is needed in a rapidly changing environment.

Whose education matters?

Another issue which arises is: whose education matters to agricultural productivity? Most studies include information on years of schooling of the household head, argument for this being that most of the farming decisions are likely to be made by its head. In that case, it is his education that matters than education of other members of the household who participate in farming. Others studies use average years of schooling of all adult household members. The challenge to use this measure is particularly the case when all adult households are not engaging in farming. Similar problem is suffered by those studies using average years of schooling attained by all household members. Using such proxy for household education is not ideal, since some household members, such as young children and the elderly, participate less in agricultural production and decision-making than others. Perhaps, it is relatively ideal to use average years of schooling of only those household members engaged in farming since decisions on farming practices is likely to be from them.

Basu and Foster (1998) argue that only one person needs be educated in the household for the entire household to benefit from the cognitive skills acquired in school. Hence, it may be years of schooling of the most educated household member which matters, rather than average years of schooling attained by all household members (Foster and Rosenzweig 1996).This may be the case in terms of the allocative benefits of schooling, such as may be derived from adopting the use of modern farm inputs (Green, Rich and Nesman1985). Certainly, households with an uneducated household head need not necessarily be less productive than those where the household head has been to school, if some other member of the household, or even a neighbour, has some schooling. Thus, children who have been to school may contribute to farm output by providing cognitive skills which compensate for lack of education of the head. However, owing to the possibility of confounding the empirical results with endogeneity, the education of children should not be included in average or maximum years of schooling in the household.

4.0 ANALYTICAL FRAMEWORK

4.1 Introduction

This paper uses the stochastic production function. A production function defines the technological relationship between the level of inputs and the resulting level of outputs. If estimated econometrically from data on observed outputs and input usage, it indicates the average level of outputs that can be produced from a given level of inputs (Schmidt, 1986). A number of studies have estimated the relative contributions of the factors of production through estimating production functions at either the individual boat level or total fishery level. These include Cobb-Douglas production functions (Hannesson, 1983), Constant Elasticity of Substitution (CES) production functions (Campbell and Lindner, 1990) and translog production functions (Squires, 1987; Pascoe and Robinson, 1998). This paper uses a production function, in particular, of the Cobb-Douglas translog functional form.

4.2 Underlying Theory

An implicit assumption of production functions is that all firms are producing in a technically efficient manner, and the representative (average) firm therefore defines the frontier. Variations from the frontier are thus assumed to be random, and are likely to be associated with mis- or un-measured production factors. In contrast, estimation of the production frontier assumes that the boundary of the production function is defined by “best practice” firms. It therefore indicates the maximum potential output for a given set of inputs along a ray from the origin point. Some white noise is accommodated, since the estimation procedures are stochastic, but an additional one-sided error represents any other reason firms would be away from (within) the boundary. Observations within the frontier are deemed “inefficient”, so from an estimated production frontier it is possible to measure the relative efficiency of certain groups or a set of practices from the relationship between observed production and some ideal or potential production (Greene, 1993).The general Cobb-Douglas stochastic production frontier function is given by:

$$InQ_{j,t} = \beta_0 + \beta_i \sum_i InX_{j,i,t} + v_{j,t} - u_{j,t} \text{ ---------------------------- } (1)$$

Where;

$Q_{j,t}$ = Output produced by farmer *j* at time *t*

$X_{j,i,t}$ = Vector of factor inputs *i* used by farmer *j* at time *t*

$v_{j,t}$ =Stochastic (white noise) error term; and

$u_{j,t}$ = A one-sided error representing the technical inefficiency of farmer *j*

The symmetric component $v_{j,t}$ represents the variation in output due to factors (weather or disease attack) beyond the farmer's control. On the other hand, a one sided component $u_{j,t}$ shows technical inefficiency relative to the stochastic frontier. Both $v_{j,t}$ and $u_{j,t}$ are assumed to be independently and identically distributed (iid) with variance σ_v^2 and σ_u^2 respectively.

Given that the production of each farmer j can be estimated as:

$$In\hat{Q}_{j,t} = \beta_0 + \beta_i \sum_i InX_{j,i,t} - u_{j,t} ---------------------------- (2)$$

while the efficient level of production (that is, no inefficiency) is defined as:

$$InQ^*{}_{j,t} = \beta_0 + \beta_i \sum_i InX_{j,i,t} ------------------------------ (3)$$

then technical efficiency (γ) can be given by:

$$In\gamma = In\hat{Q}_{j,t} - InQ^*{}_{j,t} = -u_{j,t} ------------------------------ (4)$$

It follows from (4) that,

$$\gamma = e^{-u_{j,t}} -- (5)$$

Following Batesse and Corra (1977) and Pascoe and Coglan (2000), we replace the variance parameters σ_s^2 and σ_u^2, with $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$ and $\sigma_s^2 = (\sigma_v^2 + \sigma_u^2)$ in estimating the model so that γ is constrained to take the value from zero to one (that is, $0 \leq \gamma \leq 1$). It follows from equation (5) above that If $u_{j,t}$ equals zero, then γ equals one, then production is said to be technically efficient. Technical efficiency of the j^{th} farmer is therefore a relative measure of his/her output as a proportion of the corresponding frontier output. A farmer is technically efficient if his/her output level is on the frontier, which implies that $\hat{Q}/Q^*$ equals one in value. The value of γ is used to determine the difference between farmers' output and the efficient output (Kalirajan, 1981; and Ajani and Ugwu, 2008).

5.0 DATA AND EMPIRICAL ANALYSIS

5.1 Data

The Agriculture sample survey was conducted by the National Bureau of Statistics (NBS) in collaboration with the sector ministries of agriculture.[4]The survey was conducted at the end of the 2008/09 Agriculture Year. It collected data by interviewing a sample of 48,315 small scale farming households and 1,206 large scale farming households. The survey covered agriculture in detail as well as many other aspects of rural development and was conducted using three different questionnaires: Small scale farm questionnaire; Community level questionnaire; and Large scale farm questionnaire. The small scale farm questionnaire was the main census instrument and includes questions related to crop and livestock production and practices; population demographics; access to services, resources and infrastructures; and issues on poverty, gender and subsistence versus profit making production units. Given the scope of the small scale farm questionnaire, data was collected at household/holding level, allowing for sex disaggregation of most variables at the head of household level.

The sample consisted of 3,221 villages. These villages were drawn from the National Master Sample (NMS)developed by the National Bureau of Statistics (NBS) to serve as a national framework for the conduct of household based surveys in the country. The National Master Sample was developed from the 2002 Population and Housing Census. Nationwide, all regions and districts were sampled with the exception of two urban districts. A stratified two stage sample was used. The number of villages/EAs selected for the first stage was based on a probability proportional to the number of villages in each district. In the second stage, 15 households were selected from a list of farming households in each selected Village/EA, using systematic random sampling, with the village chairpersons assisting to locate the selected households.

5.2 Empirical Analysis

In many studies of technical efficiency, the results are used to estimate the effects of various factors on inefficiency. These may be estimated using either a one-step or two-step process. In the two-step procedure, the production frontier is first estimated and the technical efficiency of each firm, derived. These are subsequently regressed against a set of variables, Z_{it}, which are hypothesized to influence the firm's efficiency. This approach has been adopted in a range of studies (See, for example, Kalijaran, 1981; Pitt and Lee, 1981).A problem with the two-stage procedure is a lack of consistency in assumptions about the distribution of the inefficiencies. In the first stage, inefficiencies are assumed to be independently and identically distributed (iid) in order to estimate their values. However, in the second stage, estimated inefficiencies are assumed to be a function of a number of firm-specific factors,

[4] Ministry of Agriculture and Food Security, Ministry of Water and Livestock Development, Ministry of Cooperative and Marketing and the President Office-Regional Administration and Local Government

and hence are not identically distributed (Coelli, Rao and Battese, 1998). Kumbhakar, Ghosh and McGuckin (1991) and Reifschneider and Stevenson (1991) estimated all of the parameters in one step to overcome this inconsistency. The inefficiency effects were defined as a function of the firm-specific factors (as in the two-stage approach), but were incorporated directly into the Maximum Likelihood Estimates (MLE). Battese and Coelli (1995) also suggested a one-step procedure for using the model (now accounting for time), such that:

$$InQ_{j,t} = f(InX) + v_{j,t} - u_{j,t} -----------------------------(6)$$

and the mean inefficiency is a function of firm-specific factors, such that:

$$u_{j,t} = Z\delta + e_{j,t} ---------------------------------(7)$$

where Z is the vector of firm-specific variables which may influence the firm's efficiency, δ is the associated matrix of coefficients and $e_{j.t}$ is an iid random error term.

In our farming case, to ensure that the estimated function represents a single farming system and production technology, only those households that reported to have grown maize in the long rainy season were chosen. Exclusion of households which are not producing maize resulted to a reduction of households from 48,315 to 31,198. From equation 6 above, the empirical model of the Cobb-Douglas translog stochastic production frontier function is specified and estimated as follows:

$$\begin{aligned} In(HARVEST)_j = {} & \beta_{0j} + \beta_{1j} In(HHTOTFARMHRS)_j + \beta_{2j} In(PLANTED)_j \\ & + \beta_{3j}(MACHINE)_j + \beta_{4j}(CREDIT)_j + \beta_{5j}(SEEDS)_j + \beta_{6j}(IRRIGATION)_j \\ & + \beta_{7j}(FERTILIZER)_j + \beta_{8j}(HERBICIDES)_j + \beta_{9j}(FUNGICIDES)_j \\ & + \beta_{10j}(PESTICIDES)_j + \beta_{11j}(extension)_j + v_j - u_j ----------(8) \end{aligned}$$

where, In denotes the natural logarithm, $\beta_{0j} - \beta_{11j}$ are parameters to be estimated, $j = 1,2,3......n$ farmers. The dependent variable in the production function is the natural logarithm of harvest (HARVEST), which is defined as the total harvest of maize in kilogram of j^{th} famer in the long rain farming season of the agricultural year preceding the survey.

The explanatory variables are a set of factors of production. They include natural logarithms of average person hours worked in a day by those household members engage in farming (HHTOTFARMHRS), and total land area planted maize in acres (PLANTED). The other explanatory variables are household use of machine (MACHINE), access to credit for farming (CREDIT), use of improved seeds (SEEDS), application of irrigation

(IRRIGATION), use of either chemical of organic fertilizer (FERTILIZER), use of herbicides (HERBICIDES), use of fungicides (FUNGICIDES), use of pesticides (PESTICIDES) and access to extension services (EXTENSION). The variable on the use of machines captures information about the extent of use of graft animals, power tiller or tractor at various stages of farming. Likewise, the variable on extension service captures information on the household access to extension services at various stages of farming, like farm preparation, planting, selection of seeds, weeding, harvest or even storage. This variable is important to this study as it will give the effect of non-formal education on agricultural outputs. With the exception of hours spent in farming and total cultivated land, all other explanatory variables take the value of 1 (one) if the j^{th} household accessed a given facility and the value of 0 (zero) otherwise. It is hypothesized that all explanatory variables have a yield-increasing effect.

The last two terms are as defined earlier, that is, v_j is a stochastic error term and u_j is a one-sided error representing the technical inefficiency of j^{th} farmer.

The technical efficiency for the j^{th} farmer is computed as an index and the average technical efficiency for the production efficiency determined. Based on a number of socio-economic factors identified to be influencing the technical efficiency of farmers, the Coelli and Battesse (1996) inefficiency model (see equation 7) is employed to estimate the parameters of the variables. The model is specified as:

$$\begin{aligned} u_j = \; & \delta_{0j} + \delta_{1j}(NOEDUHEAD)_j + \delta_{2j}(FOURHEAD)_j + \delta_{3j}(SIXHEAD)_j \\ & + \delta_{4j}(EIGHHEAD)_j + \delta_{5j} In(EDUHEAD)_j + \delta_{6j}(NOEDUHH)_j + \delta_{7j}(FOURHH)_j \\ & + \delta_{8j}(SIXHH)_j + \delta_{9j}(EIGHHH)_j + \delta_{10j} In(HHAVEDU)_j + \delta_{11j} In(HHAVEAGE)_j \\ & + \delta_{12j}(HEALTH)_j + e_j \text{ ------------------------------- } (9) \end{aligned}$$

where, In denotes the natural logarithm and $\delta_{0j} - \delta_{13j}$ are parameter to be estimated, $j = 1,2,3......n$ farmers. The dependent variable, u_i, is an inefficiency effect. Explanatory variables are those that are expected to have a bearing effect on efficiency. The first four variables (NOEDUHEAD, FOURHEAD, SIXHEAD and EIGHHEAD) are categories of education levels in which the j^{th} household heard fall. Those household heads with no formal education fall under the first category, those with up to primary four belongs to the second category, those with more than primary four up to primary six are on the third category and those with more than primary six up to primary eight fall under fourth category. The other four variables from variable 6 to variable 9 (NOEDUHH, FOURHH, SIXHH and EIGHHH)are of the same categories as those of the household heads but they represent average years of schooling attained by all j^{th} household members that are engaged in farming. These variables are dummy which take the value of 1 (one) if either the household heard or the average years of schooling for the j^{th} household fall at the relevant category and 0 (zero) otherwise. The remaining four explanatory variables in the inefficiency model are actual values. EDUHEAD and HHAVEDU represent actual years of schooling and average years of schooling attained by the j^{th} household heard and all household members respectively. HHAVEAGE stand for average age of j^{th} household members who are engaged in farming and HEALTH aims at capturing health status of the j^{th} household. Ideally, the variable for health should give the actual number of days that members of the j^{th} household failed to do farming activities because of health related problems. However, this variable was not collected in this survey. Instead, we used number of meals a day for the j^{th} households as the only best available proxy variable. The last term in the inefficient model, e_j, is a random disturbance following a half normal distribution.

The human capital variables, that is, education and health are hypothesized to have a negative relationship with inefficiency. However, it may also be argued that exposure to education can reduce efficiency in a labour market which offers better paying jobs for primary graduates. This is because as they get better paying jobs, they spend less and less time in farming, leading to a negative coefficient. This is more likely to be the case with respect to upper than lower primary levels. Finally, the sign of household average age will depend on the average age of members engaged in farming. If farmers are young, then as their ages increase they can spend more time and energy in farming so the variable will have a negative relationship with inefficiency. However, if farmers are old, the more their ages increases, the less the time and energy will be spent in farming and so the variable will have a positive relationship with inefficiency.

Another important aspect to consider here is the interpretation of education variables. Several different measures of education may be used, and different categories of labour may be considered (for example in our case, the household head versus all adult members who are engaged in farming). If education is measured as the number of years of schooling attained, the estimated coefficient represents the % age increase in output for one extra year in school. Here, several possibilities exist, including: years of schooling of the household head alone; average years of schooling of all adult household members or all non-head adult household members; and total years of schooling of the most educated adult household member. Interpretation of the education coefficient depends upon the specification chosen. For example, the coefficient on average years of schooling of all household members (logged) in a production function represents semi elasticity (that is, proportionate increase in farm output for a one year increase in the average education of all household members).

To account for the possibility that different levels of schooling have differing effects upon output, a set of dummy variables representing different levels of schooling may be used, or a set of additive categorical variables, specifying the number of adults with each level of education, may be considered. The coefficient on a 0-1 dummy variable represents the percentage increase in output due to having that level of schooling, as compared with the base case (assuming a Cobb-Douglas specification of the production function). The coefficients on the additive categorical variables represent the marginal product associated with having one more household member with that level of education.

6.0 RESULTS AND DISCUSSION

Table 1 describes the data used in the frontier production function to estimate the relationship between output and education attainment.

Table 1 Definitions and summary statistics of the variables used in the analysis

Variable	Definition	Mean	StdDev
HARVEST	Household total maize harvest in kilograms	646.78	951.00
HHTOTFARMHRS	Total number of person hours per day spent by a household in farming	6.30	4.70
PLANTED	Actual area planted maize by the household	2.17	2.63
MACHINE	The use of graft animal, power tiller or tractor in farming(=1 if a household used either or all)	0.27	0.44
CREDIT	Access of credit for farming (=1 if the household accessed and used)	0.04	0.19
SEEDS	Use of improved seeds in more than quarter of the planted area (=1 if the household used)	0.16	0.37
IRRIGATION	Application of irrigation to at least quarter of planted area (=1 if the household applied)	0.03	0.17
FERTILIZER	Application of either chemical or organic fertilizer to at least quarter of the planted are (=1 if the household applied)	0.33	0.47
HERBICIDES	Application of herbicides to at least quarter of planted area (=1 if the household applied)	0.01	0.11
FUNGICIDES	Application of fungicides to at least quarter of planted area (=1 if the household applied)	0.01	0.12
PESTICIDES	Application of pesticides to at least quarter of planted area (=1 if the household applied)	0.11	0.31
EXTENSION	Access to extension service at various stages of farming (=1 if the household accessed)	0.36	0.48
NOEDUHEAD	Household heard with no formal education (=1 if household heard has no formal education)	0.30	0.46
FOURHEAD	Household heard with formal education up to primary 4 (=1 if household heard has up to primary 4)	0.15	0.36
SIXHEAD	Household heard with formal education greater then primary 4 up to primary 6 (=1 if household heard has greater than primary 4 up to 6)	0.03	0.18
EIGHHEAD	Household heard with formal education greater then primary 6 up to primary 8 (=1 if household heard has greater than primary 6 up to 8)	0.44	0.49
EDUHEAD	Average years of schooling of household heard	4.8	4.11
NOEDUHH	Household with 0 average years of schooling (=1 if the household average years of schooling is 0)	0.11	0.32
	Households with average years of schooling greater than	0.45	0.50

Variable	Definition	Mean	StdDev
FOURHH	0 up to 4 (=1 if average years of schooling is greater than 0 up to 4)		
SIXHH	Households with average years of schooling greater than 4 up to 6 (=1 if average years of schooling is greater than 4 up to 6)	0.19	0.39
EIGHHH	Households with average years of schooling greater than 6 up to 8 (=1 if average years of schooling is greater than 6 up to 8)	0.20	0.40
HHAVEDU	Average years of schooling of the household	4.41	2.77
HHAVEAGE	Average age of the household farming members	32.00	11.99
HEALTH	Household health status (defined by average number of meals taken in a day)	2.44	0.57

Note: Means are based on the 31,198 households producing maize out of 48,315 farming households surveyed by the National Bureau of Statistics.

The table shows clearly that Tanzanian agriculture system is still a small hold with limited use of modern technology. The land holding averages only 2 acres per household. The fact that the value of standard deviation is higher than the mean suggests that majority of farmers have land holding below this level. Furthermore, we see that hardly 30% of famers practice modern farming; almost 70% of farmers do not use machines in farming and about the same parentage do not have access to the extension services. Morden inputs like fertiliser, improved seeds, pesticides and herbicides are used by hardly 10% of farmers.

What is also very obvious in Table 1 is very high level of illiteracy among farmers. On average, 11% of farmers have no formal education. The situation is even worse for the heads of farming households in which 30% of them have no formal education.

The maximum likelihood estimates of parameters which reflect the best practice farm at the existing level of technology is shown in Table 2. From the table, the δ^2 =0.534, is a ratio of performance of the j^{th} farmer specific efficiency indices to the total variation in output due to technical inefficiency. Batesse and Corra (1997) and Pascoe and Coglan (2000) defines gamma (γ) as the total variation of output from frontier, which can be attributed to technical inefficiency. It indicates the estimate of the stochastic frontier which shows the best practice, that is, efficient use of the available technology (see also Ajani and Ungwu, 2008). Our model estimates the value of gamma to be $\gamma = 0.204$. This implies that $(1-0.204) = 0.796$ or 79.6% of the total variance in output of the farmers is due to technical inefficiency. This analysis means that, on average, farmers in Tanzania are just realizing about 20% of their potential outputs feasible in the prevailing socio-economic physical and health environment. As the government implements *Kilimo Kwanza* policy, this high level of inefficiency requires an attention of policy makers.

Table 2: Maximum likelihood estimates and the inefficiency function

LHARVEST	Coefficient	Standard error	P>/Z/
Production Function			
LHHTOTFARMHRS	-0.010	0.007	0.142
LPLANTED	0.743***	0.006	0.000
MACHINE	0.143***	0.012	0.000
CREDIT	0.254***	0.027	0.000
SEEDS	0.165***	0.015	0.000
IRRIGATION	0.126***	0.030	0.000
FERTILIZER	0.370***	0.120	0.000
HERBICIDES	0.150**	0.049	0.002
FUNGICIDES	-0.117	0.059	0.092
PESTICIDES	0.374***	0.017	0.000
EXTENSION	0.024*	0.011	0.009
CONSTANT	6.405***	0.015	0.000
Variance parameters			
σ_s^2	0.534	0.008	
γ	0.204	0.021	
Log Likelihood	-38972.52		
Inefficiency model			
FOURHH	-0.159*	0.060	0.008
SIXHH	-0.178**	0.052	0.001
EIGHHH	-0.087	0.050	0.77
LEDUHEAD	-0.013	0.033	0.684
LHHAVEDU	-0.199***	0.044	0.000
LHHAVEAGE	0.348***	0.027	0.000
HEALTH	-0.061***	0.020	0.002
No of observation	28,586		

Likelihood-ratio test of sigma_u=0: chibar2(01)=1.7e+03 Prob>=chibar2=0.000
Wald chi2(11) =18629.92
Prob> chi3 =0.000
Note: Stars indicate significance: *** = 0.01; ** = 0.05; *** = 0.10

The results indicate that the outputs of farmers are not only affected by the traditional input variables: land, labour and capital (inputs like machine, fertilizer, pesticides and others), but equally by socio-economic factors; age health and education, through their impact on efficiency. The coefficients of most of the conventional production factors have the expected signs and are significant as hypothesized, but have different effects on maize production. Thus, elasticity of planted area (LPLANTED) and dummy variables for use of modern machine like tractor and power tiller (MACHINE), access to credit (CREDIT), use of modern seeds (SEEDS), application of irrigation (IRRIGATION), use of either chemical or organic fertilizer (FERTILIZER), use of herbicides (HERBICIDES), use of pesticides (PESTICIDES) and access to extension services (EXTENSION)have positive and significant influence on production of maize. This implies that increasing the quantity of any of these inputs will increase quantity of maize production. Actual planted area (LPLANTED) has the largest coefficient (elasticity is 0.74), meaning that farm size has the largest impact on maize production. Also, use of fertilizer (FERTILIZER) and application of pesticides (PESTICIDES) have relatively large coefficients $(\beta_j = 0.37)$. If more land is cultivated or additional quantity of fertilizer and pesticides are used on the farm, maize production will increase appreciably. The sign for the elasticity of average number of person hours (HHTOTFARMHRS) spent in farming is negative but insignificant in explaining total maize production. The negative sign means that production of maize decreases with increased more hours spent in farming. This follows theory, that there is a limit to increasing quantity of variable input relative to a fixed input in production, which if not obeyed will at a point cause output to decline. This is probably the case, when considering the size of farm holding, which is roughly 2 acres per household. The dummy variable for the use of fungicides (FUNGICIDES) has a negative coefficient, but also insignificant. The insignificance is perhaps associated to it limited use, only 1% of farmers use this type of input (see Table 1). The negative sign may mean that the input is applied in areas that are heavily affected with fungus, or at the wrong timing, hence do not yield expected results.

In the inefficiency model, the negative sign of a parameter indicates that associated variables have a positive effect on efficiency and vice versa. Average age of household (LHHAVEAGE) has a positive coefficient, implying that this variable decreases efficiency of the j^{th} farmer. On the other hand, education dummies (FOURHH, SIXHH and EIGHHH), average years of schooling of the j^{th} household heard (LEDUHEAD), average years of schooling of all members of the j^{th} household (LHHAVEDU) and health status education of the j^{th} household (HEALTH) carry negative coefficients implying positive effects on the efficiency.

The positive and significant coefficient of elasticity of average age (LHHAVEAGE) of the household follows a prior expectation, since productivity decreases with old age. Coefficients of elasticities for education (that is, years of schooling attained by a household heard-LEDUHEAD- and average years of schooling for the household members-LHHAVEDU) have negative signs as expected. This means that these variables are negatively related to inefficiency in maize production. In other words, farm efficiency increases with more years of schooling. While the coefficient of elasticity for the years of education for the household head (LEDUHEAD) has expected negative sign, it is insignificant in explaining efficiency. This is perhaps because of the high level of illiteracy among household heads. This suggests that households with an uneducated household head need not necessarily be less productive than those where the household head has been to school, if some other members of the household are more educated. (see Basu and Foster, 1998). In this case, the entire household can benefit from the cognitive skills acquired in school from those household members with relatively more years of schooling. The health variable (HEALTH) has a negative and significant coefficient, implying that health raises efficiency. On the other hand, all the dummy variables for education have hypothesized negative signs. These were meant to determine the level of farmer formal education that has more impact on farm efficiency. While coefficient of households with average years of schooling of primary four (FOURHH) seem to have a positive impact on efficiency, even higher efficiency seem to be associated with those households with average years of schooling of primary five to six (SIXHH). Our results confirm those of Lockheed et al, (1980). When reviewing previous studies on the validity of their findings regarding the impact of education on farmer productivity, they support the threshold of four years of education to only some countries but in others a threshold of 4 to 6 years of schooling became more pronounced in increasing farm productivity. On the other hand, while coefficient of households with eight average years of schooling (EIGHHH) is negative as expected, it is insignificant. This may be associated with more educated households being able to diversify and engage in other non-agriculture income generating activities in rural areas, hence spending less time in farming.

Of all the variables in the inefficiency model that bear hypothesized signs, average years of schooling for the household (LHHAVEDU) has a largest coefficient (that is, 0.20 or 20%), implying that additional year of schooling lead to 20% increase in farmer efficiency in maize production. There is another important interpretation of this variable, which has the highest magnitude of the coefficient of the inefficiency model; the greater part of the inefficiency of the farmer in the production of maize is a result of lower level of formal education, defined by number of years of schooling. Put it differently, it means that improving access to primary education for potential farmers will improve farmer efficiency greatly in the future.

7.0 CONCLUSIONS AND POLICY IMPLICATION

This paper is an empirical investigation on the impact of primary education on agriculture productivity. The research findings bring to the light the importance of primary education as an indispensable production input in agriculture and rural economic development of the nation as a whole. Particularly, the country is currently implementing the *Kilimo Kwanza* policy. Under this policy, the government is striving to transform agriculture away from small scale farming, thus releases agricultural labour to non-farm sectors is one of the outcomes of increases in agricultural productivity (due to use of modern inputs– fertilizers and improved seeds and breeds; mechanization (thus reduction in labour time), reliable water for irrigation, etc). Currently, the use of modern inputs in Tanzanian agriculture is very limited (see Table 1). Many previous studies have shown that the effects of education were much more pronounced in modernizing agricultural environments than in traditional ones (see Lockheed *et al*, 1980; Alene and Manyong, 2007).A move to a modernized agriculture may have huge impact on productivity with emphasis on formal education.

The coefficient associated with education variable for the household members in the model is positive, large and statistically significant; thus the paper poses that achieving self-sufficiency in food production and the much desired growth in the agriculture sector of the economy will continue to elude Tanzania if problems of accessing formal education among farmers are not properly addressed. Again, in connection to the *Kilimo Kwanza* policy, the government and private sector investment efforts focus on the identified drivers of growth in agriculture. The “drivers” are prioritized according to impact in raising productivity and creation of decent employment (with variations per region/district depending on existing relative advantages). From this study, it is evidence that formal education is one of the key drivers of growth and has huge impact on productivity. In this case, education capital expenditure is a justified basis of promoting development through large increase in famer productivity.

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