12

Human Capital and Agricultural Productivity*

Thomas C. Pinckney

Introduction

In Sub-Saharan Africa, agriculture constitutes about one-third of GDP and provides employment for about two-thirds of the labor force. Productivity growth in agriculture is therefore a key element in fostering widespread growth in income. Yet, for the continent as a whole, growth in this sector has been sluggish in recent years; according to the World Bank, agricultural growth for the continent from 1980 to 1991 averaged only 1.8% per year. Improving this growth rate is an item of increasing concern for both governments and international organizations.

Expanding educational opportunities likewise has been an important goal for African governments, with education seen both as an end in itself and as an investment in human capital. Success here has been greater than in agriculture. In Sub-Saharan Africa the percentage of primary-aged children enrolled in school increased from 42% to 68% between 1965 and 1990; over the same time period, enrollment rates of older children in secondary schools increased even more dramatically, from 4% to 17% (World Bank, 1993). Adult literacy rates during this time have increased from less than 25% to over 50%.

The early expansion of education was justified in part by the need to "Africanize" the civil service in these newly-independent countries. The need to replace expatriate civil servants in the decade after independence was important in driving both government policy toward investment in

---

* This chapter draws heavily on two earlier papers: Kaye G. Husbands, Thomas C. Pinckney, and Tobias O. Konyango, "Education and Agricultural Productivity in Kenya," forthcoming In *Public Expenditure and Economic Growth in Africa*, edited by Catherine Hill, Washington: World Bank Economic Development Institute; and Pinckney, "Does Education Increase Agricultural Productivity in Africa?" presented at the 1994 conference of the International Association of Agricultural Economists, and forthcoming in *Issues in Agricultural Competitiveness:Markets and Policies,* International Association of Agricultural Economists Occasional Paper No. 7, edited by Roger Rose. Brookfield, Vt: Dartmouth Publishing Co.

education and demand by the public for increased educational opportunities. The private returns to education in these early years were quite substantial as the few educated Africans took over jobs previously held by expatriates; presumably social returns were high also, once one considers the need to govern effectively as an important social goal. Little or nothing was said at the time about the impact of education on agriculture, as it was presumed -- correctly, for many years -- that the formal sector would hire virtually all educated Africans.

There is some econometric evidence that education did indeed increase labor productivity in the formal private sector. Knight and Sabot (1990) measure directly the impact of knowledge learned in school on wages in Nairobi and Dar es Salaam after controlling for reasoning ability and number of years in school. They conclude that most of the response of wages to level of education is the result of knowledge acquired rather than ability or the credential of a school certificate. If wages reflect labor productivity, their study helps to substantiate the continued high returns to public and private investment in quality education for those employed in the formal sector.

Once the civil service -- and, to a lesser extent, the formal private sector -- was Africanized, prospects for school-leavers in formal employment should have dimmed. Instead, the civil service expanded in most African countries in order to employ school-leavers, thereby meeting the expectations of the newly-educated population and their parents. This growth of public sector employment has been one important factor leading to bloated budget deficits in many African countries and the reduction of the share of investment in government expenditure (World Bank 1989). These fiscal difficulties now mean that public sector employment in future years may decrease in many of these countries, and cannot expand in the future as rapidly as in the past in any of them. As a consequence, a much larger share of school leavers will work outside the civil service; given the very small size of the formal private sector, most of the educated population will have to be employed in the informal and agricultural sectors. Thus, if education is to continue to be considered an investment, the rationale for continued educational expansion must be based on the spillover of educated individuals into these other sectors, and the resulting impact on productivity.[1] Consequently, the linkages between increased education and agricultural productivity, and the reasons behind those linkages if they exist, are vital for analyzing whether or not there continues to be a strong justification for substantial public expenditure on education.[2] A strong, positive link between education and agricultural productivity would indicate that the government can continue to meet educational goals and, at the same time, increase the likelihood of attaining agricultural goals through strong support for education.

The comparison between Kenya and Tanzania provides an especially interesting case study in this regard. Kenya expanded primary and secondary schooling dramatically following independence in 1963 and has had enrollment rates far above the regional average. Although Tanzania's expansion of primary enrollment was also large, the government did not allow the same expansion of secondary education witnessed in Kenya (Knight & Sabot 1990). The enrollment statistics show this clearly. Between 1965 and 1991 enrollment rates at the primary level increased from 54% to 95% in Kenya and from 32% to 69% in Tanzania. Over the same period, secondary school enrollment rates increased from 4% to 29% in Kenya, but only from 2% to 5% in Tanzania. With a rapidly expanding school-age population, the increase in the absolute number of students in Kenya is staggering: The number of primary school students has grown from about 890,000 in 1963 to over 5 million in 1992. Secondary school enrollment has increased from about 30,000 to over 600,000 in the same time period; university enrollment has increased from about 600 to over 50,000, with about 10,000 studying in other countries (Economic Survey, 1992).

These changes in flows have produced equally large changes in stocks of educated people. The adult literacy rate for Kenya as a whole has increased from 20 percent to 69 percent

---

[1] Throughout this chapter we use the term "productivity" to mean total factor productivity, where the factors are land, labor, and capital. If education has an impact on agricultural productivity, it will increase output while holding land, labor, and capital inputs constant. Alternately, education could be considered a proxy for a fourth factor of production, human capital, and thus the increase in output arising from having more highly-educated workers is a return to the greater use of human capital. The difference between these views is only semantic.

[2] Expenditures on education can be justified also by the impact of education on health and nutrition, although the evidence on this score presented in Chapter 5 above is unclear at best. See Behrman & Deolalikar (1988) for a survey that addresses this issue among others.

between 1965 and 1990; even in rural areas, adult literacy as of 1988 was estimated to be about 60 percent for males and 40 percent for females. In Tanzania, adult literacy increased from 10% in 1960 to 65% in 1990. In rural Kenya, the average number of years of schooling for the population aged 20 and above increased from 1.5 in 1969 to 2.6 in 1988 to 3.9 in 1988. The percentage of this population with some secondary education increased over the same time period from 3.6% to 10.5% to 17.8%. The number of rural residents with some secondary education increased more than 9-fold during that 19 year period.[3]

Many observers expect these large increases in the prevalence of literacy, numeracy, and, in Kenya, secondary education in rural areas to lead to improvements in agricultural productivity. Indeed, a World Bank perspective study on Africa states categorically that "raising educational levels enhances agricultural productivity" (1989: 64). The evidence for this statement comes primarily from Jamison & Lau (1982), who compile and analyze 37 earlier studies relating education to agricultural productivity. They conclude that, on average, four years of education increases output by 7.2%, and that this percentage is higher in rapidly changing agricultural environments. More recent studies have confirmed a positive relationship between education and productivity (Pudasaini 1983, Jamison & Moock 1984, Azhar 1991) or education and adoption of new technologies (Lin 1991).

There are at least three reasons to question the sanguine view of the World Bank report. First, of the 37 studies cited by Jamison & Lau only two are from Africa: Hopcraft (1974) and Moock (1973, 1981), both from Kenya. All of the more recent studies cited above are from Asia. Hopcraft finds negative, significant effects of education on output, while Moock finds an almost-significant, positive impact of four or more years of education, but a negative impact of less than four years. These mixed results combined with the slower pace of technological advance in Africa

---

[3] These statistics on rural schooling are calculated from the 1969 and 1979 census data and from the 1988 Rural Literacy Survey. The data for 1969 and 1979 are for the entire population less Nairobi and Mombasa, while the 1988 survey excludes all urban areas. Since these other urban areas almost certainly have higher levels of education on average than rural areas, the change from 1979 to 1988 given in the text understates the increase in rural education during the 9-year period.

compared to Asia cast considerable doubt on the relevance of Jamison & Lau's conclusion for Africa.

Second, results for Africa outside of Kenya are not available. Even for Kenya, the evidence presented in Jamison & Lau is mixed, with education in one case having a negative impact on productivity. Given these results and Kenya's unusual history with regard to cropping systems and educational history, more evidence from Kenya along with additional evidence from other African countries would be informative.

Third, all of the studies cited in Jamison and Lau use the number of years of schooling (either of the head of the household or an average for the household) as indicators of education. It is possible, however, that the positive impact of this variable on agricultural productivity results because education screens more able from less able persons (Knight & Sabot 1990); the significant coefficient, then, could be a reflection of the higher ability of more educated persons, even though those persons did not gain that ability through education. If education only serves to screen persons by ability, we would not expect an increase in agricultural productivity to result from increases in rural education.

This chapter tests for the impact of education on agricultural productivity in our study communities in Kenya and Tanzania, controlling for ability. Along the way, we estimate the relationship between other inputs and outputs of agricultural production. Tests of cognitive skills -- numeracy and literacy skills learned in school -- gauge how much of the knowledge learned in school is retained by household heads. Results for the two sites are striking. First, in both locations, basic literacy and numeracy skills increase output much *more* than estimates from elsewhere would suggest. Holding other inputs constant, output is more than 30% higher when agricultural decisionmakers can add and subtract two-digit numbers and read and comprehend simple paragraphs. These estimates are much larger than those found in Jamison & Lau and other studies. Additional cognitive skills beyond basic numeracy and literacy, however, have no significant impact on output in either site.

Other results differ between the sites. In the Kenyan site, education of another household member compensates partially for the lack of cognitive skills in the agricultural decisionmaker. In addition, reasoning ability of the agricultural decisionmaker is correlated with increased output. Finally, holding cognitive skills and reasoning ability constant, having attended primary school *decreases* output. None of these results carry over to Tanzania. On variables other than human capital, the marginal return to use of purchased variable inputs, while insignificantly different from one in Kenya, is over two in Tanzania, indicating serious underuse of purchased inputs, most likely as a result of credit constraints.

The chapter continues by providing more details of the policy differences between the two countries, and testing to see the extent to which national level changes in education show up in our study villages. This is followed by a discussion of the model, results, and conclusions.

Secondary Education and *Harambee* Schools

It is not surprising that, as in most countries, the government plays a predominant role in the education sector in Kenya and Tanzania. The usual economic analysis is simple: There are significant externalities to education; that is, there are some benefits of education that accrue to society as a whole rather than to the educated individual. Therefore, in the absence of government subsidy the public would spend less on education than the social optimum. Although public funding for education is thus necessary from an efficiency standpoint, it is also desirable for achieving social equity: Economic status is minimized in determining access to education. As a result, public funding for education in theory can assist the most capable citizens to acquire the skills that are required for economic and social progress.

In Kenya, however, there have been very substantial private investments in education which have not been limited to the better-off members of society. These investments include paying supplementary fees for primary education at government schools -- estimated to be about one-quarter of the total costs -- including required contributions for uniforms, shoes, books, supplies, and construction of buildings,. More dramatically, Wolff (1984) estimates that on average about three-fourths of the cost of secondary education is borne by private agents in Kenya. Indeed, over half of Kenya's secondary school students during the 1980's were educated in schools not run by the government. These schools include private secular schools, private church schools, unaided *harambee* schools, and aided *harambee* schools, but the vast majority are one of the two types of *harambee* schools.[4]

The *harambee* movement in Kenya was an attempt to improve rural infrastructure through investment by local communities. Once communities made initial investments in a certain type of project, the government would sometimes assist in developing or maintaining the project. These investments were wide-ranging, including water projects, roads, cattle dips, clinics, and schools. During the 1970's, approximately 30% of capital formation in rural areas was financed by *harambee* contributions (Thomas 1987). Schools proved to be one of the most popular *harambee* projects, constituting more than half of all such projects; contributions to education projects constituted over 60% of the total after the government decided to slow down the growth of government-maintained secondary schools in the early 1970's (Thomas 1981). Tanzania, on the other hand, actively discouraged communities from investing in such schools, with the government arguing that richer communities would simply gain access to more government and educational resources, exacerbating the existing inequities among regions.

The rapid expansion in secondary education in Kenya outlined above occurred primarily because of *harambee* schools. Between 1964 and 1979 enrollment in government-maintained secondary schools increased by about 120,000 -- an increase of over 500% -- but enrollment in private, church, and *harambee* secondary schools increased by 215,000, an increase of over 2,500% (Mwiria 1985). This expansion occurred despite the widespread belief that the quality of instruction in *harambee* schools was inferior to that in government schools. Parents wanted their children in school; if there were no spots in the preferred government schools, the children were sent to any affordable institution that would accept them. Government reaction to this huge private response was mixed. There was considerable concern in government circles that parents were *overinvesting* in education, that the quality of education in these schools was poor, and that the government was losing control of investment in education in the country (Mwiria 1985).

---

[4] *Harambee* is a Kiswahili word for "let's all pull together;" this was the motto of the Kenyatta administration (1963-1978).

The Kenyan case, therefore, provides evidence that private agents will invest substantially in education under circumstances in which they perceive private returns to be large. Furthermore, Knight and Sabot (1990), after studying the urban labor markets in the two countries, argue that the expansion of secondary school opportunities afforded by the *harambee* movement provided *greater* equity in the end than Tanzania's secondary school structure, under which communities were not allowed to build their own schools and expansion of secondary school places was much slower.

Thus the large expansion in secondary schooling in Kenya has increased educational levels in rural areas, with secondary schooling much more prevalent in Kenya than in Tanzania. But do these national level statistics show up in our study communities? We turn to this issue next.

National Trends at the Local Level

The rural communities sampled in this study have experienced the same rapid growth in the stock of educated persons as the entire countries, although the Tanzanian village was considerably more highly-educated than the nation as a whole at the time of independence. The Kenyan households are presently spending over 40% of non-food expenditure on education. Tables 12.1 and 12.2 present cross-tabulations of years of schooling by age for those 20 or older for the Kenyan and Tanzanian communities, respectively. Part (a) includes all family members in our sample who were residing at home during at least one of our survey rounds, while part (b) includes all of these plus children and spouses of the household head who reside elsewhere.

Examine the Kenyan data first. The change in educational level between age cohorts is striking. Of the village residents in Kenya over 70 years of age 85 percent had no schooling at all, and none had more than 4 years; all of the 20-29 year age group had at least some schooling. Average years of education have increased dramatically, from 0.5 for the oldest age group to 8.8 for the 20-29 age group. The extent to which the increase in education was a post-independence phenomenon also comes out in our village. The 40-49 year age group ranged in age from 12 to 21 at independence. Thus, most of their schooling was completed prior to or shortly after

Table 12.1: Years of Education by Age Group, Kenya

Age	0	1 to 3	4 to 7	Partial Secondary	Completed Secondary	Post Secondary	Total # of People	Average Schooling
Part a: Residents in 1991/92								
20 to 29	0%	3%	37%	29%	27%	4%	118	8.9
30 to 39	14%	9%	50%	5%	23%	0%	44	6.7
40 to 49	34%	17%	40%	7%	2%	0%	58	3.4
50 to 59	41%	21%	26%	10%	3%	0%	39	3.1
60 to 69	30%	40%	23%	5%	3%	0%	40	2.7
70 or more	84%	11%	5%	0%	0%	0%	19	1.3
Total #	70	43	109	46	45	5	318	5.7
Overall %	22%	14%	34%	14%	14%	2%	100%	
Part b: Residents Plus Migrant Children and Spouses								
20 to 29	0%	2%	41%	26%	27%	5%	239	8.8
30 to 39	6%	6%	48%	14%	22%	4%	125	7.8
40 to 49	26%	13%	43%	13%	4%	1%	98	4.7
50 to 59	38%	21%	29%	8%	4%	0%	48	3.2
60 to 69	31%	38%	24%	5%	2%	0%	42	2.7
70 or more	85%	10%	5%	0%	0%	0%	20	0.5
Total #	82	53	224	98	98	17	572	6.7
Overall %	14%	9%	39%	17%	17%	3%	100%	

Table 12.2: Years of Education by Age Group, Tanzania

Age	0	1 to 3	4 to 7	Partial Secondary	Completed Secondary	Post Secondary	Total # of People	Average Schooling
Part a: Residents in 1991/92								
20 to 29	5%	6%	67%	5%	15%	4%	108	7.4
30 to 39	4%	7%	65%	4%	11%	9%	46	7.5
40 to 49	5%	14%	76%	5%	0%	0%	37	5.3
50 to 59	8%	23%	66%	0%	2%	2%	61	4.4
60 to 69	21%	26%	49%	4%	0%	0%	47	3.6
70 or more	60%	15%	25%	0%	0%	0%	40	2.3
Total #	48	46	203	11	22	9	339	5.5
Overall %	14%	14%	60%	3%	6%	3%	100%	
Part b: Residents Plus Migrant Children and Spouses								
20 to 29	2%	3%	58%	4%	28%	6%	254	8.6
30 to 39	2%	1%	66%	2%	17%	12%	208	8.5
40 to 49	2%	6%	68%	3%	15%	5%	93	7.2
50 to 59	7%	19%	69%	0%	4%	1%	75	4.8
60 to 69	20%	22%	53%	4%	2%	0%	55	3.9
70 or more	59%	15%	27%	0%	0%	0%	41	1.9
Total #	51	49	441	19	126	45	726	7.3
Overall %	7%	7%	61%	3%	17%	6%	100%	

independence. This age group averages only 3.4 years of schooling for residents and 4.7 for all relatives. But the 30-39 age group, aged 2 to 11 at independence, benefited from the rapid expansion in education in the sixties and seventies, raising the average years of education to 6.7 for residents and 7.8 for all -- approximately completion of primary school. In each of the 40-49, 50-59, and 60-69 age groups, only one resident in the sample had completed secondary school.

In the 30-39 age group 10 persons -- 23% of the residents -- completed secondary school. This percentage increases to 32 percent for the 20-29 year age group; 60 percent of that group had at least some secondary schooling. Of those residents who have completed secondary school in our sample, 94% are under 40, and 74% are under 30.

While the overall trends are the same in the Tanzanian village, the changes are less dramatic. The Kilimanjaro region as a whole was relatively highly-educated during the colonial era; this fact emerges clearly in a comparison of these villages. About 40% of those over 70 and 80% of those in their sixties had some schooling; the average number of years of education is about one year greater in the Tanzanian community for these age groups. The difference is even more for those in their forties and fifties at the time of the survey, who were educated primarily in the 1940's and 1950's. Average education for residents plus migrant children and spouses is 2.5 years higher in the Tanzanian community compared to the Kenyan community for household members aged 40-49. The difference declines dramatically for members in their 30's, and disappears (for residents plus non-residents) for members in their 20's. As noted in Chapter 7, migration of educated persons in their 20's is even more prevalent in the Tanzanian village than in the Kenyan village, leading to the differences between panels (a) and (b).

Differences in secondary education are particularly striking for residents; sixty percent of the Kenyan residents aged 20-29 had at least some secondary education; this is true of only 24% of the Tanzanians. Here the national policies have made a difference.

These large increases in average education have a delayed impact in both communities on education of agricultural decision-makers given the respect for elders in the local culture. The agricultural decision-maker is under 30 in only 6% of our households, and under 40 in only 25%. The median age of these decision-makers is 50. Consequently, the agricultural decision-maker has completed secondary school in only a small number of households in either community.

This lack of education is painfully obvious when examining literacy and numeracy. Forty-five percent of the agricultural decision-makers were functionally illiterate; either they could not read at all or could mouth words from a paragraph with virtually no comprehension. Over 60 percent could not calculate simple two-digit sums. Thus the rapid increases in schooling have not yet had much impact on the cognitive skills of most agricultural decision-makers. In many households with an uneducated head, however, there is another, usually younger, member of the family who is literate and numerate. Conceivably in such cases, the agricultural decisionmaker depends on this other family member to assist when literacy and numeracy are important. If education of family members is important, then increases in education will have a more immediate impact on agricultural productivity, since it will be many years before the younger, more educated cohort takes over most farms.

Education and Agriculture

If education is to make a difference in agricultural productivity, it could operate either by imparting agriculture-specific knowledge, or by improving general cognitive skills. The first of these methods -- including agricultural subjects in the primary and secondary school curricula -- has been a matter of debate in Kenya. Agriculture was an optional subject for many years, but few students chose to take it. One of the changes implemented when the number of years of primary education increased to eight in the mid-1980's (the "8-4-4" reform) was to increase the presence of agriculture in the curriculum. The majority of primary school students now study agriculture. It is too soon to measure the impact of this reform, although we are somewhat skeptical. Agriculture is one of many subjects taught in primary school; it is taught by persons whose primary occupation is not farming. In such circumstances, Foster's (1966) critique of vocational training seems particularly germane:

> If at present the schools perform . . . basic functions ineffectively, it is patently absurd to expect them to incorporate a range of auxiliary vocational activities -- quite apart from the relative absence of staff either competent or willing to undertake such activities. Given more limited objectives the schools can make a significant contribution to development of technical competence by turning out pupils able to absorb and utilize effectively specific forms of vocational training.

. There are indeed strong reasons to believe that general education itself will lead to this further absorption of knowledge, thereby increasing productivity for those students who remain in agriculture. As mentioned above, there have been numerous attempts to link education to agricultural productivity, most notably Jamison & Lau (1982), with education usually measured simply as years of schooling. None of these studies, however, effectively distinguish the value-added of education alone from the value-added of the higher reasoning skills that allow a person to excel in school and to advance in the educational system. They thus could confuse the increased productivity from higher innate reasoning skill with productivity from schooling itself.

Thus, Kenya and Tanzania have managed to increase the stock and proportion of educated persons in the rural areas dramatically since independence. Evidence from elsewhere suggests that this should have a positive impact on agricultural productivity, although earlier evidence from Kenya is mixed. In the next section we estimate this impact for our two study villages, and discuss further how education affects productivity.

Modeling the Impact of Education on Agriculture

Education can affect agricultural productivity in several different ways. To help clarify the way that this might work, we distinguish among schooling, cognitive skills, and reasoning ability (following Knight and Sabot 1990). "Schooling" is used for the number of years completed in a classroom. We use the term "cognitive skills" to mean the knowledge of subjects taught in schools: reading comprehension, grammar, arithmetic, algebra, and the other topics generally a part of the school curriculum. "Reasoning ability" is a person's aptitude for drawing conclusions from propositions. This ability may or may not be innate, but is assumed here not to be changed by the number of years spent in school.[5] An individual's reasoning ability, however, should have an impact on the amount of cognitive skills that a person acquires while in school.

Schooling by itself -- that is, schooling that has no impact on cognitive skills -- will not have any impact on agricultural productivity.[6] But schooling could have an impact on productivity via increases in cognitive skills, while improvements in cognitive skills could affect agricultural

---

[5] This is in accord with Knight and Sabot (1990). See Raven et al (1991) for a discussion of this issue.

[6] In the wage labor market, there is considerable evidence from both less developed countries and industrialized countries that simply getting a degree has a positive impact on wages, holding cognitive skills constant. This is the credentialist explanation for the impact of education on wages. See Knight and Sabot (1990). Crops and farm animals, however, are unlikely to grow more rapidly simply because the farmer has a diploma.

productivity in several ways. First, there may be subjects in the curriculum that directly increase a person's knowledge of agricultural practices. As mentioned above, Kenya's move to the 8-4-4 system was justified partly in this way. Second, general knowledge of language, mathematics, and science could lead to a greater ability and willingness to read about and adopt improved methods of cultivation. Third, this same general knowledge may lead to better record-keeping and thus improvements in the management of scarce inputs to produce outputs, increasing allocative efficiency.

It should be possible to measure the impact of educational expansion on productivity through a two-step procedure: first, estimating the impact of increased education on cognitive skills; second, estimating the impact of that increase in cognitive skills on agricultural productivity. Difficulties arise, however, at each stage.

The impact of educational expansion on agriculture-specific cognitive skills is difficult to distinguish from learning of these same skills from parents, other farmers, or experience. In particular, the increased time allotted to the teaching of agricultural subjects in primary and secondary schools under 8-4-4 is so recent that only a few of today's farmers have been taught. Consequently, we will have little to say from our empirical evidence about agriculture in the formal curriculum. Adult education through extension staff can also have an impact on agriculture-specific cognitive skills; we will test below the extent to which farmers' knowledge of the recommended levels of application of fertilizer and sprays for major crops improves productivity.

Cognitive skills not specific to agriculture are more easily related to schooling since there are fewer alternative avenues of learning. These skills, however, are unlikely to be correlated precisely with years of schooling, since both ability to learn, motivation to learn, and school quality can vary. Government expenditure could have an impact on either the number of students in school, the quality of the existing schools, or both. We assume, then, that cognitive skills are a function of the quality of schools, the individual's reasoning ability, and years of schooling.

It is reasonable to assume that agricultural productivity is influenced separately by cognitive skills and reasoning ability. Reasoning ability could clearly have an independent impact on productivity; it is possible that earlier studies such as Jamison and Lau (1982) linking education to increased productivity were reflecting primarily returns to reasoning ability rather than education itself.[7] There are at least three reasons why cognitive skills and reasoning ability should be positively correlated. First, as mentioned above reasoning ability influences how much a person learns in school; if two persons attend the same school for the same number of years, on average the person with better reasoning ability will learn more. Second, when education has both financial and opportunity costs, individuals will continue to invest in education only if the perceived benefits outweigh the costs. Persons with lower levels of reasoning ability will do less well in school, and thus are likely to stop attending school sooner than persons with higher levels of reasoning ability; the marginal benefit of an additional year of schooling will be less for such persons.[8] Finally, school systems such as those in Kenya and Tanzania that limit secondary schooling to those who perform well on a primary level examination will tend to stop persons of lower reasoning skills from continuing.

A Human Capital Model of Agricultural Productivity

Total value of output for both agricultural and livestock activities is assumed to be a function of labor inputs, land, other fixed inputs, purchased variable inputs, and human capital. Total value of output is used rather than output of individual crops or products for two reasons: First, agricultural and livestock activities in these areas are highly integrated, usually in unmeasurable ways. Manure from livestock is placed on the permanent and field crops. Crop residues such as banana and maize stalks are fed to livestock. Nappier grass is grown specifically for livestock feed, but measuring amounts harvested and fed is highly problematical. Intercropping is prevalent; maize and beans in both sites, coffee and bananas in Tanzania, coffee

---

[7] Jamison and Moock (1984) use the same test we use below to attempt to control for reasoning ability, and do not get a significant coefficient. They, however, assume the variable has a linear impact on production, which we do not.

[8] It is likely that the opportunity cost of being in school is lower for persons of lower reasoning ability also, dampening this impact. Presumably, however, reasoning ability is more closely tied to output in school than in alternative occupations and thus the incentive to stay in school is still higher for persons of higher reasoning ability.

and beans in Kenya. In such an agricultural economy, attempting to separate out one crop or product is likely to lead to major measurement errors.

Secondly, one way that education should affect productivity is through the educated operator choosing a more appropriate crop mix. This cannot be estimated with single crop production functions (Welch 1970).

Of the total value of agricultural production in the Kenyan sample, 41% consists of livestock products, primarily milk. The corresponding percentage for the Tanzanian sample is only 12%. Coffee production constitutes 25% of the total value for Kenya, while only 15% for Tanzania. Bananas for both cooking and brewing alcohol make up 27% of the value of Tanzanian production. Overall, 47% of the value of production in the Kenyan sample is consumed on-farm, while 69% is consumed on-farm in the Tanzanian sample.[9]

The labor variable includes all reported labor on the farm, whether adult, child, hired, or donated. Land includes all land operated by the household. The primary fixed input is dairy cattle, particularly in Kenya. Purchased variable inputs include fertilizers and sprays for coffee.

Several variables make up the human capital component. The Raven's Coloured Progressive Matrices test is used to measure the agricultural decisionmaker's reasoning power. This simple 36-question test can be administered in approximately 15 minutes, and does not require literacy in the respondent. Average score on this test for the Kenyan agricultural decision-makers is 18.0 correct answers, with a range from 5 to 34 and a standard deviation of 6.9. In Tanzania, the average score is 16.3, with a range from 5 to 33 and a standard deviation of 5.6.

Literacy and numeracy tests developed by Knight and Sabot (1990) and modified slightly for our project were used to measure cognitive skills. Respondents had the choice of taking these tests in Kikuyu, Kiswahili, or English.[10] Questions range from quite simple to fairly complex, with

---

[9] Note that the percentages given for livestock products and bananas include the value of both sales and on-farm consumption.

[10] Translating the tests into Kichagga, the vernacular in the Tanzanian study site, was unnecessary since all respondents were comfortable using Kiswahili. Indeed, Wachagga enumerators usually conducted the interviews in Kiswahili. Kiswahili is the medium of instruction for all schooling in the Tanzanian village.

four multiple choice answers; these are similar to questions found on the secondary and primary school national exams. We add the scores on the two tests for our measure of cognitive skills. Out of a maximum of 62 correct answers, the total scores on these tests in Kenya range from 16 -- random guessing, the number assigned if the person could not read well enough even to begin the test -- to 49, with a mean and standard deviation of 24 and 9.7, respectively. In Tanzania, the range is from 16 to 54, while the mean and standard deviation are 23.1 and 8.9.

Because of time constraints, we did not administer any of these tests to members of the household other than the agricultural decisionmaker. In retrospect, this was a mistake. In order to test for the importance of education of family members, we include a dummy variable equal to 1 when the decisionmaker is functionally illiterate but someone else in the household has completed seven or more years of schooling.

Experience is approximated by the number of years since the agricultural decisionmaker set up a separate household. Years of schooling is also included to test for some aspect of school other than acquiring numeracy and literacy skills -- such as an increased willingness to seek out knowledge and try new methods -- having an impact on agricultural productivity.

As with most of the previous studies of education and agricultural productivity, this study uses a modified Cobb-Douglas production function.[11] The human capital variables enter in levels rather than logarithms, implying that a unit change in these variables produces a constant percentage change in the value of agricultural production. The impact of experience is hypothesized to decrease with increasing experience, and thus the usual squared term is included. Appropriate functional forms for the CPM and cognitive skills variables are unknown; there is no reason to believe, for example, that correctly recalling and using the Pythagorean theorem will have the same impact on output as correctly adding and subtracting two-digit numbers. Consequently, dummy variables for four different ranges of scores on each test were included in an exploratory regression. For both the CPM and the cognitive skills variables, estimates for test scores above a particular level of achievement had no significant impact on output. This

---

[11] Translog production functions produce the same pattern of results for the human capital variables; the hypothesis that the true functional form is Cobb-Douglas cannot be rejected.

"threshold effect" has been noted with human capital variables in several of the earlier studies of education and agricultural productivity (Jamison & Moock 1984, Moock 1981, Azhar 1991). Thus, for the regression reported here, dummy variables only are included for the CPM and cognitive skills variables. For the CPM, the dummy equals 1 for a score of 13 or above (achieved by 75% of the Tanzanian sample and 76% of the Kenyan sample). For the cognitive skills tests, the dummy equals 1 for a score of 22 or more (achieved by 50% of the Kenyan sample and 43% of the Tanzanian sample). A respondent who could add and subtract two-digit numbers, answer simple questions about the content of a paragraph, and randomly guess at the remaining questions would have an expected score on the test of about 22.

Similarly, the years of schooling variables are entered as dummies since there is no reason to believe that the relationship between years of schooling and productivity will be linear. For the agricultural decisionmaker, dummies for attending two or more years of primary school and at least one year of secondary school are included.

A dummy variable is also included to proxy for the impact of the presence of other educated persons in the household. In some households, the agricultural decisionmaker may not be educated, but may depend on another educated person in the household to read recommendations and make calculations, while he or she retains overall decisionmaking authority. If this is so, education of those other than the decisionmaker will have the largest effect when the decisionmaker is uneducated. This variable is therefore set equal to 1 when someone in the household has completed primary school, but the decisionmaker scores less than the threshold of 22 on the cognitive skills test.

Several of the earlier studies of education and productivity include an agricultural extension variable. In most cases the specification is simply the number of recent contacts with extension agents. We administered a short test of knowledge of extension recommendations, as did Jamison and Moock (1984). The coefficient of this variable is neither large nor significant under any circumstances and was left out of the equations reported below. Jamison and Moock also find no significance for this variable, but in the same equation have a significant positive impact of extension contacts. If extension contacts do not increase agricultural knowledge, it seems more likely that their significant result is related to unobserved characteristics of the farmers who seek out or receive more extension visits, rather than the impact of the contact itself. We attempt to sort out some of these unobserved characteristics below.

Empirical Results

Table 12.3 presents results from both Kenya and Tanzania. The usual factor variables all have the correct sign, although the estimates of the coefficient of land are surprisingly small and not significantly different from zero. Coefficients of labor are strongly significant and of reasonable size. The coefficient of assets is much larger in Kenya -- 0.19 versus 0.07 -- reflecting the greater importance of livestock assets in total production in that location. Variable inputs are significant and of reasonable size in both equations; the Cobb-Douglas form, however, hides an important distinction between them. Translating into levels, at the mean a Ksh 100 increase in inputs is estimated to increase output by about 98 shillings in Kenya, implying that purchased inputs are used until their marginal product approximately equals their cost. In Tanzania, on the other hand, a 100 shilling increase in inputs is estimated to increase output by 280 shillings, implying gross underutilization of such inputs. This difference may result from fact that the Kenya coffee cooperative advances funds to members for the purchase of any agricultural inputs, while the Tanzanian society only provides coffee inputs, and total credit flowing through the Kenyan society is considerably greater (see Chapter 8 above).

The human capital variables produce striking results. Of most importance, the coefficient of the cognitive skills dummy is quite large and highly significant in both equations. Agricultural decisionmakers with scores on the cognitive skills tests of 22 or higher produce over 30% more output than those with lower scores, holding other variables constant. These estimates are much higher than the Jamison & Lau (1982) meta-estimate of four years of schooling increasing output

Table 12.3: Production Function Estimates

	KENYA		TANZANIA	
Variables	Coefficient	t-statistic	Coefficient	t-statistic
Constant	4.61		8.51	

Logarithm of Labor Used	0.305	4.48	0.231	1.94
Logarithm of Land Operated	0.00837	0.15	0.0917	1.50
Logarithm of Agricultural Assets	0.191	3.58	0.0723	1.39
Logarithm of Purchased Inputs	0.160	3.03	0.107	3.28
Human Capital Variables:				
Experience	0.0159	1.51	0.0058	0.54
Experience Squared	-0.000126	-0.80	-0.0000378	-0.25
Raven CPM Score >=13	0.227	2.28	-0.0488	-0.50
Cognitive Skills Test Score >=22	0.352	2.90	0.294	2.36
Primary Education	-0.178	-1.78	-0.00586	-0.05
Secondary Education	-0.0487	-0.41	0.0814	0.50
Educated Person in HH	0.273	2.49	0.0369	0.32
R-Squared	0.757		0.500	
Adjusted R-Squared	0.727		0.434	
Observations	103		95	
Breusch-Pagan Chi-Squared (11)	9.28		3.78	

Notes: The dependent variable is the logarithm of the gross value of production. Primary Education is a dummy variable equaling 1 when the agricultural decisionmaker attended two or more years of primary school. "Secondary Education" is a dummy variable equaling 1 when the agricultural decisionmaker attended at least one year of secondary school. "Educated Person in HH" is a dummy variable equaling 1 when the agricultural decisionmaker scored less than 22 on the cognitive skills test and at least one other member of the household had completed primary school. The Raven CPM test is a measure of reasoning ability. The cognitive skills tests measures numeracy and literacy.

by 7.2%. Since these tests measure skills learned almost exclusively in formal educational settings, the results provide strong support to the hypothesis that at least in some parts of Africa, educational achievement enhances agricultural productivity.

If this study was only concerned with the Tanzanian sample, the human capital story would have stopped there. All other human capital variables give no evidence of affecting agricultural output. The coefficient of the secondary school dummy is reasonably large in size -- secondary schooling is estimated to raise output by over 8% -- but the estimated standard error is double the point estimate of the coefficient. Most notably, the Raven CPM test has no impact on output, ndicating that for this sample the returns to schooling are related to what was learned in school and not to reasoning ability. In addition, having an educated person in the household when the decisionmaker is uneducated does not raise agricultural productivity.

In the Kenyan sample, however, all human capital variables other than the secondary school dummy are important in size and significantly different from zero.[12] Decisionmakers who score 13 or higher on the Raven CPM test produce 25% more output than those who do not, holding schooling and cognitive skills constant. Having an educated person in the household, whether or not that person is the agricultural decisionmaker, appears to raise output by close to 30%. Most surprisingly, having a decisionmaker who attended primary school *lowers* output by about 19%, holding cognitive skills, reasoning ability, and the presence of other educated persons constant.

Our expectation had been that the education dummies were proxying for *positive* impacts of education on productivity other than those that arise through the literacy and numeracy learned in school. We had thought that this might include a willingness to try new methods, or a greater likelihood of accepting the advice of an extension agent. These effects, however, if they are important at all, are overwhelmed by some other effects. Recall that our evidence suggests that cognitive skills over and above basic numeracy and literacy have no additional impact on productivity. Furthermore, the CPM test controls for one type of reasoning ability, but certainly does not control for all personal characteristics that have an impact on either success in school or agricultural productivity. Because we control for literacy and numeracy in the regression, the primary school dummy is picking up the impact of having attended school and *not* becoming reasonably literate and numerate. It seems most likely, then, that this negative dummy is a proxy for personal characteristics unrelated to reasoning ability that lead to both a lack of learning in school and failure to be on the production frontier as a farmer. Having a poor work ethic may be one such characteristic.[13]

---

[12] The experience variables are not significant individually, but are significant at the 90% level jointly.

[13] It is conceivable that attending school itself leads to negative attitudes towards agriculture, an idea much discussed in Kenya in the early 1980's. For example, the 1984-1988 Development Plan emphasizes the need to change attitudes of parents and students, who view "formal education as a route to modern sector employment" when most school-leavers will have to work in "small-scale agriculture and rural non-farm activities" (Kenya 1983 149). This discussion in part led to the 8-4-4 reform of the Kenyan school system, which had as a goal a shift in the content of the curriculum to make it more appropriate for those who, in the future, would live in rural areas. Possibly, the attitude that all educated persons should work in formal employment has led to lower productivity by those school-leaverrs who, despite their wishes, become

One possible explanation for the positive impact of education on productivity is that more literate persons are better able to read literature provided by extension services, and more likely to know recommendations of the extension service. If this were the case, some of what appears to be returns to education would more rightly be labeled a return to government investment in extension. We test for this in regressions not reported here. We asked all of our agricultural decisionmakers four questions related to Ministry of Agriculture recommendations for fertilizer use on maize and coffee, spraying of coffee, and spacing of maize. The District Agricultural Officer told us he believed that all farmers in the District would know these recommendations (DAO Murang'a 1992). Only 14% of our agricultural decisionmakers in fact could state correct values for all four recommendations.

When testing this variable, we added a dummy variable equal to one if the decisionmaker knew three or four of the recommendations. The coefficient, while not trivial in size at about 6% of the value of agricultural output, is nowhere near statistical significance, and its introduction has only a small effect on estimated coefficients for the other human capital variables. Knowing these extension recommendations is not the story behind the large estimated impact of education on productivity.[14]

---

farmers. In order to be significant given the age distribution of the agricultural decisionmakers, however, this impact would have to continue to exist decades after leaving school. This persistence seems much less likely than the persistence of the unobserved personal characteristics hypothesized in the text.

[14] These results are robust across different specifications of the extension variable. The results look more favorable -- although still insignificant -- for extension if the dummy is specified as 1 when the farmer knew one or more of the recommendations; however, since there were only five farmers who knew none of the recommendations, this specification is not very informative.

Estimation of Cognitive Skills Production Function

The regressions in Table 12.4 examine a production function for cognitive skills, asking the question, how much do cognitive skills increase with additional years of schooling? The first regression relates cognitive skills to reasoning power and years of schooling in the two countries. Both variables are highly significant and quite large in size. A year of schooling increases cognitive skills on average by 1.5 points in Kenya and 0.8 points in Tanzania. The difference between those means is statistically significant, indicating that schooling has been more efficient at producing cognitive skills in Kenya. The results for Kenya are also exceptionally close to those reported by Knight and Sabot for urban Kenya.[15]

Since our production function, however, indicated that increases in cognitive skills above a minimum value had little impact on productivity, the second regression for each country estimates a logit model in which the dependent variable is a dummy equal to 1 if the cognitive skills are above this minimum level. Once again, the fit is good and the results are statistically significant.

We can use these logit results to simulate the impact of schooling on the probability of having cognitive skills at or above the minimum of 22. With a reasoning test score of 18 -- the mean for our sample -- the probability that a primary-school completer would have cognitive skills of 22 or more is 85% in Kenya and 73% in Tanzania. After four more years of schooling and completion of secondary school, this probability increases to 98% and 90% in Kenya and Tanzania, respectively. Another student with very low reasoning power --a reasoning test score of 10 -- would have a 70% chance of having cognitive skills above the minimum after primary school, and 95% after secondary school in Kenya. A Tanzanian student with the same reasoning test score would have probabilities of only 29% and 57%. A student with high levels of reasoning power as measured by a reasoning test score of 25 would have a 92% chance of having cognitive skills above 21 with only a primary education, and a probability over 99% after secondary

---

[15] The Knight and Sabot (1990) coefficient of reasoning power is 0.56, while the coefficient of a dummy variable for having completed secondary school -- 11 years of schooling at the time of their survey -- is 11.75. They did not record the average number of years of schooling for those who had not completed secondary school, but their coefficient would be comparable to ours if that average were three to four years.

Table 12.4: Cognitive Skills Production Function

Dependent Variable: Score on Literacy and Numeracy Test

	Kenya				Tanzania			
	Linear Regression		Logit Regression		Linear Regression		Logit Regression	
Variable	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
Constant	9.16		-4.07		8.51		-5.22	
Years of School	1.51	7.69	0.550	4.86	0.928	3.83	0.285	3.14
Score on Reasoning Test	0.497	4.69	0.107	2.31	0.656	4.83	0.235	3.92
R-Squared	0.62				0.36			
Adjusted R-Squared	0.61				0.34			
Observations	103		103		112		112	
Mean of Dependent Variable	24.6				23.1			
Breusch-Pagan Statistic	11.8				4.5			
% Correct Predictions			82%				76%	
Log of Likelihood			-41.4				-55.1	

Note: t-statistics reported for the linear regression for Kenya use a White correction for standard errors because of the significant Breusch-Pagan test.

education. The results from Tanzania for this high level of reasoning ability are virtually identical to Kenya.

These numbers call into question the efficacy of secondary school education for agricultural managers in Kenya. If our earlier agricultural production functions are accurate, increases in cognitive skills past rather low levels have little or no impact on increasing productivity. If the vast majority of agricultural decision-makers can reach that minimum level of cognitive skills with only primary schooling, the justification for expansion of secondary schooling will have to come from quarters other than agriculture.

In Tanzania, the story is somewhat different. Because each year of schooling is less efficient at producing cognitive skills, primary school leavers who have average or below average reasoning ability have considerably lower probability of attaining the minimum cognitive skills necessary for efficient agricultural production than their Kenyan counterparts. Given the very basic nature of these skills, however, sending students to a secondary school in order to achieve them seems improper. Improving the quality of the primary schools would appear to be a higher priority for increasing returns to education in agriculture.

.

Conclusions

Kenyan policy towards the expansion of education was driven originally by the desire of the public sector to Africanize the civil service. This led to large private -- and, presumably, social -- gains for those educated before or immediately after independence. The population, seeing those large private gains, demanded more education leading to large public and private investments in further educational expansion. After the original justification for educational expansion was met, more and more educated persons remained in rural areas. Theoretical reasoning and evidence from other countries suggest that this increase in rural education should improve agricultural productivity. The results reported here give strong, additional support to that conclusion, as knowledge learned in school has a marked impact on productivity. Just as important, in those households with an illiterate decisionmaker, the presence of an educated person in the household increases productivity almost as much as the education of the decisionmaker. Therefore, we do expect the future large increases in the number of educated persons in rural areas to be of benefit to agriculture.

These returns from agriculture alone are much higher than the costs of education. It is possible to make a rough approximation of the internal rate of return that accrues to society from educating a child. Assume that a child attends primary school for seven years, then stays as a laborer on a parent's farm for, say, 14 years. Assume furthermore that this educated child has no impact on farm productivity during that period, but then after the 14 year period becomes an agricultural decisionmaker and continues to be one for 30 years. The internal rate of return to the investment in schooling using the coefficient of cognitive skills in the first regression for Kenya for the impact on productivity -- adjusted for the probability of attaining that level of cognitive skills by attending school -- yields a result between 8% and 12%.[16] This return is huge, given that the assumption of no positive returns to education until the person becomes head of a household is

---

[16] Wolff (1984) reports that the total cost of educating one Kenyan in primary school for one year in 1980 was Ksh 400, or US$53. In order to use these numbers in the above calculations, they were inflated using CPI's for the two currencies. The benefits are based on the coefficient of cognitive skills in Regression 1, multiplied by 0.85, the probability that a person of average reasoning skill will attain cognitive skills of at least 22 by the end of 7 years of schooling. The calculation in US dollars results in an IRR of about 8%, while the calculation in Ksh results in an IRR of about 12%.

extreme. Primary education can indeed be justified on the basis of its contribution to agricultural productivity alone. These countries' large investments in education do not require job availability in the formal sector for their justification.

These results need to be tempered in four ways. First, our empirical measurements were estimated for only one agro-ecological zone. It is plausible that returns to education in an annual cropping area unsuited to dairy production would be smaller than at our site. Further research in such areas should be a priority.

Second, the negative coefficient on attending school, holding cognitive skills constant, casts some doubt on the efficacy of schooling. This negative coefficient could be interpreted as the impact of negative attitudes toward agriculture learned in school. If this is the case, school has both positive and negative impacts on agriculture; the net impact is estimated to be positive, but the negative effect is disturbing. We doubt, however, that this negative coefficient is the result of lingering negative attitudes toward agriculture learned in school decades previously, and are persuaded that it is more likely that this coefficient proxies for unmeasured personal characteristics that lead to lack of success in both school and agriculture. If this is the case, the negative coefficient is not a result of school, and thus should not be subtracted from the coefficient of cognitive skills to calculate the net impact of education on productivity.

Third, the level of cognitive skills necessary to achieve productivity gains in agriculture is low, attainable with only a few years of formal education. There is no evidence that secondary schooling or even upper primary school leads to improvements in productivity. Basic literacy and numeracy is all that is required, despite the rather complicated agricultural economy of this coffee/dairy environment. Thus, in order to reap the agricultural productivity gains from education of farmers, the government needs to continue to support primary school. Expansion of secondary schools, however, cannot be justified on the basis of its direct impact on the productivity of farmers.

Fourth, the gains to agricultural productivity measured here accrue to the household of the educated individual. They are thus private gains rather than public goods. If families have perfect foresight, they should be willing to make these investments in education, and the evidence cited above shows that Kenyan households have indeed been willing to invest large amounts in education. However, in the Kenyan site, households with a child of school age are already spending more than 40% of non-food expenditure on education. In the absence of well-functioning capital markets, it is unlikely that these families would be able to continue to purchase as much education as at present in the absence of government subsidies, even if they wish to. Thus, we believe that a continued subsidy to primary education is justified; the experience of the harambee school movement combined with empirical results of this paper, however, cast some doubt on the efficacy of subsidies to secondary school.

Finally, if the similarity in the magnitudes of the cognitive skills coefficients in the two equations is encouraging, the large differences between coefficients of other human capital variables is somewhat disturbing, particularly given the similarities between the two production systems. Moreover, these results are not fragile; other functional forms and specifications change the magnitudes, but yield the same set of significant coefficients for the two locations.

Presumably the difference relates to different production systems. The relative importance of dairy production is the most striking difference between the two communities. A much higher percentage of the dairy cattle in the Kenyan site are pure-bred exotics or improved varieties. Although the ancestors of these farmers have kept cattle for generations, zero-grazing high quality dairy cows is a new technology that has expanded rapidly in the last 15 years. It is reasonable to expect that farmers with more human capital would be more likely to adopt and then be more successful at managing this enterprise. There is no obvious reason, however, to expect that this would show up as a larger coefficient on the Raven CPM test, or increased impact of other educated persons on agricultural productivity.

Even though it was not significant in Tanzania, the significant Raven CPM test for Kenya indicates the potential usefulness of this instrument in controlling for reasoning ability. It is reasonable to conclude that the earlier studies that found a positive impact of education on agriculture were reporting screening effects in part. Future studies should investigate this relationship further, and expect threshold effects of this variable.

Despite these caveats, the basic result of this paper stands: Increases in education have had and will continue to have large impacts on agricultural productivity in Kenya and Tanzania. Through investment in education, the government and investors in harambee schools unknowingly increased agricultural productivity substantially. The benefits of these investments will be seen for many years in the future of these communities.

References

Azhar, R.A. 1991. "Education and Technical Efficiency during the Green Revolution in Pakistan," *Economic Development and Cultural Change,* Vol. 39, No. 3, pp. 651-665.

Behrman, Jere, and Anil B. Deolalikar. 1988. "Health and Nutrition." Chapter 14 in *Handbook of Development Economics* Vol 1. Edited by H. Chenery and T.N. Srinivasan. Amsterdam: North-Holland.

Bogonko, Sorobea Nyachieo. 1986. "Aims of Education in Kenya Considered in the Context of Independence," *Kenya Journal of Education*, vol. 3, no. 1.

de la Cruz, Lynnette. 1991. "Human Capital Accumulation in Rural Pakistan: Its Effects on Agricultural Productivity in Post-Green Revolution Areas." Center for Development Economics, Williams College, Williamstown, MA.

District Agricultural Officer, Murang'a. Interview, 14 May 1992.

Eshiwani, G.S. 1990. *Implementing Educational Policies in Kenya*, World Bank Discussion Papers, Africa Technical Department Series, no. 85.

Foster, Philip. 1966. "The Vocational School Fallacy in Development Planning." Pages 142-163 in *Education and Economic Development* edited by C.A. Anderson and M.S. Bowman. Aldine Publishing.

Gerhart, John. D. 1974. *The Diffusion of Hybrid Maize in Western Kenya*. Ph.D. dissertation, Princeton University.

Hopcraft, P.N. 1974. "Human Resources and Technical Skills in Agricultural Development," Ph.D. Dissertation, Food Research Institute, Stanford University, Stanford, CA.

Jamison, Dean T., and Lawrence J. Lau. 1982. "Farmer Education and Farm Efficiency." Baltimore: Johns Hopkins University Press.

Jamison, Dean T., and Peter R. Moock. 1984. "Farmer Education and Farm Efficiency in Nepal: The Role of Schooling, Extension Services, and Cognitive Skills." *World Development* 12:1 67-86.

Knight, John B. and Richard H. Sabot. 1990. *Education, Productivity, and Inequality: The East African Natural Experiment*, Oxford University Press, Oxford.

Lin, J.Y. 1991. "Education and Innovation Adoption in Agriculture: Evidence from Hybrid Rice in China," *American Journal of Agricultural Economics,* Vol. 73, No. 3, pp. 713-723..

Mellor, J.W., Delgado, C.L., and Blackie, M.J. 1987. *Accelerating Food Production in Sub-Saharan Africa,* Johns Hopkins University Press, Baltimore.

Moock, P.R. 1981. "Education and Technical Efficiency in Small Farm Production," *Economic Development and Cultural Change,* Vol. 29, pp. 723-739.

Moock, P.R., 1973. “Managerial Ability in Small Farm Production: An Analysis of Maize Yields in the Vihiga Division of Kenya," Ph.D. Dissertation, Columbia University, New York,.

Mwiria, Kilemi. 1985. "The Kenya Harambee School Movement: A Historical Perspective." Ph.D. Dissertation, Stanford University.

_______. 1987. "Kenya's Harambee Secondary School Movement: A History of Contradictions." Nairobi: Kenyatta University, Bureau of Educational Research, Seminar paper no. 20172.

Psacharopoulos, George. 1986. *Financing Education in Developing Countries*. Washington: World Bank.

Pudasaini, S.P. 1983. "The Effects of Education in Agriculture: Evidence from Nepal," *American Journal of Agricultural Economics,* Vol. 65, No. 3, pp. 509-515.

Raven, J., J.C. Raven and J.H. Court. 1991. *Manual for Raven's Progressive Matrices and Vocabulary Scales, Section 1 : General Overview*, Oxford Psychologists Press.

Republic of Kenya. *Economic Survey*. Nairobi: Government Printer, various years.

________ .1988. Rural Literacy Survey, Nairobi: Government Printer.

________. 1983. *Development Plan: 1984-1988.* Nairobi: Government Printer.

________. 1987. "Development Through Harambee: Who Wins and Who Loses? Rural Self-Help Programs in Kenya." *World Development* 15:4 (April) 463-481.

Thomas, Barbara P. 1981. "Local Organization, Politics and Participation in Rural Development: A Study of Harambee Self-Help in Kenya." Ph.D. Dissertation, Brandeis University.

Verspoor, Adriaan. 1989. *Pathways to Change: Improving the Quality of Education in Developing Countries*, World Bank Discussion Papers, no. 53.

Welch F. 1970. "Education in Production," *Journal of Political Economy,* Vol. 78,, pp. 32-59.

Wolff, Laurence. 1984. *Controlling the Costs of Education in East Africa: A Review of Data, Issues and Policies*. Washington: World Bank Staff Working Papers, no. 702.

World Bank. 1989. *Sub-Saharan Africa: From Crisis to Sustainable Growth.* Washington.

________ . *World Development Report,* various years.