THE EFFECTS OF GOVERNMENT POLICIES ON PRODUCTIVITY AND THE ADOPTION OF AGRICULTURAL TECHNOLOGY IN SELECTED SUB-SAHARA AFRICAN COUNTRIES

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IN SELECTED SUB-SAHARA AFRICAN COUNTRIES

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CHAPTER I

PURPOSE OF THE STUDY

Problem Situation

The decade of the 1970s saw the food production growth rate decline to less than the population growth rate in sub-Sahara Africa. A severe drought and falling per capita food production have led to the prospect of widespread starvation, if there is no food aid forthcoming. Mellor (48), in a 1984 International Food Research Institute report, stated that food exports from sub-Sahara Africa are declining at an annual rate of 5 percent, while food imports are increasing at more than 7 percent annually. The region moved from a net exporter of food to a significant importer in a little more than a decade. If the trend continues, by the year 2000 the region will be a massive importer of food. Commercial imports of food grains has grown more than three times as fast as the population, and food aid has also increased substantially, increasing the dependency on imported food. However, food aid is not a permanent solution. Food production must be increased in sub-Sahara Africa, which is the only region of the world recording declining food production per capita.

Agricultural output is the single most important determinant of overall economic growth of most of the countries of this region. Most of the population derive their livelihood from agriculture. The sluggish growth of agricultural output in recent years has been the principal factor underlying the poor economic performance of the countries of this region. Agricultural output is growing at 1.3 percent, while population is growing at 2.7 percent (Table I).

The World Bank (69) has identified some of the sources of slow agricultural growth to be:

- rapid population growth which has pushed cultivation into less productive areas
- neglect of agriculture by the government
- misallocation of investments
- unconducive agricultural and economic policies and institutional frameworks to increasing output
- deficient research output
- inadequate technology to raise productivity
- shift in consumption to import food items which are too costly to grow locally.

As with output, growth in yield and labor productivity have been very low compared with population growth (see Tables X, XI, XII, and XIII). Agricultural (labor) productivity did not change much in the 1970s. According to Mellor (48), this is because the cultivated area of food grains per labor force hour is small. Since a substantial proportion of the labor resources is in food production, it is necessary to raise the productivity of this resource. Failure to substantially raise the productivity of this resource in food production means leaving large numbers of people in poverty and malnourishment. Labor productivity is a function of the underlying technology. However, the nature of the production function is

Table I

GROWTH RATE OF SELECTED BASIC INDICATORS,
SUB-SAHARA AFRICA, 1961-1979

Basic Indicators	1961 - 1963 to 1969 - 1971	1969 - 1971 to 1977 - 1979
Population (percent)	2.5	2.7
Fertility Rate (per woman)	-	6.6
Agricultural Production	3.6	1.8
Agricultural Growth (percent)	-	1.3
Agricultural Growth (per capita)	-	-1.4
Agricultural Exports (percent)	2.2	6.2
Agricultural Imports (percent)	8.9	7.0
Food Aid (1975-1979) (kilo/per capita)	-	3.2

Source: World Bank Data, (69).

sensitively conditioned by sociopolitical circumstances/institutions. It follows therefore that variations in the admissible range of contractual arrangements or associated organizational forms modify the production function. Constraints on admissible contractual arrangements tend to lower output for any given input. Given the present sub-Sahara African situation, to change the production function so that the output will increase will require the adoption of improved technologies (machinery, irrigation, fertilizer, and high yield variety (HYV) seeds). Researchers have so far encouraged mostly methods that have aimed at increasing the productivity of the land (fertilizer and seed packages). This has been very important, although not enough. As Mellor (48) has stated, "African agriculture is dominated by old soils with little prospect of good water control...". Through leaching, the main plant foods have been removed from the top soil, leaving mostly a reddish mottled clay, laterite. The remaining soil has low fertility, and will require increased use of fertilizers. The exceptions are along river valleys, lakes, and in deltas, where deposits of fertile alluvial soils may be found. Volcanic soils are also fertile, but are found in very few areas of the region.

Another major constraint to increasing agricultural productivity is water. The drought in most of the region over the past several years has had devastating effects on the crops, livestock, and the farmers. To mitigate the effects of this natural calamity will require the harnessing of whatever water resources there may be primarily through irrigation.

Even where water is not the problem, the ability to properly prepare the land for planting is one that goes beyond the most common farm implements currently in use, the hoe and the machete. Generally, the one to three month period before the rains break is the driest and hottest time of the year. This makes the peasant farmers' preparation of the dry, hard ground for planting particularly arduous. The use of some mechanical implements (motorized or otherwise) will reduce the drudgery of the farmer, and will also facilitate the cultivation of a larger tract of land.

To increase agricultural productivity will require that farmers adopt a package (in varying degrees) of agricultural innovations - HYV seeds, fertilizers, irrigation, and mechanical/land preparing innovations. However, sociopolitical institutions condition the potential opportunities facing the farmers. The World Bank (69) has indicated that cultural, religious, and environmental climates affect mechanization processes and types in sub-Sahara Africa.

Increasing food production, reducing drudgery, and maintaining or improving rural employment is not just a question of mechanization or adoption of new technology. The most important factor is that farmers must have the incentive to produce at higher levels than the subsistence level. The inefficiency of marketing institutions reduces farm prices by major proportions, thus reducing farm income. Cheap food price policies of governments have served as a disincentive to produce more food and to adopt new technology.

Per capita income in sub-Sahara Africa in 1983 was 4 percent below the level in 1970 (Economist, 9/29/84). Literacy rates are also low. Government policies that affect or influence the adoption of agricultural innovations are crucial to the overall economic growth of the countries of this region. There seems however, to be a consensus that government policies have been a detriment to food production (17). It is desirable therefore, to know what impact alternative economic policies will have on food production through adoption of new and/or better technologies for production.

The purpose of this study is to determine how various government policies - macroeconomic, food, and agriculture - influence the adoption of improved technologies in agriculture, especially mechanical inputs. Food policy objectives of tropical African countries include producer welfare, self-sufficiency, food security, stable food prices, and foreign exchange. The various food and economic policy instruments used by the government could have adverse effects on farm income, and on how new innovations are adopted. An agricultural policy of setting low producer prices and a government agency managing the marketing system may lead to low farm incomes. Moreover, macro policies which are designed to accumulate foreign exchange, say for the servicing of international debt, will encourage import substitution. Since, the technology that is needed in agriculture may have no domestic substitutes, the adoption of agricultural innovations would be discouraged.

Facilitatory government policies are crucial to the mechanization of the agriculture of sub-Sahara Africa. However, some of the policies have not been conducive to increased productivity. Consumers, especially urban consumers, have enjoyed price stability because of fixed retail price policies, and subsidization of distribution channels (59). The government does the marketing for imports, and levies taxes and variable duties on these imports to maintain stable or fixed retail prices. There is no price subsidy for producers, although modern inputs - mechanization, fertilizer and improved seed, as well as land development - are subsidized. Farm incomes remain far below urban incomes. The mechanization and capital formation of agriculture is usually financed primarily out of gross farm income and this has been the case in the United States (58). It is important, therefore, that farm incomes be high enough to enable farmers to finance any mechanization.

In 1980, statistics of the Food and Agriculture Organization (FAO) of the United Nations (UN) Production Yearbook (21) showed that there were 118,978 tractors of various sizes in sub-Sahara Africa, out of a total of 443,121 in the continent (Table II). This number represented a two percent increase from the previous year, 1979, and 27 percent of all tractors on the continent. The growth in the number of tractors was just over two percent throughout the 1970s and the trend seems to be continuing. Note also the erratic changes in tractor utilization indicating drastic changes in relative prices and/or government policies. Although the use of oxen has been common in the tse-tse free areas, there will be a decline in the adoption of this technology because of the limited supply of forage at the time the animals are needed the most (5), and the need for additional expensive labor to look after the animals (17).

The use of intermediate forms of mechanization - small tractors and winches - is on the rise (5). These implements have been tested or assembled and tested in Africa. It is therefore important to examine the way small farmers in particular, are embracing this technology, and how the government is making it easy or difficult for them to adopt the technology.

Table II

FARM TRACTORS IN AFRICA, 1972 - 1980

Year	Africa	Annual Percentage Change	Sub-Saharan Africa[a]	Annual Percentage Change
1972	357816		84710	
1973	374744	4.73	87906	3.77
1974	387438	3.39	91722	4.34
1975	407907	5.28	93857	2.33
1976	415929	1.97	99509	6.02
1977	419450	0.85	99667	0.16
1978	428439	2.14	113703	4.08
1979	435818	1.72	116518	2.48
1980	443121	1.68	118978	2.11

Source: FAO, Production Yearbook, (21).

annual percentage change = $(X_{t+1} - X_t)/X_t$

[a] Does not include South Africa and Namibia.

Objectives

1. To analyze the influence of government policies on productivity (labor and land) and technology adoption in agriculture, and to classify policies according to macroeconomic, food, and agriculture policies. For example:

   (a) Macroeconomic Policies -

   These are policies targeted toward objectives of national concern which may have an impact on agriculture. It is possible that the effect of these policies may have an adverse or contradictory influence on the objectives that other policies are attempting to achieve. These policies include:

   - Exchange controls
   - Commercial trade policies such as
     - tariffs
     - quotas
     - import restrictions
     - export incentives
   - Credit and Interest Rate Controls
   - Taxes
   - Marketing Infrastructure

   (b) Food Policies -

   The consumer is the end of the line in the food chain. Food policies are often used to subsidize the consumers, especially the urban consumers. Some of these policies are:

Food Subsidy programs

Price Controls

Food Marketing by a government agency

(c) Agricultural Policies -

These are policies that relate directly to the agricultural or food production sector. These policies include:

Price Supports and pricing policies

Modern Inputs Subsidies

Marketing Boards/Agencies

Land Tenure Policies

Rural Development

An important consideration with this objective is to categorize those policies in a given country that are detrimental and those that are conducive to adoption of technology. Furthermore, since these policies will interact with one another, it may be the case that many governments are pursuing contradictory policies, i.e. simultaneously pursuing policies that both help and hinder the adoption of technological inputs. For example, many mechanical inputs must be imported and purchased on credit. Exchange rates that encourage import substitution or macro policies that keep interest rates high will discourage adoption, while subsidizing the input will encourage adoption.

2. To examine environmental factors influencing agricultural

productivity and the adoption of technological innovations in agriculture.

3. To test empirically the relationships between government policies and productivity and the technologies being adopted.

4. a) To make some inferences on productivity and technology adoption. An a priori assumption is that government policies that distort market prices affect the adoption of new innovations. The adoption of new innovations is a function of farm income and other variables. Distorted prices will affect farm income.

   b) Make some policy recommendations.

Procedures

1. Data Collection

Six countries, Cameroon, Ivory Coast, Kenya, Nigeria, Tanzania, and Tunisia were chosen for this study. They were selected because

a) inter-country comparisons would be possible, and
b) there were contacts in these countries for getting some data, but this proved to be unsuccessful.

The countries lack reliable national time-series data on basic agricultural and policy information. Some of the countries require that the researcher do the data collection in the field, which for lack of funds has not been possible. Data used here are collected from the Oklahoma State University Library and from international organizations - including the World Bank, International Monetary Fund, and the United States Department of Agriculture.

The data collected are mainly from the 1970's and early 1980's. The method of analysis is greatly constrained by the data available.

2. Analysis

Examination of adoption is from two perspectives:

a) Aggregate Adoption - although microeconomic factors are important, that is, risk, farm size, information, the data available is at the macro level, and not at the individual level.

b) Examination of adoption of technology will be primarily by way of indirect measures. These would include:

   i) correlation analysis,

   ii) estimation of productivity function.

3. Make policy recommendations

CHAPTER II

THE EFFECTS OF VARIOUS GOVERNMENT POLICIES ON AGRICULTURAL INCENTIVES

Introduction

Agriculture in most developing countries is the major source of capital for the rest of the economy in that sales of agricultural commodities are the prime source of foreign earnings used for the purchase of capital goods needed in other sectors of the economy. The agricultural sector is so large relative to other sectors that incentives to agriculture affect the behavior of other sectors, and in turn, incentives to these other sectors affect the economic performance of agriculture. For example, policies that affect the financial markets, interest rates, lending restrictions, etc., will affect the agricultural commodity markets, and vice-versa.

This chapter covers a review of the literature that deals with government policies that affect agriculture either directly or indirectly, with some discussion on specific policies relating to sub-Sahara Africa. Although internal constraints and changes in the world economy are heavily implicated in sub-Sahara Africa's slow economic growth, domestic policy deficiencies and administrative constraints have also been very important, and in many cases, decisive. Unless many of the existing policies affecting agriculture are changed, they will continue to block economic and agricultural progress. To better understand these policy implications, the chapter is divided into four sections: macroeconomic, food, agricultural or production, and selected specific policies in sub-Sahara Africa.

Macroeconomic Policies

These policies are characterized as being the product of broad development considerations, often with some emphasis on the effects to the industrial sector, but with profound implications to agriculture. Many leaders of developing nations are convinced that industrial growth is the major road to salvation, and have assigned their priorities accordingly (44). For example, in Egypt, subsidization of domestic industries - cotton spinning and weaving industries - at the expense of agricultural prices has led to unrealistic profits for these industries at the expense of the farmer (70).

Some of the objectives of macroeconomic policies include: a) growth of the industrial sector, b) foreign exchange earnings to be used for debt servicing and purchase of foreign goods, and c) improve the standard of living of the people. Macroeconomic policies will be examined in two broad perspectives: international trade and finance, and domestic monetary, fiscal and trade policies.

International Trade and Finance Policies

According to the World Bank (69), trade and exchange rate policy is at the heart of the failure to provide adequate incentives for agricultural production and for exports in much of Africa. Trade and exchange rate policies comprise policies on the official exchange rate, import duties, export taxes and subsidies, quantitative restrictions on imports and exports, and exchange controls. Governments often use exchange controls and international trade policies to encourage import substitution.

Exchange Rates

Most of the studies that have examined exchange rates in developing countries have concluded that most of the currencies are overvalued (16, 22, 53, 54, 58, 69).* Overvaluation of the domestic currency acts as an implicit subsidy to imports and a tax on exports. The World Bank (69) states that exchange rate policies of African governments has been the tendency to let real official exchange rates become overvalued because of higher inflation at home than abroad. In some African countries like Ghana, Uganda, and Zaire, the exchange rate appreciated by over 100 percent in the 1970's. A further finding of the report was that governments in this region responded to the scarcity of foreign exchange by relying increasingly on import restrictions, rather than devaluations to conserve foreign exchange.

A study by Shapouri (59) found that overvalued exchange rates held down prices received for export crops, and also that a combination of overvalued exchange rates, and almost no duty on food imports increased a country's import dependency and discouraged domestic production.

*World Bank calculation uses a base year (1970), and the special drawing right (SDR) exchange rate and the consumer price index of industrialized countries as the foreign comparators. In other studies, the exchange rate is said to appreciate if a country's inflation rate exceeds the world inflation rate, unless it devalues by more than the differential inflation rate.

Garcia (22) found that exchange rate policies adopted by Colombia, and applied without regard to movements of international prices and its relationship with monetary and fiscal policies, led to considerable overvaluation of the peso in some years. These were restrictions aimed at solving balance of payments problems, rather than to protect particular sectors. Shane and Stallings (58) found that domestic inflation in countries with tightly controlled foreign exchange regimes acted as a tax on exports, which led to contractions in the foreign sector. It further tended to slow the process of development by reducing the incentives for real investment from domestic sources.

In another study, Crockett (16) found that while in theory exchange rate devaluation increases the demand for domestic output, devaluation may not necessarily be expansionary. In a small open economy with the domestic price level determined from outside, exchange rate adjustments may affect only the purchasing power of financial assets denominated in the local currency. Also, in the short run, if the demand for imports is inelastic, devaluation will reduce real incomes and thus, demand for domestic output. The effect could outweigh the stimulatory effect of devaluation on exports, especially if supply elasticity for exports is low, and merchandise exports are smaller than imports. He suggested that economic policy should focus on removing supply bottlenecks and other structural rigidities, so that overall output capacity can be raised.

From the above, three points emerge from which some inference can be drawn as to their effects on agricultural incentives: i) taxing exports reduces the income of producers, thus making it difficult for those in agriculture to invest in modern inputs; ii) restricting imports limits the ability of farmers to acquire foreign inputs to agriculture; and iii) subsidizing of imports - the composition of the imports will be important to the ability of farmers to acquire foreign inputs. It does appear that an exchange rate policy of overvaluation is more likely to be a disincentive than an incentive to farmers.

Commercial Trade Policy

Besides using exchange rate adjustments to influence trade, tariffs, quotas, taxes, quantitative restrictions on imports and exports, licensing of imports by government trading agencies are among some of the policy instruments used to influence trade (16, 22, 23, 27, 41, 44, 59, 67, 69). Garcia (22) found that the joint policy of isolating the agricultural food sector from international markets and protecting domestic production of importable goods is inconsistent with policies aimed at promoting self-sufficiency and cheap food, as a tariff will raise the relative price of importable goods and food almost equally. He also found that protection of a particular product is not a guarantee that its output will increase. Despite protection, if other activities become more profitable, resources will move toward them. During the period under analysis (1953-1978), he found that the Colombian government discriminated against export products in the 1950's and 1960's, while in the 1970's exports of manufactured commodities were subsidized to such an extent that the gross subsidy more than offset the overvaluation of the peso, and at the same time, exports of agricultural products were taxed.

Peterson (53) has shown that export taxes on farm commodities hold domestic prices below world market levels, while overvaluation of currencies reduces export demand for farm products. A World Bank study (69) indicates that a trade system that relies heavily on import restrictions biases the incentive system against agriculture by a) forcing farmers to purchase high-cost local implements [in Upper Volta, there is a 66 percent tariff on animal-drawn plows and a 58 percent tariff on engines used for irrigation pumps], b) raising the cost of consumer goods [in Kenya there is a 100 percent tariff on textiles, which has doubled the price of clothing and reduced real rural incomes], c) serving to hold down prices farmers receive for their export crops, and d) lowering duties on food imports which has encouraged a dependence on food imports at the expense of domestic production.

A study by Gerrard and Roe (23) found that the Tanzanian Government reduced imports when foreign reserves were low, by increasing producer prices. Their study also found that the government taxed crops where the country was a low-cost producer, and subsidized where the country was a high-cost producer.

Exchange controls and international trade policies are rather different for the countries that have their currencies pegged to the French franc. These countries are all former French colonies and are members of the CFA (Communauté financière Africaine) franc zone. As members of a common currency zone, they have benefitted from relatively free payments among members, from pooling of resources, and from the ability to run a deficit financed by the French Government through an account at the French Treasury, the Operations Account (31, 69). With the French franc as the intervention currency at a fixed rate of CFAF50 = FF1, buying and selling rates for other currencies are based on the French franc. Capital movements among the operations account countries are free of exchange controls. These countries appear to have benefitted from the discipline imposed by the need to coordinate policies with partner states. However, the need for coordination also imposes constraints on individual countries; monetary growth must be coordinated, while a policy option as exchange-rate changes have not been available for use, thus putting a greater burden on other policy instruments for maintaining balance-of-payments equilibrium, particularly on fiscal, monetary, and wage policy. Because of the stresses of the 1970's, the economic environment within which the franc zone operates changed somewhat. Few countries have surpluses and more are seeking credit at the operations account.

These international trade and finance policies tend to reduce the flexibility of the economy. For example, once all non-essential imports have been eliminated, only essential imports of capital goods, spare parts, and raw materials remain to be cut in the event that severe foreign exchange shortages require such a move. Also, these restrictions tend to raise prices, which affect both the producers and consumers, and thus are a disincentive to increased agricultural production.

Domestic Monetary, Fiscal, and Trade Policies

Monetary

One of the greatest constraints to effective policies is the lack of domestic financial resources, or the budget constraint. Peterson (53) found that export taxes on farm commodities have provided an easy-to-tap source of government revenue for most LDCs, in view of difficulties in collecting income taxes. Marketing Boards, created to facilitate the marketing of certain agricultural products, have become major sources of revenue for the government (30). Perhaps of major importance in domestic monetary policies is credit policies. Without available credit, personal and national development is stymied. Smith (60) has identified needs and uses for credit as follows:

1) to buy seed, fertilizer, insecticides, and other inputs,
2) to hire extra help, especially for planting, harvesting, and marketing,
3) to store farm products,
4) to purchase livestock, feed,and veterinary services, and
5) to buy tools and farm machinery.

Much of credit is made necessary because of the seasonal characteristic of farming, and emergencies - drought, flood, disease, poor markets, death, and health problems. Credit institutions are still very lacking in developing countries. However, Smith found that there were two types of creditors or lenders in developing countries, the government and the informal lender. Interest rates charged vary from 4 to 50 percent or more. Higher rates occur during emergencies and are provided by the informal lenders. Lower rates of 4 to 10 percent are government subsidized loans. Smith thinks these subsidized interest rates may be one of the important reasons why small farmers are still receiving limited amounts of credit and that credit systems are not functioning well. An interest rate of 15 to 20 percent is probably needed to pay administrative costs and to attract funds from private savings and investors. Leite (45) has found that, in West

Africa, interest rates are kept low because of the desire to increase the level of investments, improve allocation of investments among sectors, and keep financial costs down to avoid possible inflationary effects of interest rate liberalization.

The main problem of domestic monetary policies is the lack of well developed credit institutions as in the developed countries. A very low interest rate policy is likely to convert credit into a welfare program, and may actually hinder increased food production.

Fiscal

A major source of government revenue is taxes. In the LDCs, the pay-as-you-earn (PAYE) system works only for people with recorded incomes. A majority of the working population in LDCs are largely rural and do not earn incomes that are recorded. Some of the people earn incomes that are in kind. It is therefore usually difficult to collect taxes. In Kenya, for example, people earning below a certain amount do not pay tax.* Some countries have sales tax, others do not.

The implication of this lack of well-defined tax policies is that governments would want to tax exports as much as possible since this is a major source of revenue. Export taxes, however, are a disincentive to agricultural production.

Trade

Most countries, developed and developing, tend to have agencies

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*Personal communication with Kenyan doctoral student, Arap Rop.

that market particular products or groups of products, e.g. the Marketing Boards in Canada, Israel, Australia, West Africa, and New Zealand (30). These institutions are entitled by individual governments to act as sales representatives in developing and using marketing procedures so as to affect favorably, farm prices and returns. Functions of these institutions vary among countries. A common function is that of stabilization. Some are responsible for domestic trade while others are export monopolies oriented toward international trade with emphasis on the sale of products in foreign markets.

In the LDCs the marketing infrastructure at the local or domestic level is not as fully developed, a situation that is usually made worse by the lack of roads, especially farm to market roads. There is, therefore, relatively little incentive for the farmer to want to produce more than is necessary for the family to consume since the surplus cannot be marketed.

Food Policies

These policies are consumer oriented and are often targeted at low-income and/or urban consumers. Developing nations find national food policies a necessary, but not a sufficient condition for economic development. The use of such policies does not affect development as much as the extent to which they are used (59). Objectives of food policies include stable prices, consumer welfare, and foreign exchange.

Stable prices have meant cheap food to urban dwellers. This has been possible because the cost to the government of providing cheap food to urban dwellers is reduced by passing on the lower prices to the producers (44, 59, 68, 69). A cheap food policy pays high political dividends at a relatively modest outlay of government revenues. Resources are transferred from the large diverse, politically inert rural populations to the proportionately small but politically influential urban groups. This is possible because a relatively small decrease in individual incomes for the large rural population can finance a substantial decrease in urban food prices. In most developed countries the food budget share of total income is typically less than 25 percent and often below 20 percent (44). Consumers are therefore somewhat passive about high, supported food prices. However, in LDCs where the food budget share of total income often exceeds 50 percent (6), consumers are very sensitive to price increases. It will be difficult politically to increase price support to farmers if it also means increasing food prices to consumers when the food budget share exceeds 50 percent. When personal incomes rise, demand for some food crops rise even faster. Changes in the price of food, therefore, have a major impact on the economic well-being of urban dwellers.

Besides the implicit transfer of incomes from producers to urban consumers in the form of cheap food, governments have explicitly subsidized food schemes for urban consumers. von Braun and de Haen (67) and Youssef et al. (70) in studies of the food situation in Egypt, found that countries that have plentiful nonagricultural resources are going to drift from implicit to explicit food subsidy schemes as Egypt did. When this happens, tight budgets will make severe internal distribution conflicts unavoidable. Rural income in Egypt is about half that of the urban dwellers. The paradox leads to the intensity of rural-urban migration. Given the current level of technology in developing countries, the rural-urban exodus decreases the number of people engaged in farming, but does not necessarily increase the productivity of those left on the farms. The consequence of this is decreased food output. Also, the transfer of incomes from producers to consumers takes away from producers the surplus that is needed for investment. In the developed countries, consumer welfare is usually in the form of various types of protection, especially against misinformation. In the European Community, for example, actions involve weights and measures, price displays, listing of contents, rules governing hygiene, contamination, and additives to food stuffs (27).

Agricultural Policies

These are policies that relate directly to the agricultural sector, that is, the food producing sector. Objectives of governments for this sector have included food self-sufficiency, increasing farm incomes and welfare, employment, integrated rural development, and generation of foreign exchange. Producer price support is a policy instrument that is used to meet the objectives of increasing farm income, foreign exchange, and food self-sufficiency. In a study of food policies of governments, Laird and Laird (44) found that although only 15 percent of its land can be cultivated, high domestic price supports have stimulated Japanese rice farmers to produce enough to meet current needs and the country's objective of reducing dependency on imports. According to Harris et al. (27), the European Community's system of aid to the farming community is characterized by attempts to raise the price of farm produce above the levels that would normally prevail in the market. This system of price support to prop up farm incomes also prevails in the United States. According to Webb (68), agricultural policies in developed countries seek to increase domestic producer and consumer prices, thereby transferring resources from tax payers and/or consumers to resource owners in the rural farm sector. This transfer is possible because rural resource owners in developed countries are small, relative to consumers and tax payers. In an article on French agriculture, Bergman (7) indicated that production subsidies and direct income support payments to French farmers in 1981 were close to 7 percent of gross farm income. This did not include subsidization of "credit agricole" low-interest farm loans. In the European Community, while imports are taxed, exports are subsidized. The French philosophy of small farms has slowed down the agricultural and rural exodus in that country. Agricultural policies in the developed countries have generally been very favorable to producers, and farmers' welfare has improved, and they have responded by producing agricultural growth in the post-World War II era that has surpassed industrial growth (45).

In the LDCs, producer price supports have not been a policy instrument of interest as this would be counter to cheap food policies and foreign exchange earnings. Rather, producer prices have been kept very low. In Egypt (70), wheat imported at world market prices with funds explicitly quoted in the state budget, is sold to the consumers at half the world market price. This compels local producers to sell at the lower price. There are four sets of pricing of agricultural goods:

a) Prices are set absolutely and farmers are obliged to deliver all their produce to the government at the set prices - cotton, sugar cane.

b) Prices are set for a portion of production that farmers are obliged to deliver to pooling centers with the balance of the crops marketed freely.

c) Government indirectly determines prices through control of imports, as in the case of wheat cited above, and thereby affects prices of domestic production.

d) Prices are determined by forces of demand and supply. This is applicable to mostly fresh vegetables.

Most LDCs do not have agricultural policies that pertain to food produced and consumed locally. Their agricultural policies are geared toward cash crops which earn foreign exchange capital for the development of the industrial sector.

The effect of these policies is increasing food production in the developed countries, and decreasing food production in the developing countries. As Webb (68) has noted, there are linkages between income, population growth, urbanization, and income elasticity of demand for food. Developing countries' growth in demand for food is outstripping their growth in agricultural productivity until they attain very high income levels. Developed countries are increasing food output faster than their growth in food demand while developing countries have been unable to keep pace with food demand growth. From a national policy perspective, one would expect policymakers in developed countries to make production of additional food a relatively low priority, and would discourage increased food output, while the reverse would be expected in the developing countries. Yet, in both cases, the thrust of national policies has been to stimulate further food production in the developed countries and discourage food production in the developing countries.

Sub-Sahara Africa

Although wars, civil strife, drought and poor rainfall patterns during the 1970's, and rapid population growth have in part been responsible for the rural crisis in sub-Sahara Africa, neglect of agriculture by the governments of the countries of this region has also contributed. In this section, the focus is on the government policies that have impacted on agricultural incentives. Most sub-Sahara African countries are agrarian in structure and outlook. Agriculture forms the principal activity in their economies, both in terms of occupational distribution of the labor force and its proportionate contribution to the gross national product. Objectives of governments in the region include raising revenue from the agricultural sector for the public and industrial sector, foreign exchange, consumer welfare, producer welfare, and self-sufficiency in food and employment (1, 10, 41, 69). Perhaps the most important policy instrument that governments use to achieve their objectives is pricing. They set and regulate prices. They want to provide adequate incentives for increasing food production, while at the same time seeking to protect the interests of consumers. In practice, consumer welfare in the form of regular staples at affordable prices has been the dominant objective. Producer prices are fixed at below market levels, and export crops are heavily taxed. According to the World Bank (69), producers receive only a fraction of the world market prices of major exports. Their tax burden, defined as the ratio of farmgate producer price to economic value at the farmgate is, on average, in the 40-45 percent range. Subsidies on imports and other services soften the tax impact by about 10 to 15 percent. Abang (2) found that when transportation cost is included, the divergence between producer prices and world prices is very small.

The governments of the countries of this region are aware of the fact that raising producer prices for export crops would stimulate production, but doing so would lead to sacrificing other objectives. Taxes levied on export crops are a principal source of revenue for public sector activities, especially for the nonmineral economies.

International trade policies are also very important. Imported rice and wheat are becoming cheaper than domestic staples, partly because of overvalued currencies. Concerned about the capacity of their fragile political systems to bear the effects of a slow growth rate of food production and intent on keeping urban food prices low, many governments have, in recent years, resorted to massive injections of food imports, thereby causing sharp reductions in domestic prices.

Abalu (1) has stated that the last decade saw increasing use of food as an important factor in international diplomacy and as a political weapon, and that this fact, together with the stereotype of sub-Sahara Africa as a continent of hungry and deprived people, would suggest that policy makers in Africa ought to review their positions with regard to the conflicting goals of ensuring adequate food supplies at reasonable prices through food imports and developing food self-sufficiency capabilities. Large food imports would mean the diversion of foreign earnings necessary to improve cash crop production which constitutes the bulk of exports. This in turn would result in a loss of foreign exchange and in a consequent decline in the ability to continue importing food.

Conclusions

The various policies examined here show that governments often pursue policies that are contradictory. Some objectives, especially food self-sufficiency and producer welfare, are emphasized, especially in sub-Sahara Africa, almost to the exclusion of other objectives. The literature reviewed also suggests that governments can use foreign exchange controls and international trade policies to encourage import substitution. Overvaluation of currencies squeezes farmer incomes, and thus their purchasing power for imported farm inputs. International trade and finance policies may reduce the flexibility of the economy, and possibly the ability of producers to procure new imports, as these may be competing with other sectoral capital goods for the limited foreign exchange. Food policies that favor urban dwellers against producers tend to exacerbate food problems because such policies discourage increased production and encourage migration to urban areas. The policies would tend to discourage the adoption of technology.

CHAPTER III

THE DIFFUSION OF TECHNICAL INNOVATIONS IN AGRICULTURE

Introduction

Assuming both technical and allocative efficiency, the generation of new technology is a necessary, but not a sufficient condition for increased farm productivity with given natural resources. Feder and Slade (20) have stated that in the short run, this may not even be a necessary condition, if there is a gap between available knowledge and typical farmer practices. A crucial element in the process linking the generation of new technology to increased farm productivity is the diffusion of the new knowledge among its potential users, the farmers. Another element in the process is the adoption of the new technology, or parts of it, by the farmers.

In the context of this study, the technical innovation to be focused on will be mechanical technology - tractors and any mechanical implements used for farming. To the extent that the technology is developed locally, employment and capital formation outside of the agricultural sector will increase. Without the capabilities to develop the technology locally, it has to be imported. Importing technology which is labor saving, will affect employment, productivity, and population shifts. These points shall be discussed in the sections that follow.

This chapter is divided into four parts:

1) Factors influencing diffusion and adoption.

2) The need for policy interventions for technical innovations in developing countries.

3) Mechanization and employment.

4) The diffusion process of technical innovations.

Factors Influencing the Diffusion and Adoption of Technical Innovations

The efficiency of agricultural production in any country is a reflection of the level of technology prevailing in it. Low rates of productive efficiencies identified for most crops in Africa suggest that the efficiency with which scarce agricultural resources are converted into food and raw materials has been inadequate. There is no question about the fact that new agricultural innovations in farm practices are preconditions for sustained improvements in the levels of output and productivity. However, government policies that cause distortions also depress output and productivity. In the past, increases in output were achieved through enlargement of cultivated areas into previously unused productive land (1). Rising pressure on land is rapidly eliminating this as a viable alternative for increasing output.

Many African nations do not have a technology policy, which is why highly mechanized farms operate side-by-side with a vast majority of small-scale, hand-cultivated farms. Any technology policy will need to be based on an identification of the constraints on production in each country. Per Eklund has noted that agricultural technology is location specific, and also that productivity factors reflected in agroclimatic and topographic variations are the most consistent factors in explaining adoption behavior. This view is shared by Kamarck (36), who has stated that climate is probably the one most important factor influencing agricultural production. Besides climate, Kamarck also stated that soil type affects agricultural production. The choice of the type of mechanical technology for use in tropical regions with a thin layer of top soil has to be carefully made. Technology development for peasant agriculture requires an institutional structure that reflects properly the nature of the innovation process.

Beside these, there are also other factors likely to be associated with the adoption of mechanical technology. Perhaps a basic requirement is awareness of the existence of the technology by potential adopters. It is necessary that information be available on the costs of using the new technology; how to use it, expected increases in production and income from the use of the new technology in good, average, and poor years, and levels of use.

Another consideration concerns the adequacy of the new technology, that is, is it superior or not to the old one, and whether farmers will continue to use the new technology or not. A very important consideration is the risk involved in using the new technology. This is especially important to small farmers who have restricted access to credit, technical knowledge, and material means of production. This same group of farmers may not consider profit maximization as an incentive for adopting new technology, rather, they may consider meeting subsistence requirements, minimizing risk, and accumulating wealth (1) as more important objectives.

The characteristics of the farmers - family, education, land tenureship - are also factors that will influence adoption. The economic and technical characteristics of the technology will also influence the adoption of the technology.

The Need for Policy/Government Intervention

When new technology first becomes available, its perceived and true characteristics diverge because farmers have insufficient information (20). For farmers to reap the full benefit of the new technology, they should base their choice of the new technology and resource allocation decisions on the true characteristics. Information on new technology in the agricultural sector is often a public good, and therefore, provides justification for the public sector to intervene in information diffusion. The main channel for the dissemination of publicly sponsored agricultural knowledge is usually the extension service. The quality of the extension service is therefore very important.

Governments tend to subsidize new inputs. The justification for this price intervention is temporary, until enough information is available to eliminate the divergence between the objective and subjective distributions of the new technology. Continued intervention beyond this point may lead to misallocation. Therefore, the intervention should be phased out as the diffusion progresses.

Another form of intervention should be in the credit markets. Where a new technology requires significant cash outlay, the imperfect credit markets may lead to a situation where the amount of credit socially desirable is not fully available to the farmer. Government subsidized credit programs may sometimes be monopolized by wealthier and influential farmers. Public policy may also affect adoption in the financing of complementary physical infrastructure, such as irrigation facilities - canals and dams.

Cooper (15) has stated that the social and economic factors in developing countries generally do not produce much demand for local science and technology. Formal sector technology is mainly imported from advanced countries. Complete reliance on foreign technology has disadvantages in terms of high costs and inappropriateness of some of the technology from industrialized countries. The government therefore may have to intervene on behalf of the potential users of the new technology.

Mechanization and Employment

Development economists have stated that there is underemployment or disguised unemployment in developing countries. Consequently, the introduction of labor saving mechanical technology may further reduce employment (47, 49, 54, 55). In the case that this is true, the productivity of the labor force not displaced may increase and wages will increase also. However, where the introduction of mechanical technology leads to better and quicker plowing which can increase yields (double or treble cropping), more labor will be required for weeding and harvesting, possibly to a degree sufficient to offset the labor saved in land preparation. To avoid this seasonal demand for labor, peak periods can be spread out or modified by using seeds that mature at different times (25).

Many studies have examined the impact of mechanization on employment in developing countries (1, 42, 49, 55). Shyamal Roy and Melvin Blase found that farm tractorisation in the Punjab region of India played a complementary role in the production process, thereby contributing to increased output. Marginal value products of inputs were found to be higher on tractor farms than on those without tractors. They also found that tractorisation increased the demand for labor - casual, as well as permanent. Kikuchi and Hayami (42) found that tractor use and employment were inversely related in a study done in the Philippines. They also found that differential employment growth induced labor migration in a direction to reduce interregional income and employment disparity. Pudasaini (55) found that cropping intensity, yields, income, and employment were higher on mechanized farms than on traditional farms in Nepal (Bara District). The study indicated that much greater use of cash inputs and higher education levels associated with mechanized farms made it difficult to attribute yields and income effects solely to machinery. He could not clearly link tractors with any on-farm labor displacement, and he found that pump sets raised farm employment. Nair (49) found that in India, output increased as a result of agricultural mechanization, while marginal costs decreased through reductions in labor costs. Reduction in marginal costs will be more evident in labor-scarce economies where agricultural wages are high. He found that, in spite of the large supply of labor force in agriculture in developing countries, farmers find it more profitable to mechanize because

1) the prevailing wage rate in agriculture is not sufficiently low in relation to the excess supply of the labor force, due

to the rigidity of wage rate in the downward direction;

2) seasonal variations in the demand for labor in light of its supply create excess demand or supply in one region or another at any point in time; and

3) due to low degree of mobility of farm labor, such excess demand/supply can exist in different regions at the same time.

The study also confirmed that mechanization results in the displacement of labor, but noted that if mechanization is partial, and is followed by increased cropping intensity and application of land-augmenting technology, leading to higher yield, then the associated demand for labor can be more than the initial labor displaced. Agarwal (3), in a study on agricultural mechanizations and labor use in the Punjab region of India, found that types of labor affected by mechanization depended on the agricultural operation mechanized and on the size of the farm concerned. Use of tube wells increased use of labor time, while tractorisation decreased use of labor time. Mechanization, as these studies show, will increase output, but will have mixed effects on farm employment, depending on the type and scale of operation, and the type of mechanical technology being used.

The Diffusion Process

Geographical diffusion is the changing distribution of an innovation as it spreads from one or more areas where its use has become more general at an earlier time than in the surrounding areas (18, 19). This is the macro aspect of diffusion. This process also implies a time lag between early and late accepters of the innovation, and between an early and a late attainment of a particular level of acceptance by a certain area. Since diffusion is concerned with the collective response to an innovation, communication forms the basic element in the diffusion process.

Recent studies into the diffusion of farming innovations have demonstrated that the curve describing the process, expressed cummulatively, approximates an S-shaped curve (18, 20, 24, 26). An S-shaped curve replotted in terms of increments for constant time units produces a bell-shaped curve, which may or may not be symmetrical (Figure 1). Using the normal curve as a conceptual model for the diffusion process, Jones (34) has shown that any individual's position, U_i, for the adoption of a particular innovation in a given time scale is determined from

$$U_i = \frac{x_i - \bar{x}}{\sigma_x} \qquad (1)$$

where

x_i is an individual's actual date of adoption

$\bar{x}$ is the mean adoption date

σ_x is the standard deviation of adoption dates among population of adopters.

This formulation provides a measure of an individual's position in relation to other members within the distribution. It is therefore possible to determine the lateness or earliness of adoption.

Spatially, it would be unlikely that all the regions within the country would adopt a particular innovation at the same pace as the

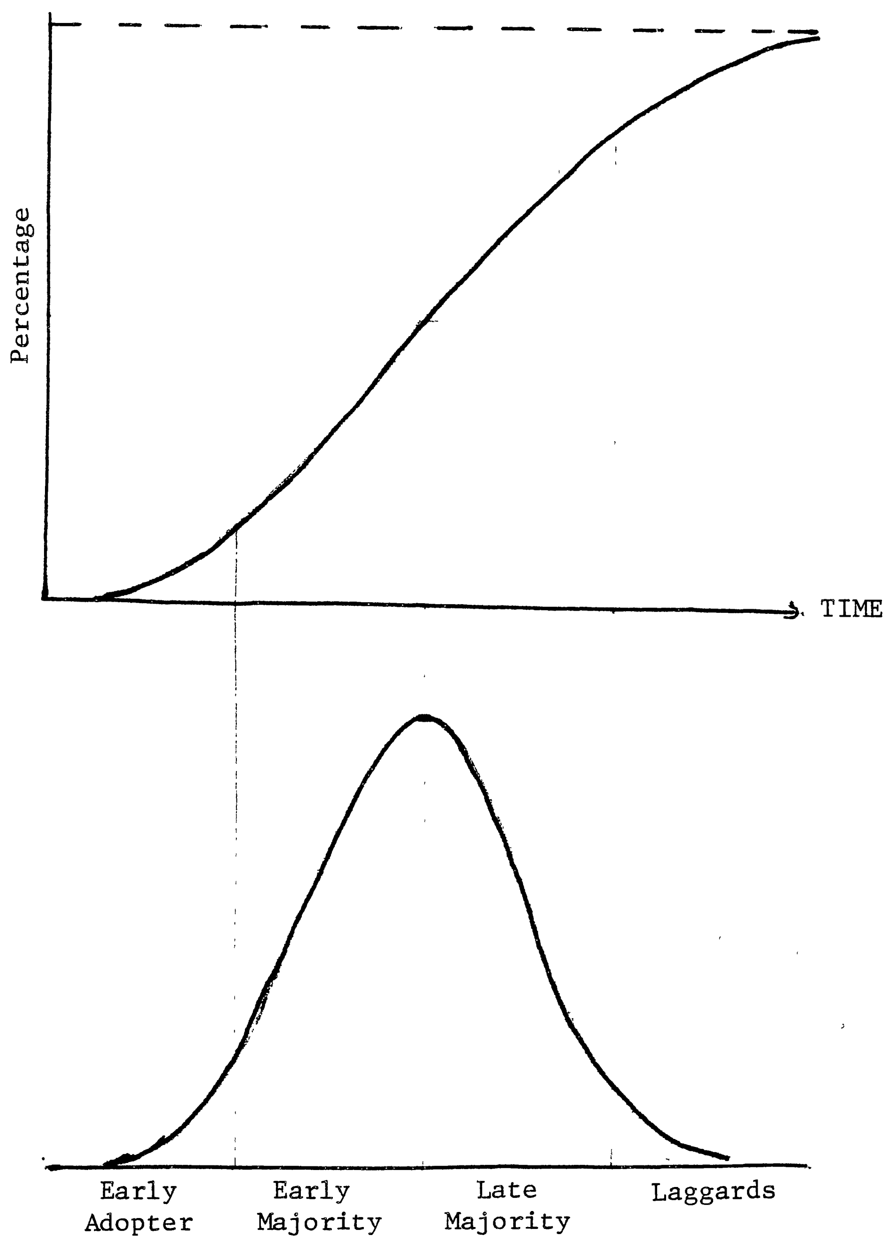

Figure 1. The Rate of Adoption and Types of Adopters

country as a whole. A time lag may be expected between most progressive and least progressive areas. If the innovation is equally available in all parts of the country simultaneously, it may be possible to have the diffusion curves in Figure 2.

Methodologies of Analysis

Although there are a number of analytical techniques useful in technology adoption analysis, it is necessary to use one that captures the dynamic nature of the process; one that includes time.

Lekvall and Wahlbin (46) have considered the logistic function, which is based on the assumption that the diffusion rate at a given point in time is proportional to the remaining distance to some predetermined saturation level as well as to the instantaneously attained diffusion level. This is expressed mathematically as

$$dy/dt = ay(N - y) \tag{2}$$

where

y is the current technology level

N denotes the saturation level

t is time

a is constant of proportionality.

Solving the differential equation with respect to y yields the following diffusion function.

$$y(t) = \frac{N}{(1 + b\exp(-aNt))} \tag{3}$$

where b is a constant depending on the initial conditions. This gives the S-shaped diffusion curve.

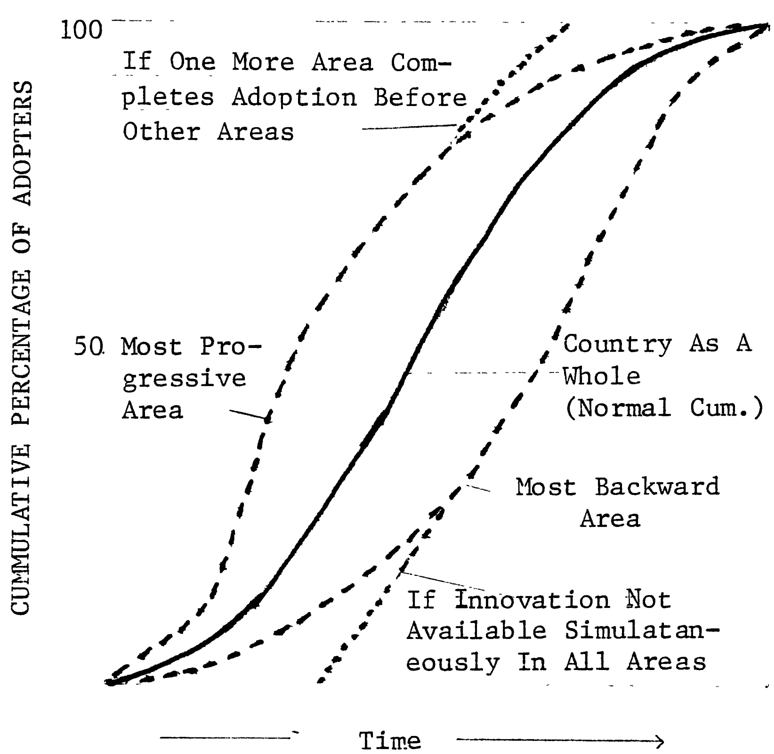

Figure 2. The National Diffusion Curve and Possible Regional Variations

Griliches (26) used a similar function to explain the diffusion of hybrid corn in the U.S.

The logistic function he used,

$$P(t) = K[1 - e^{-(a + bt)}]^{-1} \tag{4}$$

was a significant function of t where K was the long-run upper limit on adoption aggregate. P is the percentage planted with hybrid seed, b the rate of growth coefficient, and a the constant of integration.

Just and Zilberman (35) considered a model based on the risk considerations of the farmer. The assumptions they made were that the farmer was risk averse with utility function $U(\cdot)$ defined on wealth, $U' \geq 0$, $U'' < 0$; wealth, W, at the end of each season is represented by the sum of land value, $P_L\bar{L}$, where P_L is land price, and the return from production (L is profit per acre). The farmer can allocate all his land to the traditional technology, or incur a set-up cost of k for the new technology. If L_o is land allocated to traditional farming, L_1 is land allocated to new technology, and L is total land, the decision problem is described mathematically:

$$\max_{\substack{I=0,1 \\ L_o, L_1, f}} EU[P_L L + \Pi_o L_o + I(\Pi_1 L_1 - k)] \tag{5}$$

subject to

$$L_o = IL_1 \leq L$$

$$L_o,\ L_1,\ f > 0$$

where I is the adoption indicator (I = 0 for nonadoption and I = 1 for adoption).

Feder and Slade (20) developed a model to include public policy which affects the adoption process. Mathematically stated, the model is of the form:

$$\text{Max } [(PY_o - C)L + R(L_o - L) - (\rho/2)\,(1+\delta)L^2P^2] \tag{6}$$

where the traditional technology yields a profit of R dollars per hectare with certainty, the new technology costs C dollars per hectare and yields output Y which has a true distribution with mean Y_0 and variance δ. The farmers know the true mean but overestimate the variance to be $(1 + \delta)\delta$. Farmers have to decide how much land will be allocated to the new technology (say L) out of total available land L_o. The market price of the crop produced under the new technology is P, and $\rho/2$ is the risk aversion parameter.

They give

$$L^* = \frac{(PY_o - C - R)}{[\rho\,(1 + \delta)\,P^2]} \tag{7}$$

as the optimal allocation, given the distribution perceived by the farmer, and

$$L^{**} = \frac{(PY_o - C - R)}{[\rho\,\delta\,P^2]} \tag{8}$$

as what true optimal allocation should be.

According to their assumption, public policy of intensifying information should reduce δ. Optimal solutions can also be obtained by introducing a subsidy on the crop produced by the new technology (where the crop is distinct) that is equal to a proportion

$$\frac{PY_o + [P^2Y^2 - 4(PY_o-C-R)(C+R)(1+\delta)]^{.5}}{[2(1+\delta)(PY_o-C-R)]} - 1 \qquad (9)$$

of the price, or a subsidy on the cost per acre amounting to a proportion $(P_o - C - R)/C$ of the cost, or a subsidy of $(PY_o - C - R)$ per acre cultivated with the new technology.

Production functions have been used as analytical techniques to show the introduction of a new technology. Herdt and Capule (29) presented technological change as a shift in the production function.

The pre-existing technology is given by

$$Q = f_o(F, L) \qquad (10)$$

where

Q = Output

F is fertilizer

L is land

and new technology is given by

$$Q = f_1(F, L) \qquad (11)$$

where

$$MP_{f_o} < MP_{f_1}$$

If use of new technology requires more knowledge or some other fixed input costing k, then returns from this technology will be given by

$$R_1 = P_q Q_1 - P_f F_1 - k \qquad (12)$$

Feder (18) also uses the production function given by

$$Q = Y(L, X) + \varepsilon.H(L, X) \tag{13}$$

where

Q - actual (random) output

Y - mean output

H - a term related to output variability and assumed to be positive

ε - a random variable with mean zero

L - land input allocated to modern crop

X - fertilizer/new technology

He defines certain properties which characterize production.

Pudasaini (55) to measure farm efficiency and factor productivity, used the production function given by

$$Y = f(X_i, E, D_j) \tag{14}$$

where

y - output

X_i - factor inputs

E - education of farm operator

D_j - types of farms

Estimates of $\delta Y/\delta X$ and $\delta Y/\delta E$ provide Marginal Value Products (MVPs) for factor inputs and education.

Kaneda (38) used a translog production function of the form

$$\ln Y = \ln Q_o + \sum_i Q_i \ln X_i + \sum_{ij}\sum B_{ij} \ln X_i \ln X_j \tag{15}$$

to show that the nature of technological change in agriculture, through its impact on the demand for factors of production, influences the sector's employment, income distribution, and intersectoral flows of resources, including internal migration of labor and patterns of human settlement.

Gort and Klepper (24) identify five stages in the evolution of an innovation given by the following general process:

$$F_t = P_t(N - n_{t-1}), \tag{16}$$

where

F_t - expected number of people adopting innovation in time t

P_t - probability of adoption by each potential adopter

N - population of potential adopters

n_{t-1} - number of those that have already adopted the innovation by t-1

Shyamal and Blase used a standard neoclassical production function of the Cobb-Douglas type to determine whether using tractors increased productivity, intensity of cultivation, and displaced human labor. Their model:

$$y = ax_1^{b1}x_2^{b2}x_3^{b3}x_4^{b4}x_5^{b5}e^u \tag{17}$$

where

y = gross value of total output

x_1 = expense on fertilizer

x_2 = total employment of human labor

x_3 = operated area (acres)

x_4 = proportion of cropped area irrigated from all sources

x_5 = tractor use (hours)

u = random disturbance term

Delgado (17) used a constrained maximization technique (Linear Programming) to show that animal traction using oxen in isolation from companion innovations provided only marginal improvements in net returns to farm labor.

Conclusions

This chapter reviewed the rationale for the need to adopt technical innovations and the factors that influence potential users to adopt, the need for some public intervention and/or support, given the knowledge and understanding of the innovations by the potential users, the farmers, and also a review of the diffusion process of these innovations.

These studies have shown that there are many factors that affect the diffusion and adoption of technology, from climate and environment, to risk and government policies. One flaw, though perhaps unavoidable, is to consider these factors in isolation without regard to other factors.

A major objective of agricultural and rural development in African countries should be progressive improvements in rural levels of living achieved primarily through increases in small farm income, output, and productivity. Among agricultural factors to be considered is mechanical innovation suited to the needs of the small scale farmer.

CHAPTER IV

COUNTRY PROFILES

Introduction

A World Bank study has indicated that agricultural output is the single most important determinant of overall economic growth in sub-Sahara Africa. The growth rate of agricultural production has declined to less than population growth, thus leading to the per capita decline in agricultural output. Although this statement holds for the region, the degree to which it holds varies from country to country. In this study, six countries within this region have been selected for analysis. These are Cameroon, Ivory Coast, Kenya, Nigeria, Tanzania, and Tunisia.

This section of the study deals mostly with the profiles of these countries. These profiles cover the location, topography, climate, soil types, land tenure systems, major crops grown for export and local consumption, the importance of agriculture within the economy, and the human resources.

The section is divided into subparts, each subpart containing the profile of each of the countries.

Country Profiles

Cameroon

Cameroon, referred to by the Cameroonians as Africa in miniature, is located in the West-Central part of Africa, covering some 475,400 square kilometers (183,500 square miles). It forms an irregular wedge which extends northeastwards from a coastline on the Gulf of Guinea, an arm of the Atlantic Ocean, to Lake Chad, more than 1,130 kilometers inland. To the west of Cameroon is Nigeria, and to the east is the Central African Republic and the Congo. Gabon, Equatorial Guinea, and the Gulf of Guinea are to the south.

Cameroon has four distinct topographical regions. Behind the swamps and lowlands of the southwestern coastal zone, the land rises to mountains and plateaus above 1,520 meters, extending more than 800 kilometers inland before descending to a flat plain of moderate elevation in the far north. The climate is as varied as the topography. It ranges from the equatorial heat and humidity of the southern border and southwestern coast, through a seasonably cooler and drier region in the central plateau and mountain regions, to the arid northern plain which lies on the approaches to the Sahara Desert.

Natural vegetation in most of the south and coastal zone is a dense, tall, evergreen rain forest. On the southern and southwestern plateaus, the natural cover is a mixture of evergreen and deciduous forest. Farther inland, the natural cover is wooded savanna, a mixture of grasslands, scattered trees, and patches of forest, shading into open grassland with fewer trees in areas to the extreme north. Volcanic soils are found in western Cameroon, especially around the

Cameroon Mountain, and mostly lateritic soils elsewhere.

The land tenure system is predominantly traditional, with land belonging to the tribe. During the colonial days, some of the more fertile land was alienated for plantation agriculture, a process that is gradually being pursued today. Over 50 percent of Cameroon land is forest, 18 percent meadow, 13 percent fallow, and only 4 percent cultivated.

The predominant agricultural practices are traditional, varying among districts, depending on ethnic criteria, availability of land and water resources, the character of the natural vegetation cover, and the local climate. Cultivation of food crops is generally the task of women, and cash crops the domain of men. The man's most important tool is the machete, and the woman's is the short-handle hoe.

In the southern and central portions of the country, forest or bush fallow with relatively short periods of cultivation and long periods of fallow is practiced. The slash-and-burn technique is practiced country-wide. Mixed cropping, which is common, is of greater value in soil conservation than the monoculture of maize or millet. The system also furnishes crops that ripen at different times during the year.

The 1983 mid-year estimate of the population was 9,251,000, with an annual average growth of 2.6 percent. This estimate did not take into account the migration between Cameroon and Chad in the recent years of fighting in Chad. The density was 18 inhabitants per square kilometer (49 per square mile). Life expectancy was estimated at 46 years, and literacy at 70 percent (National Geographic, 1981), with more than 90 percent of school age children attending school.

Major crops grown for exports are coffee, cocoa, bananas, palm oil and palm kennels, and tea. Grown for local consumption are the following crops: plantains, corn, cocoyams, cassava, millet, sweet potatoes, and yams.

Table III shows that in 1970, agriculture contributed 30.6 percent of the GDP, and about the same in 1980. Eighty-five percent of the economically active population were in agriculture in 1965 (Table IV). This percentage fell to 70.3 by 1982.

Ivory Coast

The Ivory Coast lies on the West African Coast to the east of Ghana, south of Mali and Burkina Farso, west of Guinea and Liberia, and north of the Gulf of Guinea, part of the Atlantic Ocean. The country covers an area of 323,750 square kilometers (125,780 square miles).

The topography of the country is one of coastal lagoons in the southeast, densely forested southern region, especially in the thinly populated southwest. The northern region is a savanna zone of lateritic or sandy soils, with the vegetation decreasing from south to north. The inland south-central area is lush tropical forest. The country is mostly flat, except in the northwest, where the Man Mountains rise to 1,460 meters. The climate is warm and humid with two short dry seasons, except the northwest which has only one. Annual rainfall is over 50 inches and heaviest along the coast and western mountain areas. The temperature range is narrow, especially in the south.

The system of holding land for agriculture is founded on the African customary law of collective proprietorship, where all members

TABLE III

AGRICULTURE AS A PERCENT OF GDP, SELECTED SUB-SAHARA COUNTRIES, 1970-1980

Country	1970	1975	1980
Cameroon	30.63	33.60	29.82
Ivory Coast	27.15	28.80	24.00
Kenya	33.61	30.20	27.90
Nigeria	49.01	28.10	22.20
Tanzania	36.86	36.90	46.35
Tunisia	16.73	17.80	14.19

Source: United Nations. Yearbook of National Accounts Statistics (62).

TABLE IV

PERCENT OF ECONOMICALLY ACTIVE POPULATION IN AGRICULTURE, SELECTED SUB-SAHARA COUNTRIES, 1965-1982

Country	1965	1970	1975	1980	1982
Cameroon	85.1	81.7	77.4	72.5	70.3
Ivory Coast	85.3	81.1	75.6	69.7	66.9
Kenya	83.3	80.4	77.2	73.8	72.2
Nigeria	68.7	67.0	65.0	62.8	61.8
Tanzania	87.6	85.9	83.8	80.5	78.9
Tunisia	51.3	46.4	41.8	32.6	30.8

Source: United Nations. Statistical Yearbook (63).

of the community have rights to the use of the land, which is the common heritage of the group. The size of land held varies with the crops and capabilities of the families. The land holding system has, however, been changing since independence, from customary occupancy to holding under registered title, as introduced in the colonial era by the French, who also introduced plantation agriculture, which requires large tracts of land.

Most farm work is done by hand without the aid of draft animals or motorized equipment. The most common implement is the short-handle hoe. Spades, forks, axes, and rakes are being adopted. Some ploughs are used in the north where horses and oxen can live relatively free from diseases. Shifting cultivation, where farming is done for three or four years and left for periods of up to 10 years for the soil to regain its fertility is practiced. The slash-and-burn technique is also practiced. Burning in the savanna region is meant to let young shoots grow for grazing.

The major export crops of the Ivory Coast are cocoa, coffee, bananas, and palm oil and palm kernels. The major crops grown for local consumption are yams, plantains, paddy rice, and millet.

As can be seen from Table III, agriculture contributed 27.2 percent of the GDP in 1970 and 24 percent in 1980. In Table IV, 85.3 percent of the economically active population was in agriculture in 1965, and 67 percent in 1982.

In 1983, the population of the Ivory Coast was estimated to be 8,890,000, with an annual growth rate of 3.2 percent.

Kenya

To the south of the Sudan and Ethiopia, on the east coast of Africa, lies Kenya, a country covering some 582,750 square kilometers (224,960 square miles). Other countries bounding Kenya are Somalia to the east, Tanzania to the south, and Uganda to the west. The country is also bordered by the Indian Ocean to the southeast.

The topography of the country is one of plateaus, plains, and mountains. The land rises gradually westward from the coastal plain in a series of plateaus, culminating in highland areas that are bisected north to south by the great Rift Valley. The northern and northeastern parts of the country are mostly arid plains peopled by semi-nomadic pastoralists.

Although the country lies on the equator, the climate varies with the topography. The highlands have bracing temperate climate, while the coastal zone has high temperatures and humidity. The arid areas are generally hot with low humidity.

During the colonial period, over 3,076.9 million hectares of mostly good farmland was set aside as the White Highlands. Plantation agriculture was practiced on this land. After independence, some of the land was bought from owners and redistributed to the landless subsistence farmers. The land tenure system currently being pursued is one of getting the small landholders to make the transition from traditional system dependent on group sanction to individually registered free hold title.

Of Kenya's total land area of 58,265 million hectares, about 20 percent is thought to be of high or medium potential for crops and intensive forestry and stock raising. Over 70 percent is thought to be usable for extensive grazing. Most of the land is semi desert.

Although Kenya's plantation farms are fairly mechanized with modern implements, the subsistence sector which caters to the existence of most of the population relies on the hoe and other hand implements. Many of these subsistence farmers farm on marginal cropland. Due to population pressure, the bush fallow system of plot rotation has given way to permanent cultivation, thus requiring improved methods of land preparation.

Kenya's main export or cash crops are coffee and tea. Grown mostly for local consumption are corn, wheat, cassava, and paddy rice.

From Table III, 33.6 percent of Kenya's GDP came from agriculture in 1970, and 27.9 percent in 1980. Table IV shows that in 1965, 83.3 percent of the country's economically active population was in agriculture. This percentage declined to 72.2 by 1982. Kenya's 1983 mid-year population was estimated to be 18,580,000, growing at an annual average of 4.1 percent.

Nigeria

Nigeria is located on the West Coast of Africa and covers an area of some 923,768 square kilometers (356,667 square miles). In 1983, the mid-year population estimate of this most populated African country was 85,219,000, and growing at an average annual rate of 3.4 percent. The country is bounded to the east by Cameroon, northeast by Chad, north by Niger, west by Benin, and south by the Gulf of Guinea, an arm of the Atlantic Ocean.

The country has five major geographic divisions, a low coastal zone along the Gulf of Guinea, succeeded northward by hills and low plateaus that stretch into the Niger-Benue River valley. This region is followed by a broad stepped plateau stretching to the northern border and containing high elevations of 1200 meters. There is also the mountainous zone along the eastern border.

The climate is tropical. The southern part is hot and humid throughout the year, with the humidity decreasing northwards toward the Sahara Desert. Rainfall is heavy in the south, especially in the delta region, decreasing northwards.

A 1978 Land Use Decree designed to establish a uniform land tenure system, in effect nationalized all land held under customary and statutory rights by requiring certificates of occupancy from the government and the payment of rents to the government. The decree, however, declared that anyone who normally occupied a piece of land and carried on its development would continue to enjoy the right and benefit of occupancy and could sell, transfer, or otherwise assign interest in the development of the land.

Although most of Nigeria's 91.1 million hectares of land can eventually be used for cultivation, excessive use of the area under cultivation has led to loss of soil fertility. The traditional and predominant form of farming is one of bush fallow. The short-handle hoe and the machete are the most important implements being used. Prior to the government's limited involvement, irrigation was carried out in a primitive way by traditional farmers, especially in the northern part of the country where there is limited rainfall.

The country's soil is clayey in the south and sandy in the north, with a relatively thin top soil, especially in the south. Because of the abundant rainfall in the south, root crops - cassava, yams, cocoyams, and sweet potatoes - are the main staples, while tree crops - cocoa, oil palm - are the areas principle cash crops. In the fairly arid north, millet is the staple, with some corn and rice in the lowlands. Groundnuts have been the chief commercial crop of the north.

Agriculture accounted for 49 percent of the GDP of Nigeria in 1970, and 22 percent in 1980 (Table III). In 1965, 68.7 percent of the economically active population was in agriculture, and 62 percent in 1982 (Table IV).

Tanzania

Tanzania is located in East Africa and covers a total area of 931,082 square kilometers (363,708 square miles). This includes the offshore islands of Zanzibar, Pemba, and Mafia. The country is bordered to the north by Kenya and Uganda, to the west by Rwanda, Burrundi, and to the southeast and south by Zambia, Malawi, and Mozambique.

The 1983 mid-year population estimate of the country was 20,524,000, with an annual average growth rate of 3.2 percent. The population density was 21.8 per square kilometer.

The topography of the country is one of coastal lowlands yielding to plateaus of 915 meters to 1,830 meters toward the inland. Mountains to 2,845 meters border the country in the southwest.

Weather conditions are dominated by Indian Ocean monsoons that bring two rainy seasons which affect different parts of the country at different times. Most of the country is dry, and the rainfall uncertain. Temperatures vary with place and altitude, with ground frosts occurring at altitudes of over 2,440 meters.

Land tenure system in Tanzania has undergone quite a few changes. In the pre-European period, land belonged to the community and the occupant had usufructary rights only, which were, however, permanent and could be passed on to heirs. Land was not conceived of as a marketable commodity. In the colonial days, substantial land was set aside for plantations, thereby introducing the European concept of private ownership and leaseholds. After independence, and with the introduction of socialism, came the process of villagization, Ujama villages. This establishment of planned villages was meant to lead to a rapid increase in agricultural production. Farmers were asked to group themselves into socialist villages to work and farm the land collectively. Cooperative farm machinery will then be effected, and the purchases of supplies and the marketing of crops done jointly.

The basic agricultural implement used by the subsistence farmers in Tanzania is the long-handle hoe. The government has been trying to alter the traditional structure of rural production, which has been the bush fallow system.* Because about 60 percent of the land is infested with tse-tse flies, use of draft animals is limited.

Cash crops include coffee, tea, cashew nuts, cloves, and coconut products, while crops for local consumption include paddy rice, corn, beans, cassava, and sweet potatoes.

Table III shows that in 1970, agriculture accounted for 36.9 percent of the GDP. By 1980, this contribution had risen to 46.4

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*Bush fallow is where farm land is left fallow for over three years to allow for regrowth of natural vegetation which replenishes soil nutrients.

percent. Table IV shows that in 1965, 87.6 percent of the economically active population were in agriculture, dropping to 78.9 percent by 1982.

Tunisia

Tunisia is not a sub-Sahara country. It is one of the North African countries. The country is bounded by Algeria to the west and southwest, Libya to the southeast, and the Mediterranean Sea to the north and northeast. The country covers an area of 164,000 square kilometers, with 1,600 kilometers of coastline.

The dominant natural feature is the Dorsale Mountain chain, which extends across the north-central portion of the country. North of Dorsale is uneven terrain which is generally mountainous except where the Majardah River passes through a fertile flood plain. To the south is the Sahara Desert. The climate is Mediterranean with occasional frosts in the interior. Precipitation decreases southward. Heavy morning dew supplements the scanty rainfall in parts of the country.

The agricultural utility of land is very much affected by the terrain and the weather. Apart from the alluvial valleys of the north, the soil is dry, sandy, and frequently saline.

Before the colonial period, different land tenure systems existed in the north and southern parts of the country. In the north, Muslim law of equal inheritance among heirs prevailed, leading to great fragmentation of the land. In the south, the land was collectively owned as tribal property, which gave the individual a right to share in the use of the land. Another land tenure system, an old Islamic institution, the habus was a foundation from which the revenues were dedicated in perpetuity for a charitable purpose. Property so endowed could not be expropriated and was inalienable. In the colonial period, all uncultivated land was decreed to be state land. This land was then sold to European farmers. After independence, some of the European landholders sold their land to the government, while some of it was confiscated. This land was then operated as a cooperative under the auspices of the government. The land tenure system operating today is a mixture of all of these systems.

Realization of the full potential of the country's farmlands is hampered by low-yielding, traditional farming practices. The traditional practices are marked by heavy dependence on hard labor or, at best, use of draft animals. Farm implements and equipment are rudimentary, and little use is made of crop rotation, fertilizers, or soil conservation techniques such as terracing. Most of these subsistence farmers work on land that is only of marginal value, unless improved by irrigation or other means. Irrigation is extremely important in the agriculture of Tunisia.

Major crops grown are barley, wheat, olives, grapes, citrus fruits, and vegetables.

Looking at Tables III and IV, it can be seen that in Table III agriculture accounted for 16.7 percent of the GDP in 1970 and 14.2 percent in 1980, while in Table IV, 51.3 percent of the economically active population were in agriculture in 1965. This percentage fell to 30.8 by 1982.

The 1983 mid-year population estimate was 7,020,000, with an annual average growth rate of 2.6 percent.

Conclusions

Although the percentage contribution of agriculture to the GDP has been declining over the years, its contribution is still so substantial as to make it the backbone of the economy of these countries. Agriculture is also the major employer in these countries.

Given the profiles of the countries, some pertinent points emerge, which make the agricultural sector suited for adopting new agricultural technology. These points which are common to all or most of the countries include:

- predominate practices of soil preparation which tend to bleach the soil of its nutrients.
- growing population pressure on the land which limits the practices of shifting cultivation.
- low productivity of traditional methods.
- most of the farmers are subsistence farmers, and they farm mostly marginal land.
- except Tunisia, the countries have portions of the land infested with tse-tse flies. Animal power cannot be used here.
- all the countries have arid areas that can be brought under cultivation through irrigation, depending on the water resources.
- there is a physical effect on the farmers, especially in Cameroon, Ivory Coast, and Nigeria, where traditional farmers use the short-handle hoe.

The mix of the types of agricultural technology that can be adopted will vary from country to country, but will include land preparing implements, HYV seeds, and irrigation.

CHAPTER V

POPULATION DENSITY AND INTENSITY OF LAND CULTIVATION

Introduction

Rapid population growth in sub-Sahara Africa is stretching the food producing capabilities of the farmers tremendously, given their present level of technology. Increasing food demands, without the accompanying improvements in the farming methods, including technology, leads to exhaustion of the land under cultivation. The traditional farmers' means of coping with reductions in per capita land availability and increasing demand for food has been to bring additional land into cultivation, and to reduce fallowing in some cases.

Some farming systems, such as hunting pastoralism, and long-fallow agriculture can support only sparse populations. A sudden increase in the rate of populations growth leads to reliance on imported food if starvation is to be averted. Densely populated areas have to employ systems of intensive agricultures such as annual cropping or multicropping. This means that there is a positive correlation between population density and the intensity of food supply system.

Population density is, however, not the only factor that influences the intensity of land use. Soil fertility is also a factor that influences the intensity of land use. The marginal productivity of labor is relatively higher on more fertile soils, and hence would encourage in-migration, given an increase in population and a good infrastructure. Migration to the more fertile areas would lead to reductions in cultivable areas per capita. Areas with better access to markets either through transport networks or those in the proximity of urban centers would be more intensely cultivated.

The focus of this chapter is to determine to what extent there is any correlation between population density and some farm technologies. Population density is one of many determinants or causal factors for technological change.

Analysis and Discussion of Results

Table V presents the relationships between the intensity of the agricultural system and population density. As the density of the population increases and the demand for food increases, the intensity of the farming system increases. The level of the intensity of cultivation affects forests and regrowth, which in turn affect soil fertility.

According to the classifications of Table V, Cameroon, Ivory Coast, Kenya, Tanzania, and Tunisia would be classified as bush and/or short fallow, while Nigeria, with a population density of 90 inhabitants per square kilometer (1982), would be classified as an annual or multicropping food system. This compares with France and India with population densities of 97.8 and 205.7 inhabitants per square kilometer which should be classified as annual or multicropping, and the United States with a population density of 24.5 inhabitants per

TABLE V

FOOD SUPPLY SYSTEMS

Food Supply System	Farming Intensity* (percent)	Population Density (persons/km^2)	Climatic Zone
Gathering	0	0-4	
Forest Fallow (15-25 yrs)	0-10	0-4	Humid
Bush Fallow (8-10 yrs)	10-40	4-64	Humid & Semi-Humid
Short Fallow (1-2 yrs)	40-80	16-64	Semi-Humid & Semi-Arid
Annual Cropping	80-120	64-256	Semi-Arid
Multicropping	200-300	764	Semi-Arid

* Farming Intensity or Frequency of cropping is average cultivated area as percentage of cultivated plus fallow area.

Source: Boserup, Ester. Population and Technological Change, p. 19 (9).

square kilometer which should fall under bush and/or short fallow. However, as Figure 3 shows, Kenya and Tunisia fall under no fallow or annual cropping. These countries have a large share of their national territories as unirrigable deserts and mountains too steep for terracing or use as pastures. The arable land is quite small (13 percent for Kenya and 28 percent (arable and tree crop) for Tunisia). Nigeria falls under short fallow, while Tanzania, Ivory Coast, and Cameroon fall under medium to long fallow or short to bush fallow by the classification in Table V.*

Figure 4 shows the correlation between population density and irrigation. Although all the countries have either desert or semi-desert regions, only Tunisia has a significant amount of irrigation. There is no noticeable correlation between population density and irrigation. Given Nigeria's population density it would have been expected that the level of irrigation will be higher. Nigeria, however, has a higher percentage of arable land (33 percent) than the other countries.

Given suitable soil conditions, areas with better access to markets either through transport networks or places near urban centers will be intensely cultivated. Figure 5 presents the correlation between population density and infrastructure. There is a weak correlation between population density and infrastructure, with the Ivory Coast falling away from the trend curve. The Ivory Coast, with a population density less than that of Nigeria, Tunisia, and Kenya, has

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*Country classifications are from country studies. See Chapter IV.

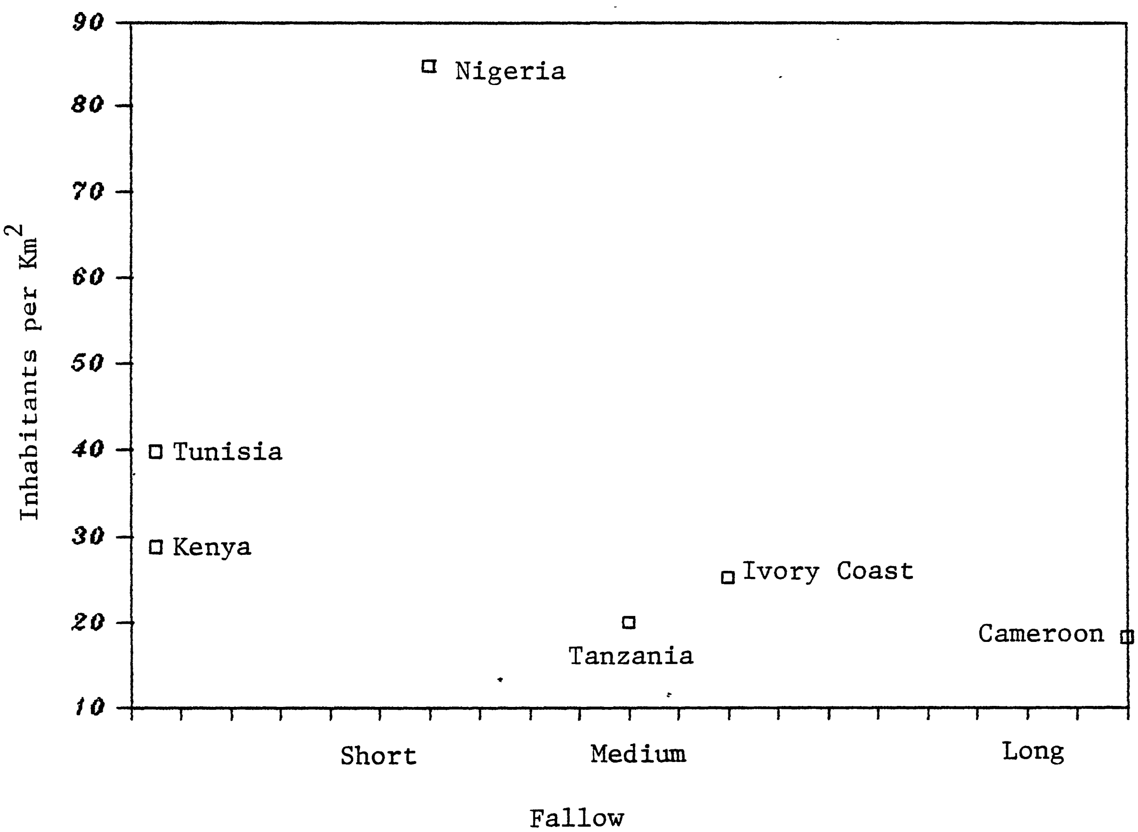

Figure 3. Population Density and Fallow, Selected Sub-Sahara Countries, 1981

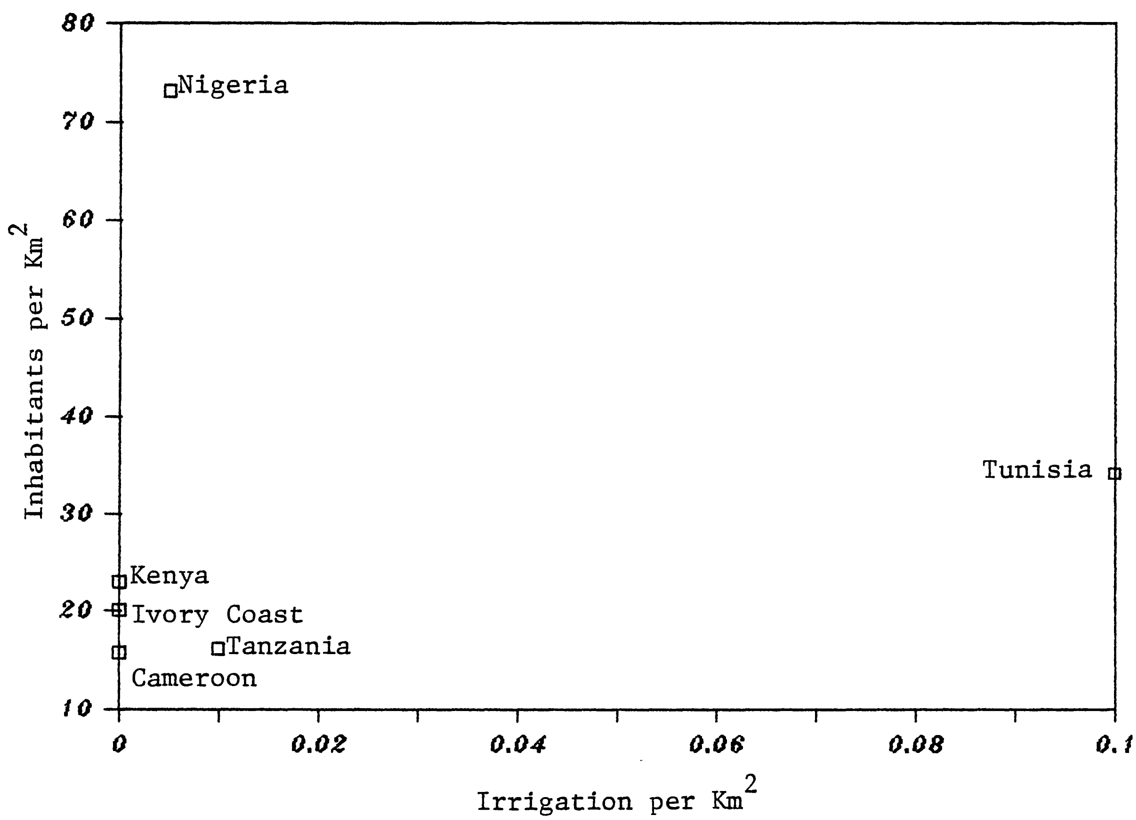

Figure 4. Population Density and Irrigation, Selected Sub-Sahara Countries, 1981

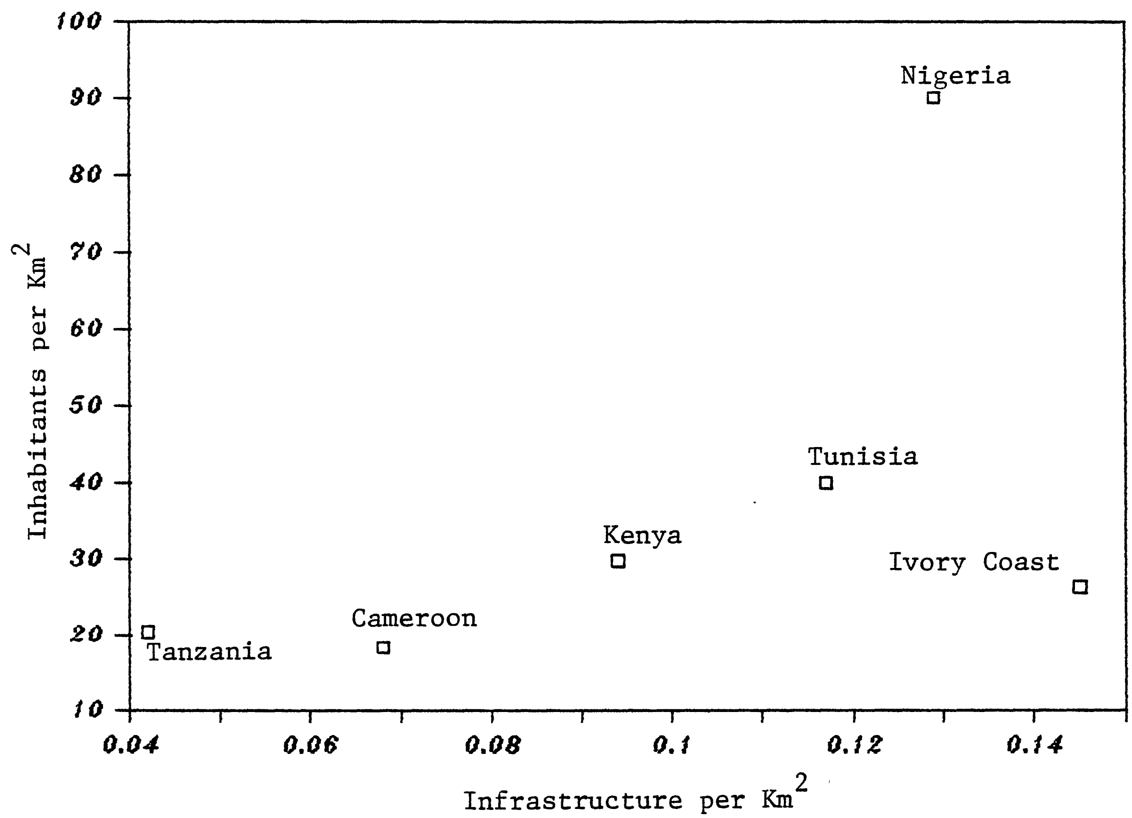

Figure 5. Population Density and Infrstructure Density, Selected Sub-Sahara Countries, 1981

the highest infrastructure density of the six countries in the study. Tanzania, with the poorest infrastructure in 1981 has a slightly higher population density than Cameroon, the next country with a poor infrastructure.

A correlation between population density and infrastructure will lead to intensification of cultivation because higher prices and elastic demand for food will imply that marginal utility of effort will increase, and hence, farmers in the region will begin cultivating larger areas, and higher returns to labor will encourage immigration into the area from other regions.

Figure 6 presents the correlation between population density and labor productivity. Labor productivity is in metric tons per agricultural worker. Because there is no pattern, it can be inferred that there is no correlation between population density and labor productivity. Tunisia, with the highest labor productivity, has a population density much lower than that of Nigeria, although higher than the other countries. Cameroon, with the lowest population density, has a labor productivity slightly higher than or equal to Kenya and Tanzania. Nigeria has the highest population density, and a labor productivity slightly higher than or equal to the Ivory Coast, but higher than Cameroon, Kenya, and Tanzania.

For purposes of comparison, the United States has a population density about the same as the Ivory Coast, but has a productivity much higher than all of the countries in the study. France and India have population densities higher than the countries in the study. The productivity of France compares to that of the United States, while that of India compares to that of the Ivory Coast.

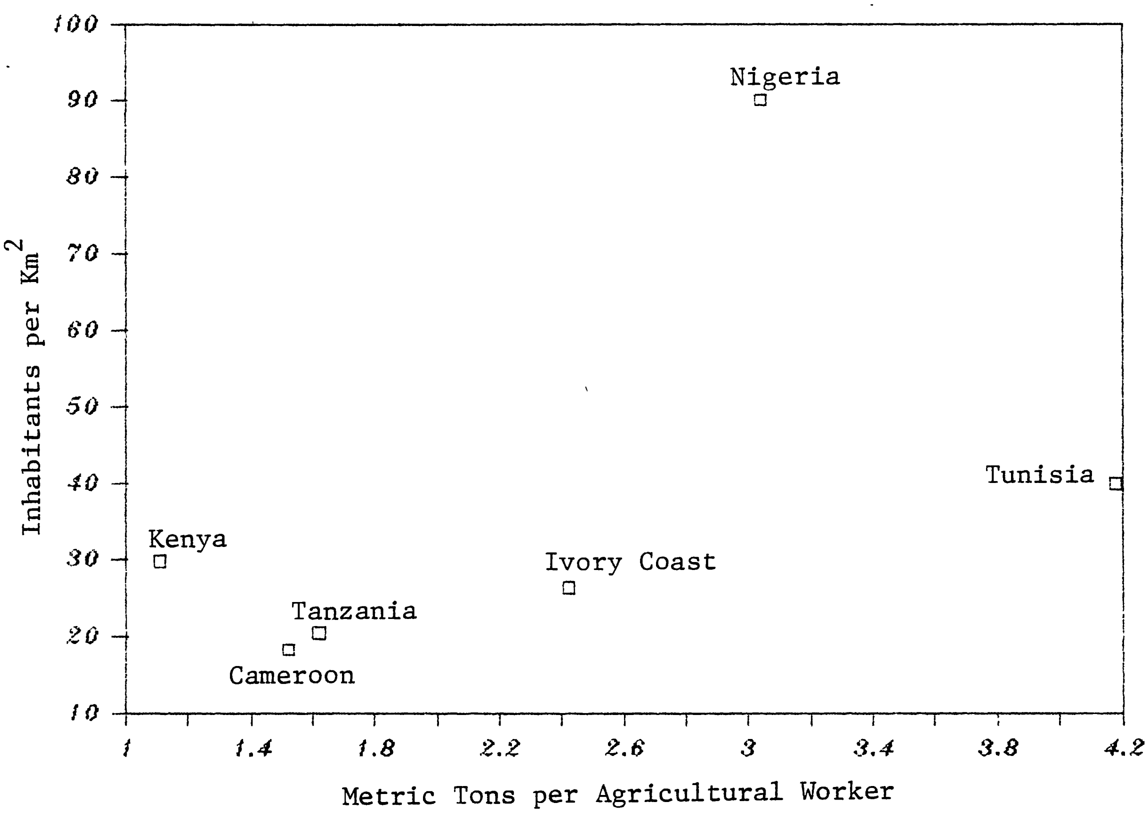

Figure 6. Population Density and Agricultural Labor Productivity, Selected Sub-Sahara Countries, 1981

The correlation between population density and tractor density is shown in Figure 7. Except for Nigeria, there is a weak correlation between population density and tractor density. Cameroon has the lowest population and tractor densities. Tunisia has the highest tractor density. Nigeria, with the highest population density has a tractor density about the same as the Ivory Coast, but slightly lower than Tanzania and Kenya.

Figure 8 shows the correlation between population density and fertilizer density. There is a correlation between population density and fertilizer density, but with Nigeria as an outlier.

Table VI shows countries grouped by population density and technological level. Determination of technological level is based on four indicators:*

a) energy consumption per capita,

b) number of telephones per thousand inhabitants,

c) average life expectancy at birth, and

d) literacy among persons 15 years and older.

The table covers the years 1965, 1970, 1975, and 1980. In 1965, Cameroon, Ivory Coast, Tanzania, Kenya, and Nigeria were in technology group I, while Tunisia was in technology group II. Cameroon, Ivory Coast, and Tanzania were in the lowest population density group (8-16), Kenya and Tunisia were in the 16-32 population density group, and Nigeria was in the 32-64 density group. By 1980, all of the countries had moved up a group in population density and technology group, except

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*For a detailed explanation of these indicators, see Boserup, Ester. Population and Technological Change, pp. 12, 13.

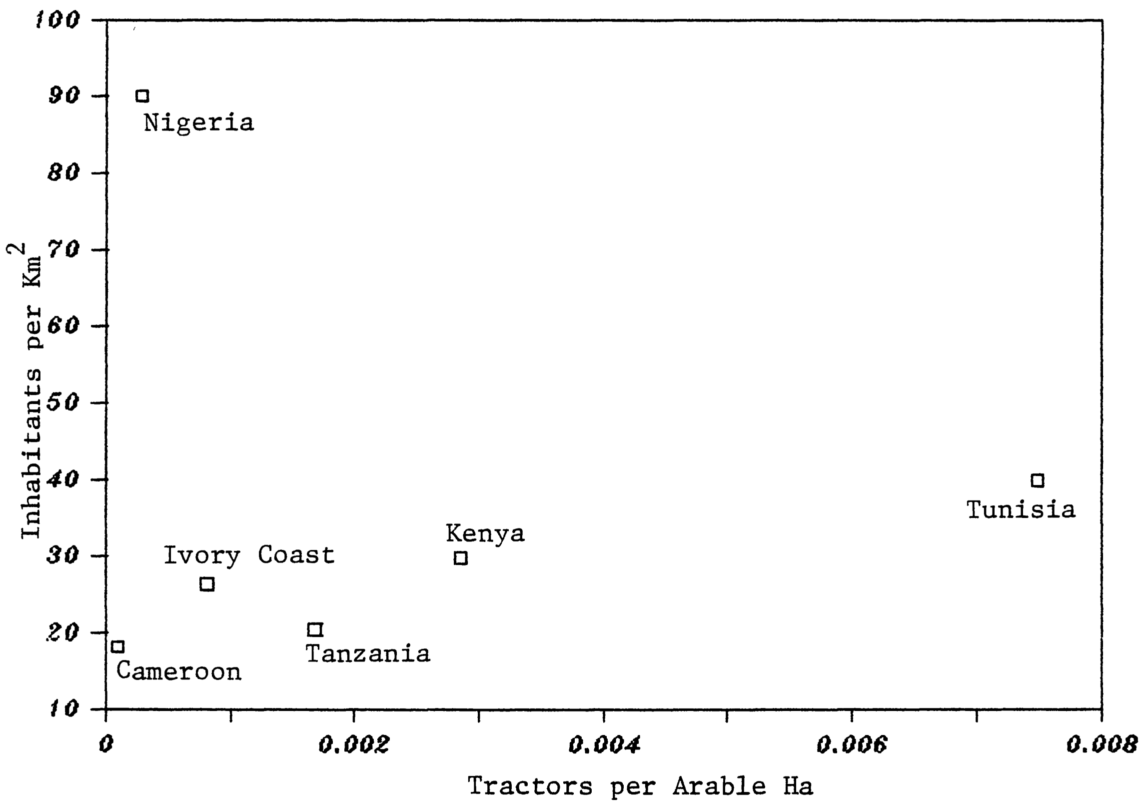

Figure 7. Population Density and Tractor Density, Selected Sub-Sahara Countries, 1981

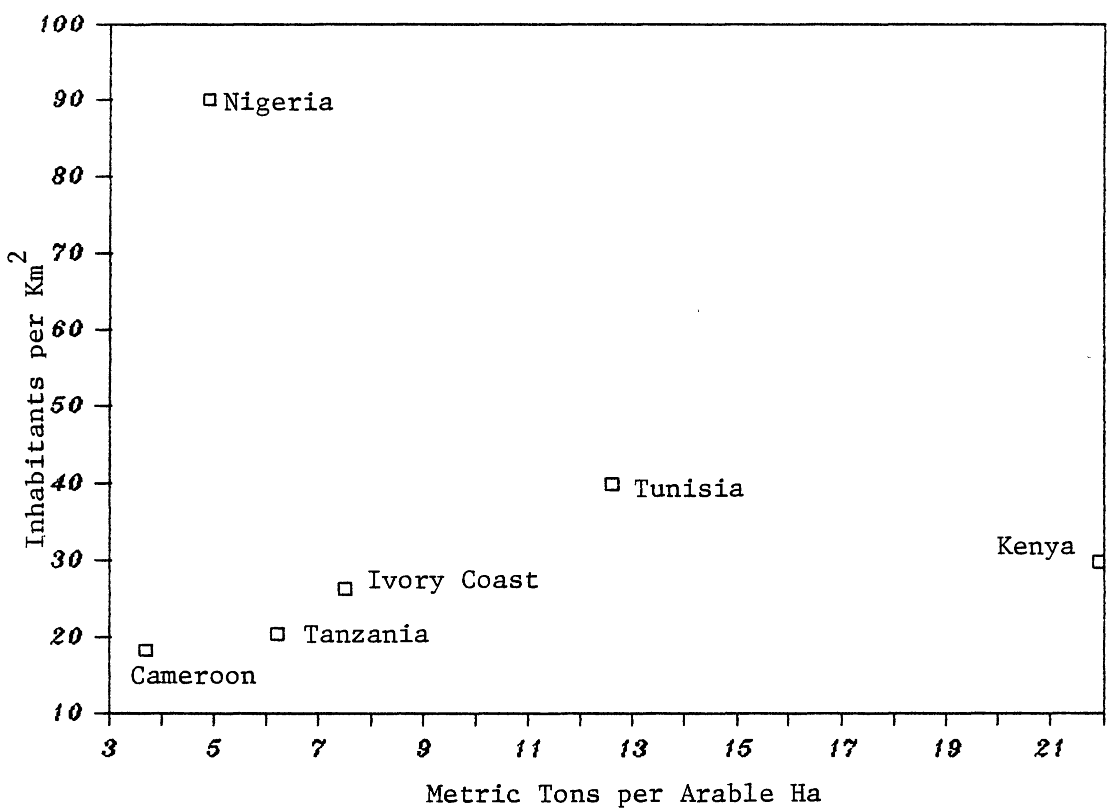

Figure 8. Population Density and Fertilizer Density, Selected Sub-Sahara Countries, 1981

TABLE VI

COUNTRIES GROUPED BY DENSITY AND TECHNOLOGICAL LEVEL;
1965, 1970, 1975, 1980.

Year	Technology Group I	II	III	IV
1965	Cameroon (5) Ivory Coast (5) Tanzania (5) Kenya (6) Nigeria (7)	Tunisia (6)		
1970	Cameroon (5) Nigeria (7)	Ivory Coast (5) Tanzania (5) Kenya (6)	Tunisia (6)	USA (6) France (8)
1975	Cameroon (5) Nigeria (8)	Ivory Coast (5) Tanzania (5) Kenya (6)	Tunisia (7)	
1980	Nigeria (8)	Cameroon (6) Ivory Coast (6) Kenya (6) Tanzania (6)	Tunisia (7)	

Density in inhabitants per square kilometer:
5 = 8-15
6 = 16-31
7 = 32-63
8 = 64-127

Source: Based on data from Boserup, Ester. <u>Population and Technological Change</u>. CIA. <u>World Factbook</u>, and UN <u>Statistical Yearbook</u>, (9, 12, 63).

Kenya and Nigeria. Kenya had moved up one technology group but was still in the same population group (16-32), while Nigeria had moved up one population group, but had stayed in the same technology group (I). In general, population density increased faster than technological level. For example, in 1970, the United States in a population density group of 16-32 was in technology group IV, while France in a population group of 64-128 inhabitants per square kilometer was also in technology group IV. India in a population group of 128-256 was in technology group II, together with the Ivory Coast, Kenya, and Tanzania. Tunisia was already in technology group III.

Conclusions

Information from the correlation charts supports the existence of a weak relationship between population density and some of the proxies for the adoption of technology. Nigeria, however, appears to be an outlier in most of the charts. This probably reflects a different development strategy favoring oil production.

The relationship between population density and some of the proxies for the adoption of technology is weak because population density is only one of many determinants of technological change. Other determinants, particularly government policies, may be of critical importance. In an environment with little or no government policies, a stronger correlation between population densities and some of the proxies for the adoption of technology would have been expected. In particular, the weak correlation between population densities and productivity suggests that population density is providing little explanatory power and that other determinants of the adoption of technology must be considered. Moreover, some government policies may actually be detrimental to the diffusion process.

CHAPTER VI

POLICY FACTORS INFLUENCING PRODUCTIVITY AND ADOPTION OF NEW TECHNOLOGIES IN AGRICULTURE

Introduction

Increasing output and productivity will require a combination of biological and man-made factors that affect production. In the last chapter, emphasis was on the biological factors that influence the adoption of productivity and yield improving technologies. In this chapter, the emphasis is on the man-made or policy factors that influence the adoption of new technologies.

The chapter is divided into five parts. The first, part (a), examines the degree to which some food objectives have been met. Part (b) deals with direct and indirect measures of technologies that have been adopted, while part (c) examines the same, but on an individual country basis, as an attempt to establish some relationship between productivity and output, and technology. Part (d) examines some of the policy factors that influence the adoption of new technologies in agriculture, and part (e) presents an empirical test of causal relationships.

Food Objectives

Table VII presents the stated government food policy objectives

TABLE VII

STATED GOVERNMENT FOOD POLICY OBJECTIVES AND GOALS

Country	Consumer Welfare	Producer Welfare	Government Revenue	Foreign Exchange	Self Sufficiency	Stable Prices	Food Security
	X Indicates Presence of Objectives						
Cameroon		X		X	X		
Ivory Coast		X		X	X	X	
Kenya		X		X	X		X
Nigeria		X			X		
Tanzania					X		
Tunisia		X		X	X		

Sources: USDA and University of Minnesota: Food Policies in Developing Countries
USDA: Sub-Saharan Africa. Outlook and Situation Report, 1984, (64, 66).

and goals of the countries in this study. Self-sufficiency is an explicit goal of all the countries. It is often considered a measure of agricultural success and, given that it is an explicit goal, it is worthwhile to judge the efficacy of agricultural policy to meet this goal. The data (Table VIII) suggest failure. The countries were less self-sufficient in 1978-80 than they were in 1964-66. Kenya showed very little change, while the other countries showed substantial changes. Nigeria had the most decline (about 15 percentage points). Food self-sufficiency in the Ivory Coast has been the lowest of any of the countries under consideration.

Being less than fully self-sufficient, and given the starvation and malnutrition in the region, creates a greater urgency to increase production and adopt the appropriate technology. Another important stated food objective is producer welfare. However, as Table IX indicates Cameroon and Tanzania tax their agriculture heavily, while the other countries are mixed, subsidizing some commodities and taxing others. In Kenya and Tanzania the policy is to tax agricultural commodities where they have a comparative advantage, and to subsidize other agricultural commodities.

It would appear that without attaining the goal of self-sufficiency, the objective of food security cannot be met. Stable consumer prices, if lower than the cost of production, will be a disincentive to producers.

Indicators of Technology Adoption

The countries in this study do not have good time series data bases from which researchers can draw for effective research work. The

TABLE VIII

FOOD SELF-SUFFICIENCY RATIOS*, SELECTED SUB-SAHARA COUNTRIES, 1964-1966, 1978-1980

Country	1964-66 (Percentages)	1978-80
Cameroon	95	87
Ivory Coast	73	71
Kenya	97	96
Nigeria	98	84
Tanzania	96	93
Tunisia	95	95

Source: Agarwal, R., Price Distortions and Growth in Developing Countries (3).

*Definition: Production/(Production + Imports - Exports).

TABLE IX

NOMINAL PROTECTION/TAXATION OF AGRICULTURE, SELECTED SUB-SAHARA COUNTRIES, SELECTED YEARS*

		Rice	Wheat	Maize	Coffee	Tea	Sugar	Beef	Cotton	Average
Cameroon		.53(70-76) 1.40(77-83)	Cocoa 0.37(71-75) 0.45(76-80)		.42 (70-83)	0.51 (71-80)			.16 (70-83)	.50
Ivory Coast		1.17	.41(Cocoa) (1971-79)	1.0	.32 (1971-79)	.91 (Copra)	.88 (Ground- nut)			.73
Kenya	1974/5-80	1.64	1.43 (75-80)	.96(71-75) 1.33 (76-80)	0.94 (71-75)	0.89 (71-75)	2.5	0.97	1.07 (71-75)	1.32
Nigeria	(74/75)	2.88	1.23 (sorghum)	1.67	1.49 (millet)		1.59 (Ground- nut)			1.77
Tanzania		0.51 (81-82)		0.23 (81-82)	0.70 (71-80)					.48
Tunisia			1.13 (75-80)	.97 (Barley)(75-80)						1.05

*NPC = Producer Price/(World Price - Transport and Marketing Costs)

Source: Agarwal, R., Price Distortions and Growth in Developing Countries. Burfisher, Mary, Cameroon: A Market Profile. World Bank, Accelerated Development in Sub-Saharan Africa (4, 10, 69).

data used here are mostly that obtained from the United Nations Food and Agriculture Organization, and the World Bank. These sources do not have the data subclassified as needed in this study.

Two measures of productivity are considered here, productivity per hectare, and productivity per worker. Table X shows productivity relative to agricultural workers. Three of the six countries, Cameroon, Kenya, and Nigeria, showed almost no change in productivity per worker over the decade of the seventies. The other three had significant increases. Tanzania had a 50 percent increase, Tunisia a 40 percent increase, and Ivory Coast a 26 percent increase. Productivity is generally low, averaging only 1.58 metric tons per agricultural worker per year in Cameroon, 2.20 metric tons in the Ivory Cost, 1.07 metric tons in Kenya, 3.00 metric tons in Nigeria, 1.40 metric tons in Tanzania, and 3.65 metric tons in Tunisia.

Tables XI, XII, and XIII show yields in kilograms per hectare for cereals, corn, and roots and tubers. Kenya has the highest yield per hectare for cereals and corn, while Tunisia has the highest yield per hectare for roots and tubers. However, Kenya has the lowest productivity per agricultural worker. This is due in part to the higher density of farm/agricultural workers per hectare of arable land (2.30 as compared with .48 for Cameroon, .21 for the Ivory Coast, .53 for Nigeria, 1.25 for Tanzania, and .13 for Tunisia for the 1982 agricultural population). An increased yield in the more land abundant countries will increase the productivity per worker.

To increase yield will require the adoption of some high yield varieties or some other technology. Table XIV and Figure 9 show total fertilizer consumption for each of the six countries. Kenya, Tunisia,

TABLE X

AGRICULTURAL PRODUCTIVITY, SELECTED SUB-SAHARA COUNTRIES, 1971-1981[a]

Year	Country					
	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
	(Metric Tons/Ag. Worker)					
1971	1.51	1.92	.93	3.01	1.08	2.98
1972	1.50	1.93	.95	2.99	1.10	3.30
1973	1.51	1.96	.99	3.04	1.10	3.57
1974	1.51	2.12	1.01	3.05	1.24	3.83
1975	1.65	2.24	1.09	3.04	1.37	3.95
1976	1.72	2.29	1.18	3.00	1.53	3.76
1977	1.73	2.26	1.20	2.93	1.55	3.49
1978	1.62	2.28	1.14	2.95	1.58	3.42
1979	1.54	2.35	1.09	2.99	1.58	3.66
1980	1.53	2.40	1.08	3.01	1.61	3.98
1981	1.52	2.42	1.11	3.04	1.62	4.18
Average	1.58	2.20	1.07	3.00	1.40	3.65

Source: Calculated from USDA Data (65).

[a]3 Year Moving Average

TABLE XI

CEREALS YIELD, SELECTED SUB-SAHARA COUNTRIES, 1969-1981

	Country						
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia	Africa
				(Kg per Ha)			
1969	882	865	1288	776	669	421	914
1970	842	823	1234	783	787	415	925
1971	937	1001	1295	621	713	564	979
1972	871	879	1245	674	804	664	991
1973	836	895	1223	547	785	700	853
1974	1040	933	1146	645	1054	749	983
1975	957	1015	1252	655	921	796	985
1976	968	749	1580	667	742	692	969
1977	907	754	1552	672	780	522	924
1978	980	753	1410	686	841	647	972
1979	916	763	1277	686	757	597	928
1980	932	729	1618	725	684	915	1003
1981	942	693	1717	732	668	972	1055

Source: FAO Production Yearbook (21).

TABLE XII

ROOTS AND TUBERS YIELD, SELECTED SUB-SAHARA COUNTRIES, 1972-1981

	Country						
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia	Africa
				(Kg per Ha)			
1972	3722	4054	6523	9803	4059	26250	6934
1973	3578	4297	6699	9839	4313	16905	6966
1974	3706	3981	7306	10066	5222	23810	7001
1975	3616	4927	6862	10054	5811	23444	7112
1976	3607	5377	7628	9982	4877	21000	7006
1977	3563	5373	7464	9736	4878	17347	6898
1978	3684	3812	7937	9704	4941	10825	6599
1979	3675	3893	8012	9376	4942	12500	6563
1980	3631	3822	7898	9431	4981	11215	6608
1981	3728	3832	7979	9431	5127	11475	6685

Source: FAO Production Yearbook (21).

TABLE XIII

MAIZE (CORN) YIELD, SELECTED SUB-SAHARA COUNTRIES, 1969-1981

	Country						
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia	Africa
				(Kg per Ha)			
1969	1069	783	1329	1040	518	--	1130
1970	117	561	1273	1040	628	--	1152
1971	1263	667	1364	721	523	--	1282
1972	1182	665	1292	829	705	--	1356
1973	1154	682	1280	603	683	--	1078
1974	1207	533	1120	754	1033	--	1364
1975	1029	589	1280	714	900	--	1308
1976	1044	477	1635	837	690	--	1225
1977	1000	480	1626	864	745	--	1280
1978	747	468	1456	904	801	--	1283
1979	897	471	1286	901	692	--	1194
1980	907	467	1725	906	577	--	1320
1981	926	463	1842	905	577	--	1499

Source: FAO Production Yearbook (21).

TABLE XIV

FERTILIZER CONSUMPTION (NITROGENOUS AND PHOSPHATE), SELECTED SUB-SAHARA COUNTRIES, 1966-1981

	Country					
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
			(1000 M.T.)			
1966	2.4	3.9	15.5	1.9	2.7	17.0
1967	10.1	7.6	30.5	6.2	5.5	19.9
1968	12.9	5.7	30.8	9.4	6.0	25.6
1969	10.0	6.5	39.0	9.7	8.5	24.6
1970	15.4	9.3	46.2	5.9	12.0	32.0
1971	15.4	9.7	44.4	6.9	12.0	37.6
1972	8.3	12.8	46.9	13.5	14.0	31.5
1973	10.1	12.1	48.3	11.3	12.9	36.9
1974	11.6	12.1	48.4	10.2	16.9	37.1
1975	12.2	12.2	48.8	23.9	25.6	45.4
1976	9.4	16.5	42.1	46.3	26.2	49.1
1977	6.2	17.3	49.7	60.0	24.3	51.8
1978	21.6	26.8	46.5	60.0	25.1	40.5
1979	22.3	23.0	41.9	57.9	23.3	51.2
1980	19.7	25.0	30.3	93.3	27.5	56.0
1981	25.4	29.6	50.7	148.4	32.2	58.8

Source: UN Statistical Yearbook, (63).

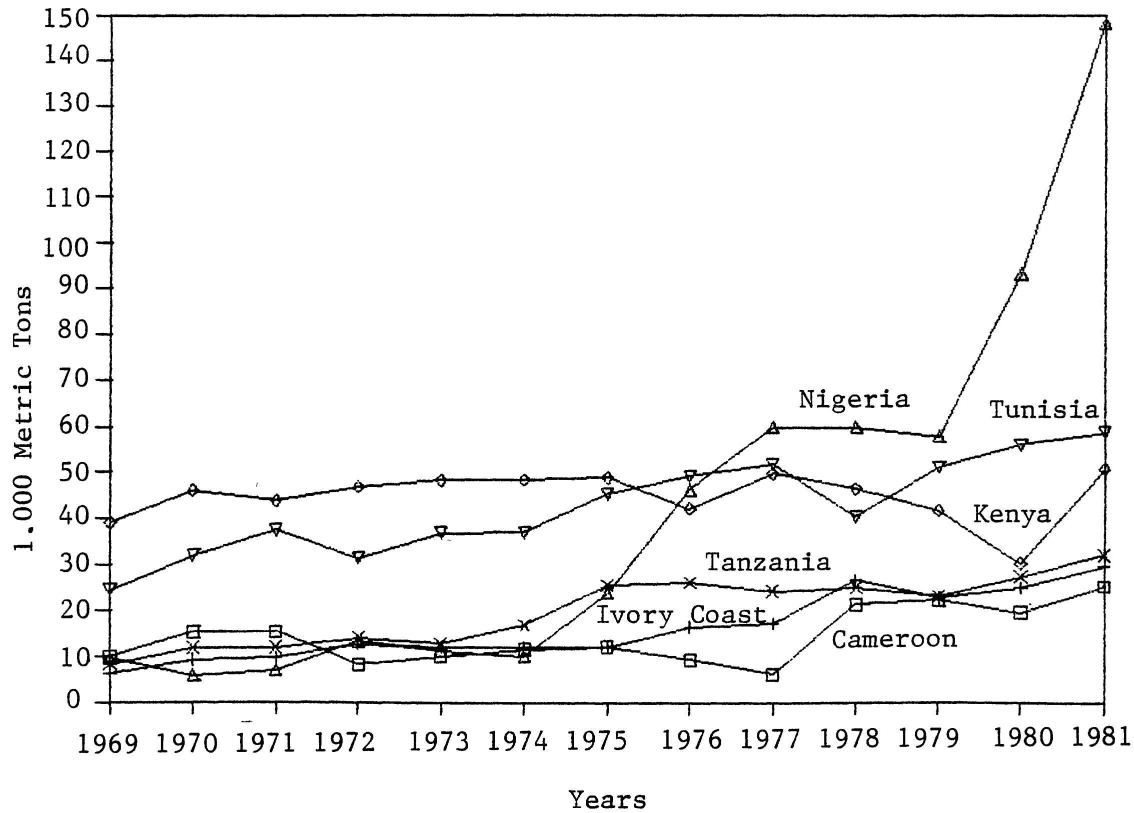

Figure 9. Fertilizer Consumption, Selected Sub-Sahara Countries, 1969-1981

and Nigeria (from 1976), consumed about two-thirds of all the fertilizer consumed by the six countries. However, when fertilizer density measured by metric ton per arable hectare is considered (Table XV), Nigeria falls below Tanzania and Ivory Coast. Kenya has the highest fertilizer density, followed by Tunisia. Cameroon has the lowest. It would appear then, that there is a relationship between fertilizer use and yield. These indicators reflect a variety of possible technologies (for example, HYV's, mechanization, etc.) and can not attribute productivity to just one (say fertilizer).

Another technology that may influence yield is mechanization. Table XVI and XVII show the tractors in use in the different countries, and the tractor density for the arable land. Tunisia is by far the largest user of tractors (using more than three times the next highest user), and Cameroon is the smallest user of tractors (less than one quarter the next higher user). Tractor use in Kenya increased least (percentage-wise) from 1965 to 1981. For tractor density, Tunisia still has the highest per arable hectare, followed by Kenya, with Cameroon at the bottom.

Although tractors may not directly influence yield, it may directly influence labor productivity, by bringing more land into cultivation, allowing for multicropping, and better land preparation. A combination of tractor and fertilizer use should increase output and productivity.

To examine the relationships between these indicators of technology adoption, plots of agricultural productivity (labor and land productivity), fertilizer density, and tractor density by countries will be considered. Land productivity is measured by yield per hectare

TABLE XV

FERTILIZER DENSITY, SELECTED SUB-SAHARA COUNTRIES, 1969-1981

	Country					
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
			(M.T. per Ha)			
1969	0.0017	0.0023	0.0188	0.0003	0.0018	0.0055
1970	0.0026	0.0034	0.0223	0.0002	0.0025	0.0071
1971	0.0026	0.0035	0.0213	0.0002	0.0025	0.0084
1972	0.0013	0.0045	0.0223	0.0005	0.003	0.0069
1973	0.0016	0.0042	0.0223	0.0004	0.0026	0.0078
1974	0.0018	0.0035	0.0216	0.0003	0.0034	0.0076
1975	0.0019	0.0035	0.0217	0.0008	0.0051	0.0093
1976	0.0014	0.0045	0.0185	0.0015	0.0052	0.0099
1977	0.0009	0.0046	0.0219	0.002	0.0048	0.0081
1978	0.0032	0.0071	0.0205	0.002	0.0049	0.0081
1979	0.0032	0.006	0.0185	0.0019	0.0045	0.0104
1980	0.0028	0.0065	0.0132	0.0031	0.0054	0.0114
1981	0.0037	0.0075	0.0219	0.0049	0.0062	0.0126

Source: Calculated from FAO Production Yearbooks, and UN Statistical Yearbook (21, 63).

TABLE XVI

TRACTORS IN USE, SELECTED SUB-SAHARA COUNTRIES, 1969-1981

	Country					
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
			(Number)			
1969	84	1231	6500	2000	5180	18800
1970	80	1412	6550	3000	5500	19100
1971	96	1619	6600	3800	6100	19500
1972	100	1800	6650	6500	6500	20000
1973	230	1800	5721	7000	6800	20500
1974	250	1950	6195	7300	7000	28000
1975	280	2150	6013	7500	7100	29000
1976	300	2300	5982	7700	7200	30000
1977	350	2700	6186	7900	7300	31000
1978	400	2850	6449	8100	7500	32000
1979	421	3000	6374	8300	8500	33000
1980	572	3100	6546	8600	8600	34000
1981	675	3200	6600	8800	8720	35000

Source: FAO Production Yearbook, U.N. Statistical Yearbook (21, 63).

TABLE XVII

TRACTOR DENSITY, SELECTED SUB-SAHARA COUNTRIES, 1969-1981

	Country					
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
			(No. per Arable Ha)			
1969	.000012	.000313	.002807	.000066	.000998	.004023
1970	.000012	.000359	.002828	.000099	.001060	.004087
1971	.000014	.000412	.002850	.000125	.001175	.004173
1972	.000014	.000458	.002871	.000214	.001252	.004280
1973	.000033	.000458	.002470	.000230	.001310	.004387
1974	.000360	.000496	.002675	.000240	.001349	.005992
1975	.000040	.000547	.002595	.000247	.001368	.006206
1976	.000043	.000585	.002582	.000253	.001387	.006420
1977	.000050	.000687	.002671	.000260	.004407	.006634
1978	.000058	.000725	.002785	.000267	.001445	.006848
1979	.000061	.000763	.002752	.000273	.001638	.007062
1980	.000082	.000789	.002826	.000283	.001657	.007276
1981	.000097	.000814	.002850	.000290	.001680	.049700

Source: Calculated from FAO Production Yearbooks, and UN Statistical Yearbook (21, 63).

of cultivated land, while labor productivity is measured by total output divided by the economically active population in agriculture. To fit the four variables into one graph, yield was divided by 100 and tractor and fertilizer densities were each multiplied by 1000 each.

Figure 10 shows the plots for Cameroon. There is no response, but a jump in fertilizer use in 1978 was followed by a jump in yield in 1979 to reverse the downward trend in yield. Tractor use and labor productivity seem to go together. These relationships are not very apparent, given that fertilizer and tractor use are very low in Cameroon.

In the case of the Ivory Coast (Figure 11), fertilizer use, tractor use, and labor productivity trend upwards over the period covered, although in differing degrees. Yield per hectare trend downwards. There may be other factors influencing yield.

In Figure 12, yield does not appear to be related to fertilizer use in Kenya. Labor and tractor use move together, although it is not very obvious.

The trend in the case of Nigeria (Figure 13) is more obvious, especially from 1974 when fertilizer use and yield moved in the same direction. Labor productivity and tractor use showed little change over the period under consideration. Tractor and fertilizer use in Nigeria has been very low, especially in the early periods of the study (see Tables XIV and XVI).

Tanzania (Figure 14) shows a relationship between fertilizer use and yield. Variations in yield are, however, more obvious than in fertilizer use. This is probably due to other factors that influence yield - especially the weather. Labor and tractor use seem to move in

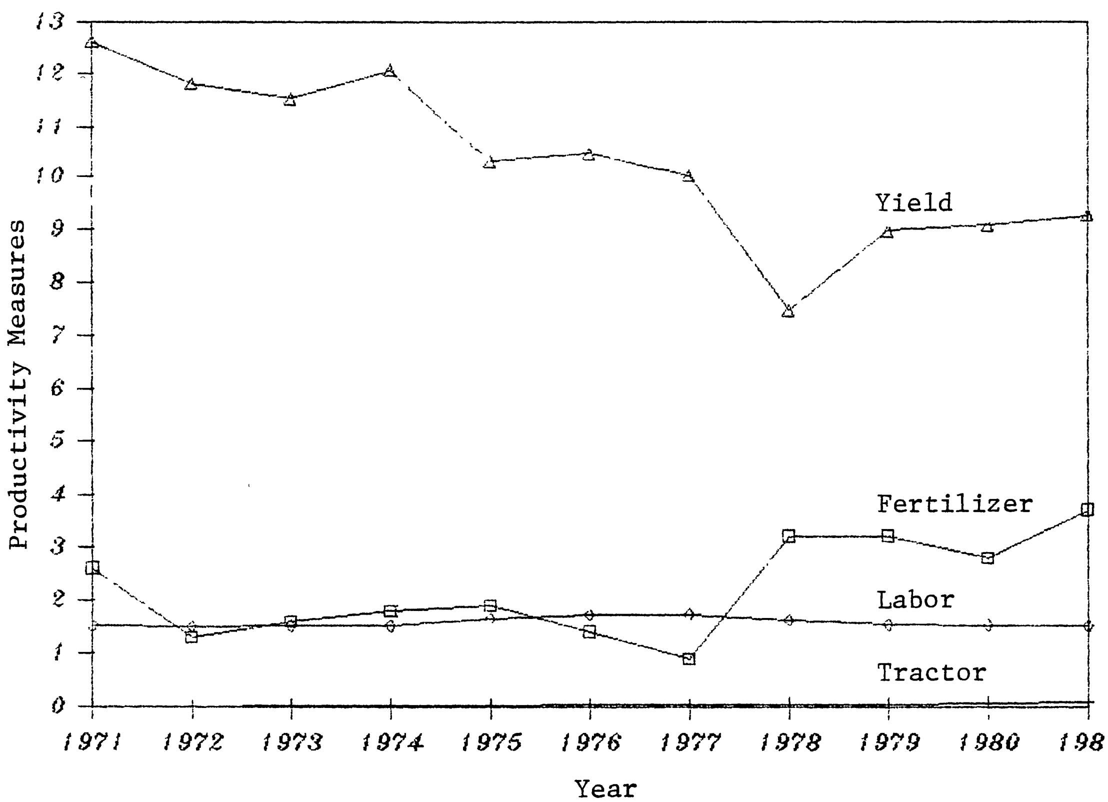

Figure 10. Measures of Productivity - Cameroon, 1971-1981

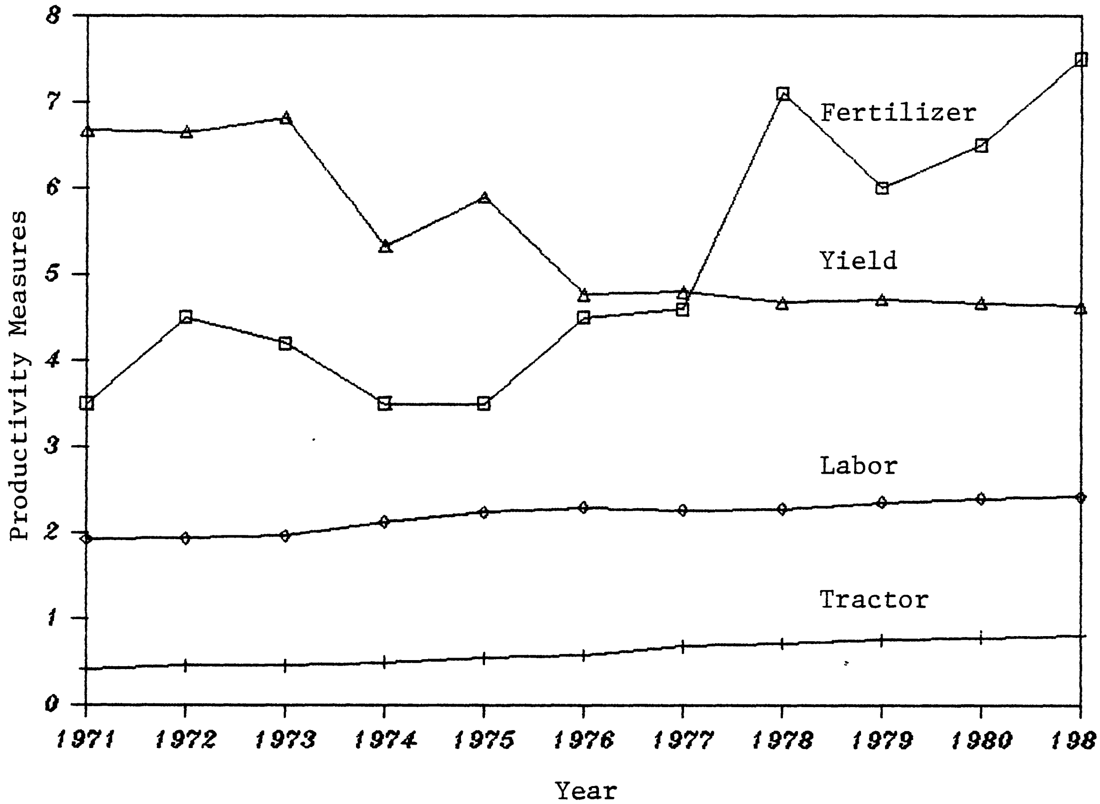

Figure 11. Measures of Productivity - The Ivory Coast, 1971-1981

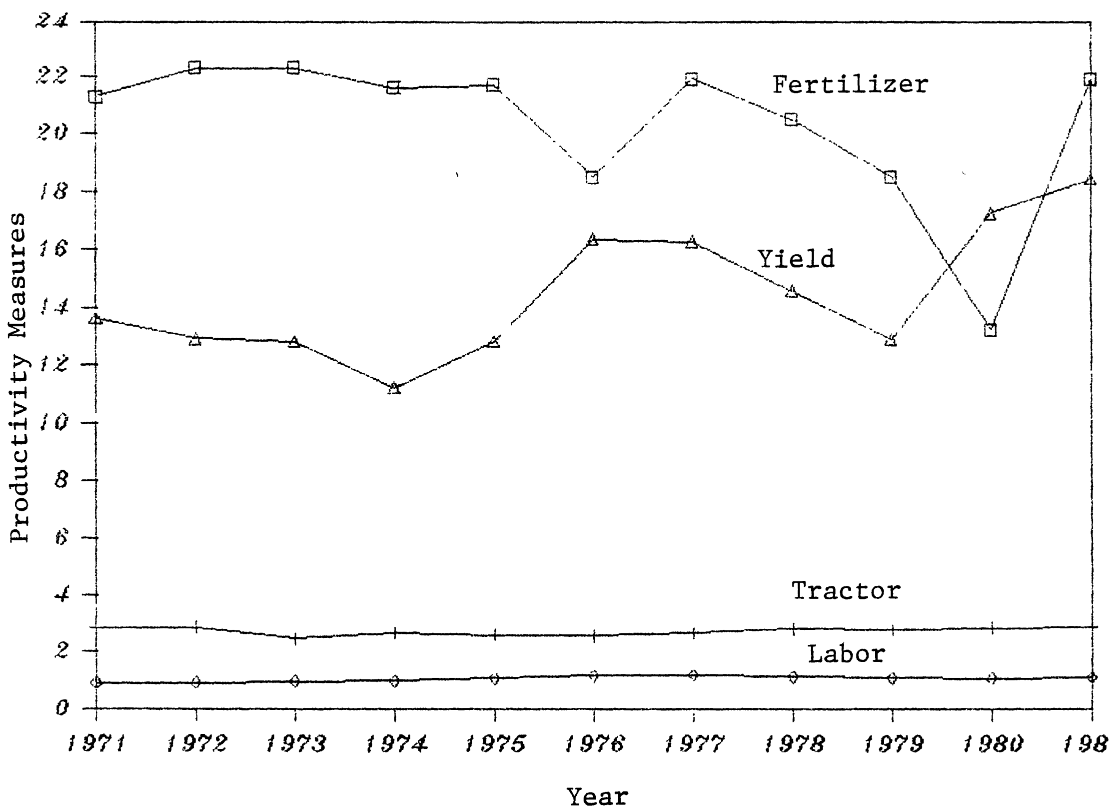

Figure 12. Measures of Productivity - Kenya, 1971-1981

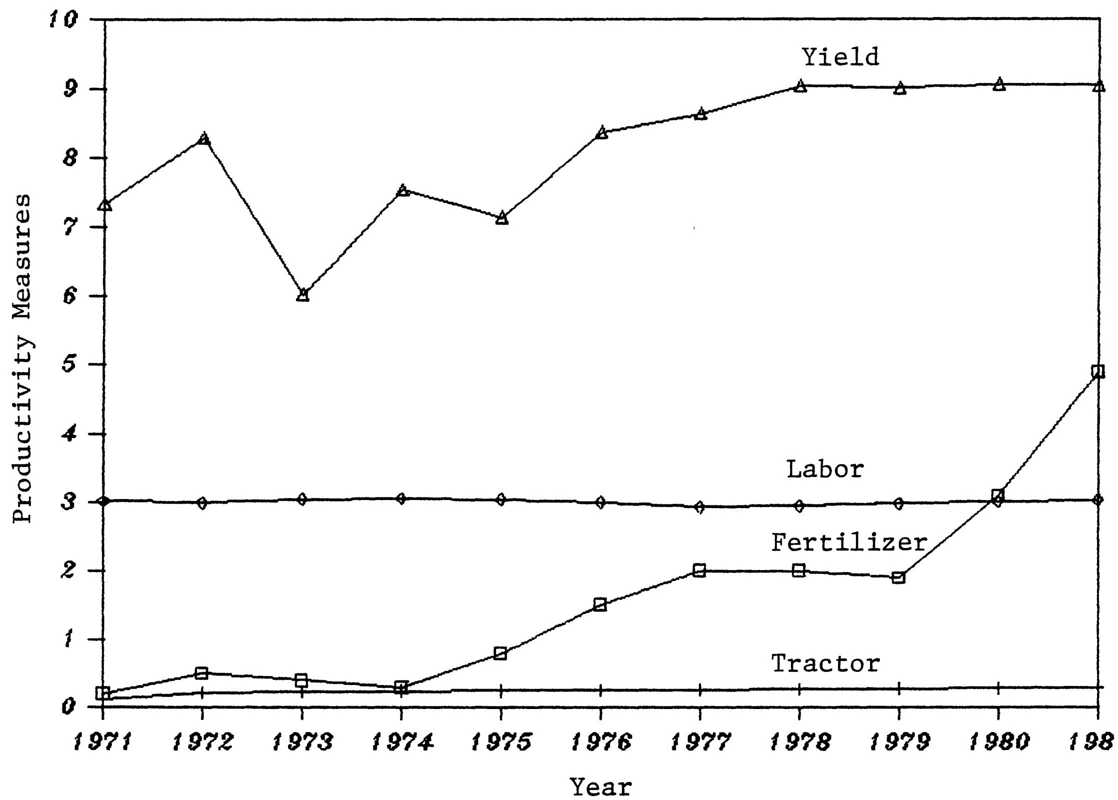

Figure 13. Measures of Productivity - Nigeria, 1971-1981

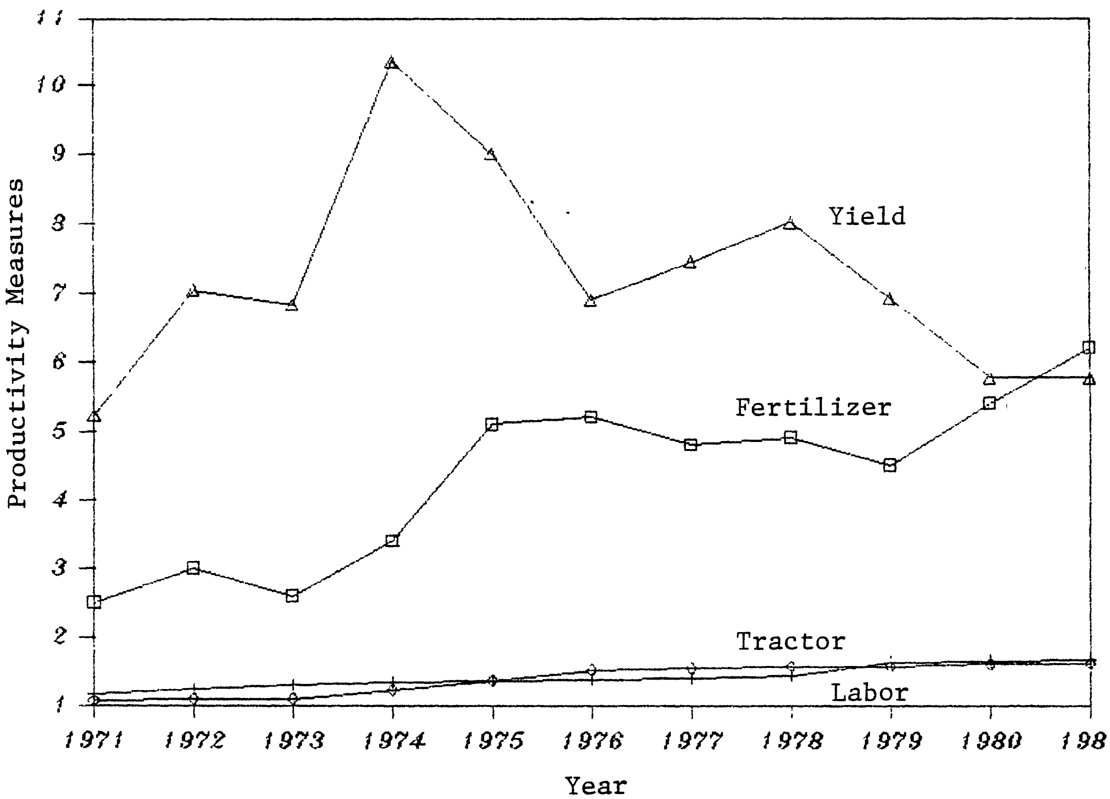

Figure 14. Measures of Productivity - Tanzania, 1971-1981

the same general direction (upwards), although not very noticeably (especially in the case of labor).

Figure 15 shows the relationship between fertilizer density, tractor density, yield, and labor productivity in Tunisia. The four variables trend in the same direction. There is a relationship between fertilizer and tractor use and yield and labor productivity.

All the country graphs have shown that there is some relationship between fertilizer and tractor use, and productivity (yield per hectare and output per agricultural worker). In some of the countries, these relationships may not be as obvious, because of very low levels of usage and other factors - weather - that influence especially yield. However, it can be concluded that increased fertilizer and tractor use will increase productivity.

Policy Factors Influencing Adoption of New Technologies in Agriculture

Because of the lack of data, the policies will not be analyzed in as much detail as would be the case with the available information. While some of the policies considered here may be directly related to the adoption decision, some of them are only indirectly related.

Procurement of Agricultural Inputs

A priori it might be expected that the private sector would be more efficient in providing inputs to the farm sector. However, private firms that supply the inputs could be government sanctioned monopolies who would not supply inputs at a competitive price. Table XVIII shows the mix of the procurement of agricultural inputs in the

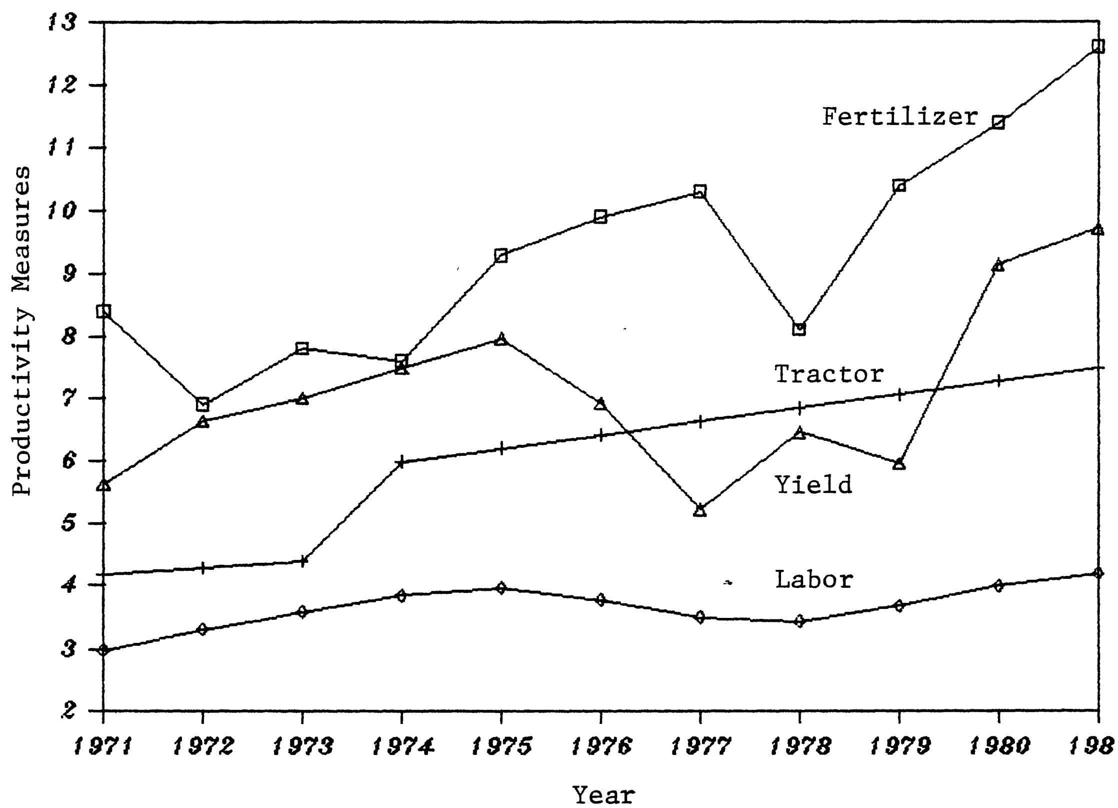

Figure 15. Measures of Productivity - Tunisia, 1971-1981

TABLE XVIII

PROCUREMENT OF AGRICULTURAL INPUTS, SELECTED SUB-SAHARA COUNTRIES, 1983

Countries	Fertilizer Supply			Seed Supply			Chemical Supply			Farm Equipment		
	Private	Gvt.	Mixed	Private	Gvt.	Mixed	Private	Gvt.	Mixed	Private	Gvt.	Mixed
Cameroon			X		X				X	X		
Ivory Coast			X			X			X			X
Kenya	X			X					X	X		
Nigeria		X			X				X			X
Tanzania		X			X			X			X	
Tunisia*			X			X			X			X

Sources: World Bank Data (69).

*Subsidies.

six countries. Procurement and distribution activity is considered private if more than 80 percent of it is carried out by the private sector and government if more than 80 percent is carried out by the public sector.

The mixed supply arrangement is preferred by a majority of the countries. A correlations graph of procurement and productivity - labor and land - shows that for farm equipment, countries with mixed supply arrangements had higher labor productivity. Kenya had the private supply arrangement for fertilizers and the highest yield. In both cases, countries with government supply arrangements had low productivity (land and labor). It makes sense to have a mixed supply arrangement for farm equipment because of the initial fixed capital that is required, while for fertilizer it may be used in divisible amounts, depending on the size of the farm and the financial situation of the farmer.

Foreign Reserves

Tables XIX and XX show the international reserves (excluding gold) and the foreign exchange, respectively. A limited foreign reserve and foreign exchange as in the case of Ivory Coast and Tanzania constrain the purchases of foreign goods, which may include capital goods for the agricultural sector. A limited foreign reserve means competition among economic sectors for purchase of foreign inputs.

Tables XXI and XXII show the ratio of exports to imports and the balance of trade. While the Ivory Coast and Nigeria exported more than they imported, Tunisia and Kenya imported more than they exported. Cameroon and Tanzania imported more than they exported except for a few

TABLE XIX

INTERNATIONAL RESERVES (EXCL. GOLD), SELECTED SUB-SAHARA COUNTRIES, 1969-1981

Year	Country					
	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
	Million Dollars (U.S.)					
1969	48.1	74	170	115	80	33
1970	80.8	119	220	204	65	55
1971	73.6	90	171	411	60	143
1972	43.6	87	202	364	120	218
1973	51.2	88	233	559	145	302
1974	79	66	193	5602	50	413
1975	29	103	173	5586	65	380
1976	44	76	276	5180	112	366
1977	42	185	522	4232	282	351
1978	52	448	353	1887	100	443
1979	126	147	628	5548	68	579
1980	189	20	492	10235	20	590
1981	85	18	231	3895	19	536

Source: IMF Financial Statistics (32).

TABLE XX

FOREIGN EXCHANGE, SELECTED SUB-SAHARA COUNTRIES, 1970-1982

	Country					
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
			(Millions of SDR)			
1970	71	105	202	174	56	55
1971	54	62	133	333	42	130
1972	23	54	157	269	97	187
1973	25	47	164	385	103	231
1974	54	38	156	4495	39	317
1975	15	73	144	4502	55	304
1976	29	54	234	4063	92	293
1977	28	144	416	3078	226	268
1978	33	326	260	1016	71	320
1979	89	81	394	3808	49	414
1980	136	3	365	7522	16	432
1981	44	5	189	2662	14	424
1982	45	2	176	1421	4	515

Source: IMF Financial Statistics, (32).

TABLE XXI

RATIO OF EXPORTS TO IMPORTS, SELECTED SUB-SAHARA COUNTRIES, 1965-1981

	Country					
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
1965	.92	1.17	.81	.96	1.05	.49
1966	.99	1.22	.75	1.12	1.11	.56
1967	.84	1.23	.71	1.09	1.10	.57
1968	1.05	1.38	.70	1.08	.94	.72
1969	1.12	1.36	.76	1.29	1.02	.62
1970	.96	1.21	.69	1.17	.79	.60
1971	.83	1.14	.56	1.19	.70	.63
1972	.73	1.22	.67	1.45	.80	.68
1973	1.10	1.21	.79	1.89	.74	.62
1974	1.14	1.25	.64	3.49	.54	.82
1975	.75	1.05	.66	1.29	.48	.60
1976	.84	1.26	.85	1.23	.77	.52
1977	.90	1.23	.93	1.06	.72	.51
1978	.76	1.00	.60	.82	.42	.53
1979	.88	1.01	.67	1.75	.49	.63
1980	.86	--	.60	1.64	.47	.62
1981	.62	1.06	.57	1.06	--	.62

Source: International Monetary Fund. Direction of Trade (33).

TABLE XXII

BALANCE OF TRADE, SELECTED SUB-SAHARA COUNTRIES, 1969-1981

	Country					
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
			Billion Dollars (U.S.)			
1969	.02	.12	-.09	.20	.01	-.10
1970	-.01	.08	-.14	.18	-.07	-.12
1971	-.04	.06	-.25	.29	-.11	-.13
1972	-.08	.10	-.18	.67	-.08	-.15
1973	.03	.15	-.14	1.66	-.13	-.26
1974	.06	.24	-.37	6.92	-.35	-.21
1975	-.15	.05	-.34	1.73	-.40	-.57
1976	-.10	.34	-.15	1.87	-.15	-.74
1977	-.08	.40	-.09	.69	-.21	-.90
1978	-.25	--	-.69	-2.31	-.67	-1.01
1979	-.15	.02	-.55	7.66	-.55	-1.06
1980	-.22	--	-.94	10.47	-.66	-1.34
1981	-.69	.15	-.88	1.21	--	-1.51

Source: International Monetary Fund. Direction of Trade (33).

years prior to 1973.

A negative balance of trade leads to depletion of foreign reserves and to borrowing from foreign countries or international organizations to pay for foreign purchases. It also leads to curtailment of foreign purchases of all nonessentials. Again, agriculture will have to compete with other sectors to fit into the category of essentials. This may hurt the purchases of new inputs in agriculture.

Over-Valuation of Domestic Currency

Overvalued currency is a two-edged sword when considering adoption of technology, especially when the adopted technology is imported and the overvalued currency makes the technology less expensive than it otherwise would be. However, export crops are less competitive with an overvalued exchange.

Determining an overvalued currency is very difficult. Traditionally a balance of trade deficit signifies an overvalued currency. However, with international capital flows becoming more prominent, the capital accounts, in part, also determine the exchange rate. A country with excess savings may run a balance of trade surplus but not have a devalued currency since they need to import securities (export money), which balances out with trade surplus. Similarly, a country with investment opportunities and relatively low savings needs to export securities (import capital) to pay for its investments and will run a balance of trade deficit to get the overall balance of payments to balance.

For example, Nigeria ran a sizeable trade surplus in 1974 due to its oil earnings, but this surplus deteriorated into a deficit by 1978.

This makes sense because investing in oil was profitable and meant that capital was imported. When these and other investments went bad starting in 1981-82, a balance of trade deficit probably meant an overvalued currency. While Nigeria's exchange rate was rising in the 1970's (Table XXIII), it was probably not "overvalued" although it made agriculture less competitive in the output market. In hindsight, it is apparent that Nigeria's development strategy of emphasizing oil and government vis-a-vis agriculture and other industries might not have been a wise policy. The exchange rate for Cameroon also rose during the 70's, although to a much lesser extent than Nigeria's.

One other method of determining an overvalued exchange rate is to look at the IMF series, Use of Fund Credit in two forms - raw data and the percent of credit. These funds are for temporary shocks in the export markets, but some countries that use large amounts of this credit for a few consecutive years are financing imports with an overvalued exchange. Depletion of International Reserves has the same effect. If the LDC's allow this to carry on for a few years it does have a detrimental effect on exporting sectors (e.g. agriculture). In Tables XXIII and XXIV, the Ivory Coast and Kenya used fairly large amounts of the Fund credit from 1981-1983 (over 200 percent). Nigeria did not use any of the credit.

Nominal Protection/Taxation of Agriculture

Table IX shows the nominal protection/taxation of agriculture. A coefficient greater than one implies protection or producer subsidy, while a coefficient less than one implies taxation of the agricultural commodity. Prices paid to producers and all expenses incurred to get

TABLE XXIII

USE OF FUND CREDIT, SELECTED SUB-SAHARA COUNTRIES, 1969-1983

	Country					
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
			(Million SDR)			
1969	--	--	--	--	--	13
1970	--	--	--	--	--	13
1971	--	--	--	--	--	3
1972	--	--	--	--	--	--
1973	--	--	--	--	--	--
1974	5	11	32	--	39	--
1975	12	11	69	--	63	--
1976	34	23	85	--	84	--
1977	34	13	48	--	87	24
1978	33	--	52	--	64	24
1979	25	--	108	--	85	24
1980	12	--	152	--	93	--
1981	3	319	175	--	85	--
1982	1	435	310	--	74	--
1983	--	589	398	--	48	--

Source: IMF Financial Statistics (32).

TABLE XXIV

USE OF FUND CREDIT

	Country					
Year	Cameroon	Ivory Coast	Kenya	Nigeria	Tanzania	Tunisia
			(pct. of quota)			
1969	--	--	--	--	--	37.5
1970	--	--	--	--	--	37.9
1971	--	--	--	--	--	5.3
1972	--	--	--	--	--	--
1973	--	--	--	--	--	--
1974	13.2	21.5	66.8	--	92.5	--
1975	34.7	21.5	142.8	--	149.1	--
1976	96.8	44.9	177.1	--	199.1	--
1977	96.8	25.8	99.3	--	206.5	50.0
1978	72.8	--	75.8	--	116.5	38.1
1979	55.1	--	157.0	--	155.2	38.1
1980	17.7	--	147.2	--	113.3	--
1981	5.2	280.0	169.4	--	102.6	--
1982	.8	381.2	299.6	--	89.2	--
1983	--	356.2	280.4	--	45.3	--

Source: IMF Financial Statistics (32).

the commodity to an international buying center (New York, London, Paris, etc.) is compared with an average of the prices paid for a unit of the commodity at these buying centers.

Cameroon taxed agriculture very heavily, although from 1977 on it subsidized rice production. Cotton was taxed the most. For every dollar paid for Cameroon cotton, the government took away 84 cents on the average, from 1970 to 1983. Cocoa and coffee, the main cash crops of the country were also heavily taxed, with the government taking over 58 cents for every dollar.

The Ivory Coast taxed cocoa and coffee very heavily also (63 cents for coffee and 59 cents for cocoa), but subsidized rice production. Kenya subsidized rice, wheat, cotton, and sugar production, while taxing coffee, tea, and beef. This is in keeping with the country's objective of taxing the commodities where it has a comparative advantage,and subsidizing where it does not. This may not necessarily be a sound economic policy, as taxing commodities where there is comparative advantage kills producer incentives. Even in the case of coffee and cocoa where, because of resource fixity producers have to continue producing, reducing amount of care of the trees, reduces the yield. On the other hand, subsidizing where there is no comparative advantage, leads to a transfer of resources from producers with a comparative advantage to producers with no comparative advantage. Nigeria subsidizes, and heavily too, rice, sorghum, maize, millet, and groundnut production, while Tanzania taxes, and heavily too, rice, maize, and coffee production. Tunisia subsidizes wheat production.

Infrastructure

Areas with better access to markets through transport networks will be more intensively cultivated. This intensification occurs for two reasons:

a) higher prices and elastic demand for exportables implies that marginal utility of effort increases, hence farmers in the region will begin cultivating larger areas.

b) higher returns to labor encourage immigration into the area from other areas.

Table XXV presents the infrastructure density.* Ivory Coast has the best infrastructure, while Tanzania has the worst. Ivory Coast is closely followed by Nigeria and Tunisia, with Kenya and Cameroon following fairly far behind.

Infrastructure is typically a public good. A good infrastructure increases the incentive for the farmer to produce for the market and not just for subsistence.

Statistical Tests of Relationships

This section deals with the estimation of a productivity function to show that adopting new technologies in agriculture leads to increased output and productivity. The framework for the analysis is a Cobb-Douglas - type production function that incorporates the possibility of intercountry productivity differences, and within

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*Infrastructure Density - $\frac{\text{(Highways + Railways + Waterways)}}{\text{Country Area}}$

TABLE XXV

INFRASTRUCTURE DENSITY*

	1975	1977	1981	1982
		(km per sq. km)		
Cameroon	.034	.069	.068	.070
Ivory Coast	.079	.141	.145	.145
Kenya	.059	.093	.094	.094
Nigeria	.068	.110	.129	.129
Tanzania	.035	.051	.042	.041
Tunisia	.068	.111	.117	.122

Source: Calculated from CIA World Factbook (12).

*(Highways + Railways + Waterways)/Country Area

country productivity changes. It should therefore be possible to make intercountry comparisons.

Considering the two-country scheme of Figure 16, a time-shift of the production functions and changes in the input-output combinations is reflected by shifts in x_1 to x_2 in Country 1, and y_1 to y_2 in Country 2. As depicted in the graph, productivity in Country 2 is higher than in Country 1. Mathematically, the production function is given by:

$$Y_{it} = f(X)e^{\alpha_i+\gamma_{it}}$$

where,

Y_{it} - index of total agricultural production value index in country i in year t (i = 1, ..., 6))(t = 1969, ...,1981).

X - Vector of inputs

X_1 - labor

X_2 - land

X_3 - fertilizer

X_4 - tractor

α_i - country-specific level coefficient

γ_{it} - time trend coefficient.

The data used for the estimation has been used elsewhere in the text. An average over the years 1969-71 is used to represent the base year.

To estimate the equation using ordinary least squares, it was necessary to transfer the data into logarithm form. By so doing, the regression coefficients are interpreted as elasticities of production, proportional to the marginal products of the factors.

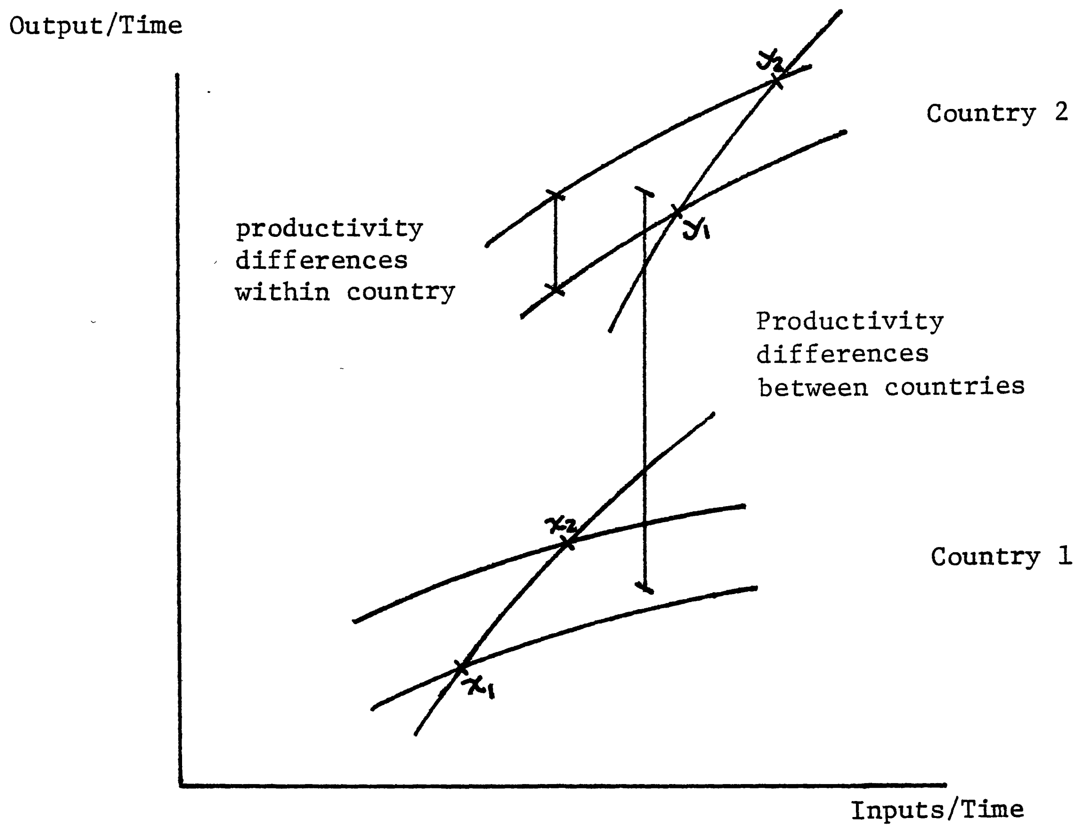

Figure 16. Production Functions

Given

$$Y_{it} = f(x)e^{\alpha_i + \gamma_{it}} \quad (18)$$

$$Y_{1969-71=100} = A \prod_{j=1}^{4} X_j^{B_j} e^{\alpha_i + \gamma_{it}}, \qquad j=1,2,3,4 \quad i=1,\ldots,6 \quad (19)$$

$$\frac{Y}{Y_{1969-71}} = \frac{A}{Y_{1969-71}} \prod_{j=1}^{4} X_j^{B_j} e^{\alpha_i + \gamma_{it}} \quad (20)$$

$$\log \frac{Y}{Y_{1969-71}} = \log \frac{A}{Y_{1969-71}} + \sum_{j=1}^{4} B_j \log X_j + \alpha_i + \gamma_{it} \quad (21)$$

This was the form estimated, with α_i and γ_i as dummy variables.

Results of the regression are shown on Table XXVI. The estimates vary a great deal between regressions and within regressions. The regressions also vary in the expected signs, and in the magnitude of the coefficients. A priori, it was expected that the signs would all be positive to show that as inputs increased, output would increase. Only regression 2 has the expected signs, although the intercept (constant) is negative, and the coefficients (elasticities) are very large. Regression 1 shows that output will increase with increases in fertilizer and tractor use within and between countries, but will decrease with increased use of labor and land. In regression 3, only increased use of fertilizer will increase output. Increased use of the other inputs-labor, land and tractor--will decrease output. Regression 4 shows that output will increase as labor and land increase, but will decrease with increased use of fertilizer and tractor.

Inclusion of the country-specific level and trend dummy variables affects the size and signs of the coefficients. Intercountry

TABLE XXVI

PRODUCTION FUNCTION REGRESSION STATISTICS
FOR SIX SUB-SAHARA COUNTRIES

Regression	1	2	3	4
R^2 (adj).	.39	.74	.91	.86
Intercept	154.8	-1071.4	-11352.3	-9142.4
Labor	-7.0 (2.7)	107.9 (4.3)	-.7 (.03)	19.9 (.9)
Land	-2.9 (1.0)	51.3 (2.6)	-24.3 (1.5)	23.8 (1.6)
Fertilizer	12.5 (3.5)	4.0 (1.3)	3.0 (.8)	-3.1 (1.2)
Tractor	1.4 (.81)	7.4 (1.7)	-4.9 (.8)	-9.7 (2.5)
Country Specific				
Level (α_i)	--	x	x	--
Trend (γ_j)	--	--	x	x

t values in parenthesis

comparisons cannot be made because of the poor results of the regression run, especially regression 3, which contains the within and between country variable α_i, and the trend variable γ_{it}. A comparison will require country-specific intercept, e^{α_i} and the trend, e^{γ_i}. To get e^{α_i} and e^{γ_i} requires taking the antilog of -11352.2, the constant from the regression. The process is of the form:

$$\text{Log } (A/Y_{1969-71}) = \text{Constant} = -11252.3$$

$$Y_{1969-71} = 100$$

$$\text{Log } A - \log Y_{1969-71} = -11352.3$$

$$= e^{-11352.3} = 0.$$

This invalidates any comparisons that can be made.

Country intercepts would have provided information on differences in efficiency of production and use of resources between the countries while the time trend would have provided information on technological change over the time period under consideration.

While the test has not supported the hypothesis fully, it has provided a methodology for analysis which gives promise of better results, given better data. The absence of other useful variables in the model has contributed to the poor results. Weather is probably the one most important variable not included because of lack of data. With the right land preparation, fertilization, and use of HYV seed, if there is no water, or if it is not available in the right amount, the yield will be affected. A 1984 USDA (64) report on the outlook and situation in sub-Sahara Africa stated that the probability of drought in Kenya in a given year was 30 percent. The same report stated that drought slowed agricultural growth in the Ivory Coast. Other variables such as government inefficiencies, technical inefficiencies also affected the model.

Better time series data on all of the variables mentioned above will mean better specification of the model, and better results.

Correlation Analysis

In this section, an analysis using correlation graphs and coefficients is made to determine if there is a relationship between government policies and some technology indicators. The first correlation graph (Figure 17) shows the correlation between fertilizer and tractor densities, and the procurement of agricultural inputs. The procurement of inputs is done either by the government, in a mixed arrangement (combination of government and private), and private. From the graphs a mixed and/or a private system of procuring inputs tended to be associated with greater usage of inputs. The countries using these systems (Tunisia, Ivory Coast, Kenya, and Cameroon) consumed more of these inputs than the countries where the government procures the inputs (Tanzania and Nigeria). The government policies that affect input supplies will affect how much of the inputs are consumed by the farmers.

The next correlation graph (Figure 18) shows the relationship between productivity, fertilizer consumption, tractor use, and nominal protection coefficients. All the countries tax their agriculture in varying degrees, with Cameroon and Tanzania taxing the highest, Tunisia and Ivory Coast taxing moderately, while Kenya and Nigeria subsidize or protect their agriculture. These measures apply mostly to the export crops. Productivity (land), fertilizer, and tractor use are high in

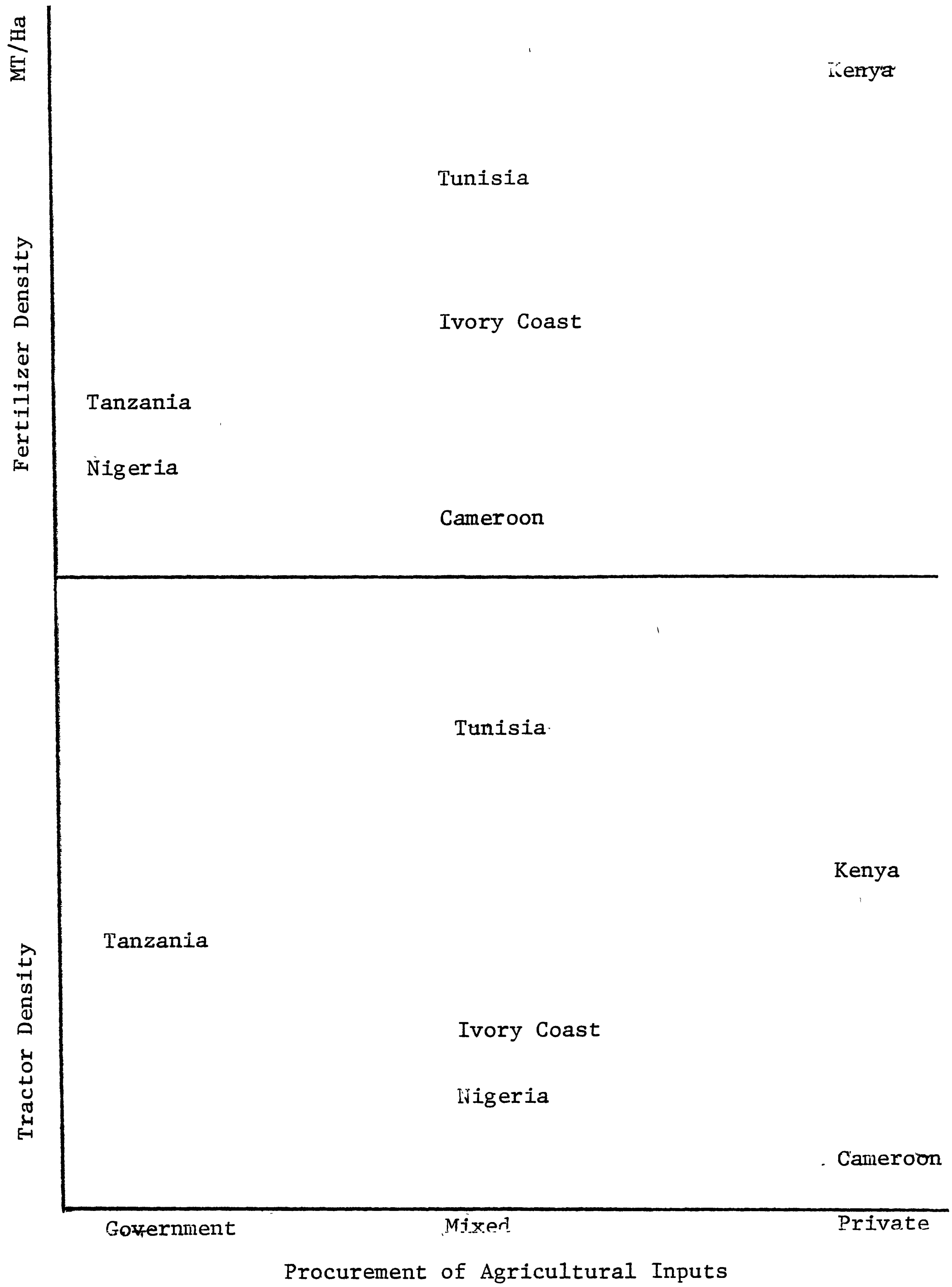

Figure 17. Tractor and Fertilizer Densities vs Procurement of Agricultural Inputs

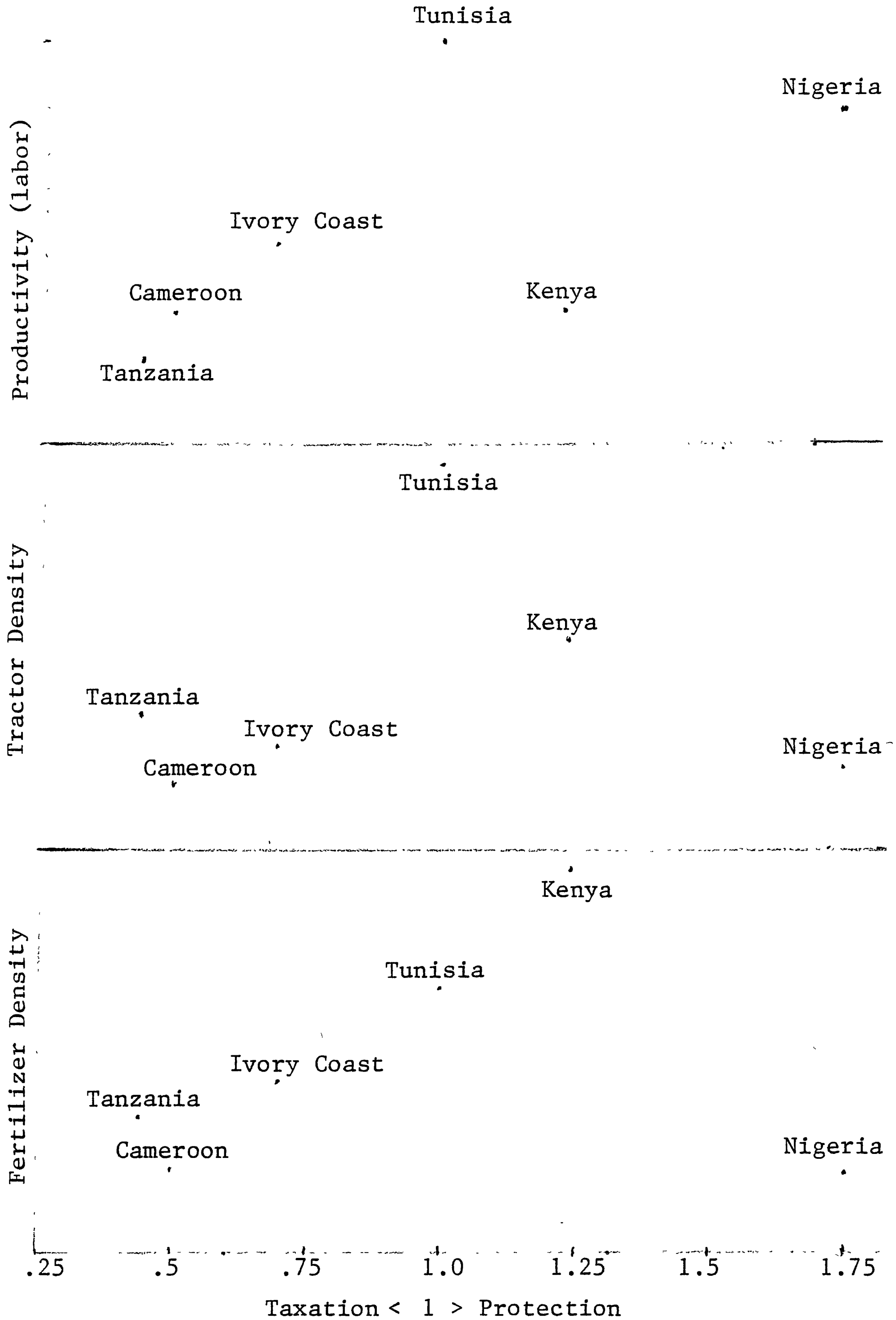

Figure 18. Nominal Protection Coefficients vs Fertilizer Density, Tractor Density, and Labor Productivity, Selected Sub-Sahara Countries, 1969-1981

Kenya, moderately high in Tunisia and the Ivory Coast, and low in the other countries. It follows therefore that a government policy of taxing agriculture affects the adoption of agricultural technology. Table XXVII shows the correlation coefficients for nominal protection coefficients, tractor density, fertilizer density and productivity. There is a relationship between NPC and the technology indicators.

The third correlation graph (Figure 19) presents the relationship between the technology indicators-productivity, fertilizer consumption and tractor use--and the policy variable, infrastructure density. Ivory Coast, with the best infrastructure density is moderate in productivity, fertilizer use and tractor use. Tunisia and Kenya with fairly good infrastructure densities have the best productivity (land), fertilizer consumption, and tractor use. Nigeria has a good infrastructure, but is poor in productivity, fertilizer consumption, and tractor use. Except for labor productivity, the correlation coefficients between infrastructure and the technology indicators indicate that the relationship is very weak or does not exist (Table XXVII).

Conclusions

Discussion in this section has centered on selected governmental policies that will affect the adoption of new technologies. Some of these policies like the procurement of agricultural inputs, nominal protection/taxation of agriculture and import restrictions are direct, while others, such as infrastructure are indirect. The procurement of agricultural inputs is done in three ways - private, mixed (government and private), and government. The procurement of inputs is mostly

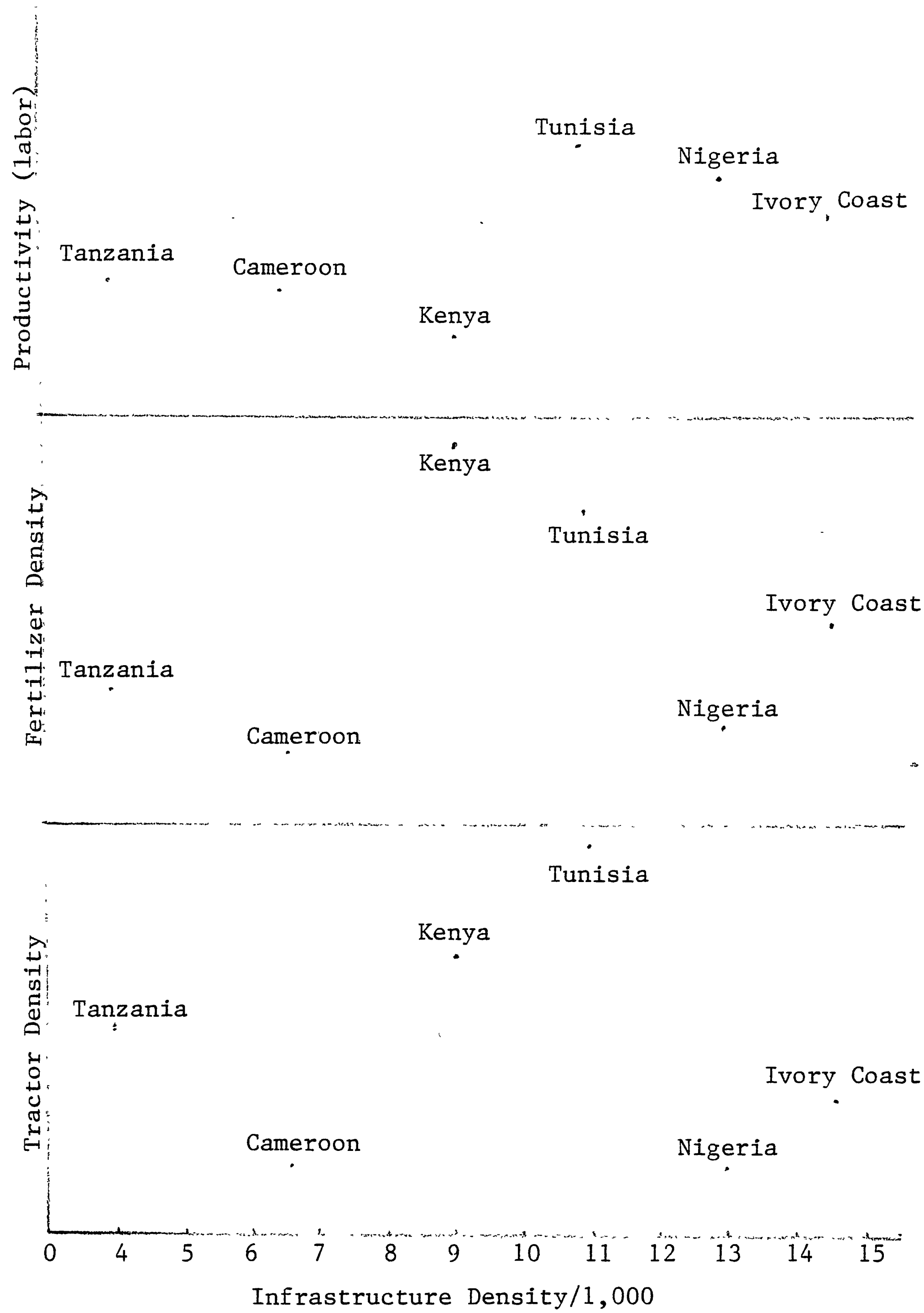

Figure 19. Infrastructure Density vs Labor Productivity, Fertilizer Density and Tractor Density, Selected Sub-Sahara Countries, 1969-1981

TABLE XXVII

CORRELATION COEFFICIENTS FOR PRODUCTIVITY MEASURES, SELECTED SUB-SAHARA COUNTRIES

	NPC	Infrastructure
Tractor Density	0.1079	0.0579
Fertilizer Density	0.3441	0.0000
Labor Productivity	0.3349	0.5785
Cereals - Yield - Kg/Ha	0.2986	-0.0713

Correlation Coefficients $= \frac{\text{Cov }(x,y)}{s_x\ x_y}$ where Cov $(x,y) = \frac{(x-\bar{x})(y-\bar{y})}{N-1}$

y = Government Policy Indicators, NPC and Infrastructure
x = Technology Indicators, Tractor Density, Fertilizer, Labor and Land Productivity.

private in Kenya, mixed in the Ivory Coast and Tunisia, government in Tanzania, and varies in Cameroon and Nigeria. Cameroon, Ivory Coast, and Tanzania tax agriculture. Kenya and Nigeria subsidize agriculture. The Nominal protection coefficient does not take into account domestic inflation rates and uses official exchange rates though a currency may be overvalued. Infrastructure density is low in all the countries. These factors have a bearing on how the farmer adopts new technologies. Also, an attempt to estimate a production function to show that adoption of new technologies improves productivity was unsuccessful because of misspecification of the model. The production function that was estimated has been successfully estimated (i.e. reasonable results were obtained) by other studies using data for LDC's in other continents besides Africa. Two omitted variables are weather, (especially with the drought experienced in Africa) and government policies (e.g. poor information leading to technically inefficient production).

CHAPTER VII

SUMMARY AND CONCLUSIONS

One of the major purposes of this study was to reach a conclusion as to why the Sub-Sahara region is different from other regions in the world in that food production per capita has been declining over the past decade. Certainly, population growth, unique environmental factors, and the droughts in this region explain some of this decline. (Political instabilities due to civil wars and coup d'états and guerilla wars which have profound effects in the rural areas, also affect agriculture.) However, the influence of the government must be a major factor that needs to be studied. Using correlation graphs, it was determined that there is a relationship between government policies and the technology indicators used here. However, the rate of adoption is very low. One reason suggested in the literature for the low adoption rate is that governments pursue policies that are contradictory. For example, to have a stated food policy goal of self-sufficiency, and at the same time be taxing agriculture heavily, takes away farmer incentives.

Six countries were chosen for this study - Cameroon, Ivory Coast, Kenya, Nigeria, Tanzania, and Tunisia. They were selected for purposes of inter-country comparisons and because there were contacts in these countries for getting some data. The latter proved to be unsuccessful in furnishing data.

Summary

The prevailing socio-political institutions condition the potential opportunities facing its human agents. The traditional farming systems of fallowing predominate in the countries of this study. The farming implements are also traditional - the hoe and the machete. Traditional farmers in the relatively land-scarce countries of Kenya and Tunisia farm on marginal land. A number of factors were identified as factors influencing farming intensities. These factors included:

- population density,
- land (arable) availability,
- land tenure systems, and
- levels of technology.

Higher productivity (both labor and land) has been considered as a desirable objective to achieved by the countries included in this study. Factors that were determined as influencing productivity were:

- weather. All the countries in the study have experienced drought in varying degrees.
- soil types. Apart from the alluvial and volcanic soils found in limited areas of some of the countries (Tunisia, Kenya, Tanzania, Cameroon), the top soil is thin and can easily be washed away. Farming is therefore a delicate activity.
- technology. HYV seeds, fertilization, and irrigation increase land yield, while mechanical technology increases labor productivity.

Adoption of a technology package will affect output. The indicators of technology adoption used in this study were:

- productivity, an indicator for many types of adoption.
- fertilizer consumption, an indicator for HYV and irrigation. (The HYV require that the soil nutrients and the water level be right.)
- tractors, an indicator for agricultural machines which save and/or increase labor output.

Fertilizer density was highest in Kenya, and land productivity (yield/hectare) was also highest in Kenya. Tunisia had the highest tractor density and the highest labor productivity. These relationships supported the hypotheses that mechanical technology increased labor productivity and fertilizer use increased land productivity.

A number of government policies were identified which impact on farmer abilities, either directly or indirectly, to adopt new technologies. These included a) the procurement of agricultural inputs, b) nominal protection coefficients, or the rate of taxation/protection of agriculture, c) infrastructure, and d) irrigation. Cameroon, the Ivory Coast, and Tanzania taxed agricultural commodities, while Kenya and Nigeria protected or subsidized agriculture. Procurement of inputs was mixed, ranging from complete government control to complete private control.

A statistical test for intra- and inter-country comparisons using a Cobb-Douglas type production function was not helpful in the analysis because the model could not be properly specified given the lack of appropriate data. Correlation graphs and coefficients were used to establish relationships between technology indicators and governmental policies.

Conclusions

Considering the countries in this study, the conclusion has to be made that nature's heritage forms neither a necessary nor a sufficient condition for increased agricultural output. Rather, the technology level is a necessary condition for increased agricultural output, while the technology level and the environmental factors provide a sufficient condition for agricultural productivity. Tunisia has the highest labor productivity because it is in the highest technology level. Kenya has the highest yield per hectare, and the highest fertilizer density.

The political structure of a country, that is, the institutions, the environmental factors, population dynamics, and government economic policies influence productivity and the adoption of technology. At the micro level, farmers' circumstances - natural and economic environment, goals, preferences, and resource constraints - will lead them to adopt or not adopt technologies.

Policy Recommendations

The institutional arrangements which allow people to participate in the economy are very important to the productive ability of the people. All the countries in this study have two agricultural systems operating side by side, a high technology system involving plantations and a traditional subsistence system where very crude implements are used. Although the systems operate side by side, technology and knowledge from the plantations are not being disseminated to the subsistence farmers. To diffuse the technology to subsistence farmers, the following policy measures appear necessary:

a) Appropriate technology - the government has to acquire and make available the appropriate type of technology.

b) Procurement of agricultural inputs - because of the financial constraints, the government should procure the inputs that require heavy initial investments - tractors and other machinery. Arrangements then could be made for farmers to acquire the variable inputs - seeds, fertilizer, etc. - without too much difficulty.

c) Infrastructure - improvement of the transportation means will bring the rural farmers into the monetary economy. This will be an incentive for them to produce more. Revenues from sales of food produced above that for local consumption will be invested in better food production methods.

d) Extensions Service - a good extension service is needed to diffuse knowledge to small farmers.

Implementation of these policies should increase farmer awareness of the potentials available for them to increase their output and productivity.

Limitations of the Study

Although the literature has many studies on government policies and agricultural incentives, there are almost no studies that have examined the effects of government policies on technology adoption from a macro perspective. This was the approach attempted in this study. However because of the lack of appropriate data, the analysis is limited. For example, in the case of overvaluation of domestic currencies, it could not be determined in this study that any of the currencies were overvalued, although more than one method of analysis was used.

Recommendations for Future Research

The method of analysis used in this study was mostly correlation analysis. This was because of data limitations. Future studies in this area should consider multivariate analysis and/or some production function analysis, using either the ordinary least squares, or a non-linear form of estimation to determine the sign and size of parameters. A good set of time-series data definitely will be necessary.

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