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PAST TRENDS AND FUTURE PROSPECTS FOR AGRICULTURAL DEVELOPMENT IN SUB-SAHARAN AFRICA

by

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by

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I - INTRODUCTION

1.1 Agriculture and the Growth Process in Africa

As early as the end of the 1950s, the need for increased agricultural production and supply of food to sustain the industrialization process in Less Developed Countries was recognized. This is reflected in the findings that "industrialization depends upon agricultural improvements;" "industrial and agrarian revolutions always go together;" and "economies in which agriculture is stagnant do not show industrial development" (Lewis 1954, p. 173). Agriculture-oriented development strategies received substantial support in the development literature beginning in the 1960's (Johnson and Mellor, 1961, etc.).

Available evidence lends strong support to the close relationship between agricultural development and overall economic growth. Delgado et al (1994), show that an initial increase in rural incomes in a set of African countries is amplified through growth multipliers averaging 2.0 and above[2]. Furthermore, agricultural multiplier estimates obtained by other authors (e.g. Hagggblade et. al. 1989) range from 1.5 to 2.7 and are comparable to estimates for Asian countries which range from 1.5 to 2.4.

Since agriculture provides a third of Gross Domestic Product (GDP), employs about two thirds of the labor force, and is in many cases the primary provider of foreign exchange in most African countries, it is unlikely that any significant and sustained recovery of national economies can be achieved, unless countries succeed in reversing the economic decline of the agricultural sector. From the middle of the sixties to the middle of the eighties, agricultural growth in African countries averaged 2 percent, turning sharply downwards towards the end of the period, compared with growth rates of around 3 percent for developing Latin American and Asian countries. During the same time, per capita GDP in African countries grew by less than 1 percent, compared to 1.5 percent for Latin

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[1]Managing Director, Dunstan Spencer and Associates, PMB 108, Freetown, Sierra Leone. Paper prepared for the workshop on Agricultural Transformation in Africa, co-sponsored by the African Development Bank and the Sustainable Development Office of USAID's Africa Bureau, September 26 - 30, 1995, Abidjan, Cote d'Ivoire.

[2] A rural growth multiplier is the addition to total rural income from adding a dollar of new (exogenous, tradable) income as a result of structural changes such as technological progress, improvement in export prices, etc.. Thus, a multiplier of 2.0 suggests an addition of $1.00 on extra income for each $1.00 of new agricultural income , through a re-spending on non-tradable consumer items and intermediate inputs.

American countries and 2.5 and 5 percent respectively, for East and South Asian countries (World Bank 1989, 1993a).

Because of the high marginal expenditure shares for food, consumption linkages play the main role in agricultural growth multiplier effects (Haggblade et. al., 1989; Haggblade et al, 1991). This implies that increments to income have to be wide-spread for the growth multiplier process to assume importance. At the current level of development of African economies, only agriculture-based activities can bring about broad-based increases in per capita income. In addition, sustaining the process of growth will call for improved competitiveness and greater responsiveness in the domestic consumer goods sector, as expenditure patterns shift in favor of the latter. This puts promotion of appropriate technology in agriculture and the creation of an enabling policy environment at the center of the challenge facing African countries.

The rest of this paper examines historical trends in economic growth in SSA and the possible cost and returns from pursuing alternative development strategies. Chapter II examines the trends in population growth, economic development, food and nutrition input use and infrastructure development in each of five regions. In the third chapter, the possible investment cost and likely effect on food production, of development strategies that focus on using available green revolution technologies in high potential regions of SSA, and those that imply a more broad-based development path are examined.

II HISTORICAL TRENDS IN AGRICULTURAL GROWTH AND DEVELOPMENT IN SUB-SAHARAN AFRICA

2.1 Diversity of Africa

The physical, environmental and socio-economic conditions in Africa are diverse. All discussions of economic development must take that into account. No general policy prescription can be made for all countries or ecosystems of the continent. Agroecological zones are a very useful basis for discussing agricultural development issues, since the natural resource base, including biodiversity, is a key determinant of agricultural production possibilities. Agroecological zones cut across national boundaries. However, the agricultural policy framework, another important determinant of agricultural development prospects is best differentiated within national and regional boundaries. The Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) has therefore defined ecozones, which are regionally defined agroecological zones, i.e. the boundaries of the ecozones follow national boundaries (TAC/CGIAR, 1991; Gryseels and Kassam, 1994). TAC has delineated four principal ecozones for Sub-Saharan Africa (SSA) - Warm Arid and Semi-Arid Tropics, Warm Sub-Humid Tropics, Warm Humid Tropics, and Cool Tropics.

For consistency with the country groupings in the International Food Policy Research Institutes (IFPRI) International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) simulation model, which is used later to trace the possible outcomes of alternative development strategies for SSA, all the discussion in this paper refer to five zones in SSA. These zones are a slight modification of the TAC ecozones. Nigeria in the TAC Warm Humid Tropics, is treated as one zone

because of its population. The rest of the countries in the TAC Warm Humid Tropics are combined with those in the Warm Sub-Humid Tropics to form the Central-West Africa zone. The TAC Cool Tropics is divided into two zones - Eastern and Southern Africa. The main characteristics of the resulting five zones are shown in Table 1.

Table 1 Characteristics of major Zones in SSA

Zone	Countries	Land Area	Population (1991)		GDP (1991 U.S.$)	
		1000 Km^2	Total (millions)	Density (persons / Km^2)	Total (millions)	Per Capita
Nigeria	Nigeria	911	99	109	34,124	345
Northern	Burkina Faso, Chad, Mali, Mauritania, Niger, Sudan, Somalia, Ethiopia	9153	121	28	23,695	196
Central - West	Benin, Cameroon, Comoros, Cote d'Ivoire, Central African Republic, Congo, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Sao Tome, Senegal, Sierra Leone, Togo, Zaire,	5344	117	34	61,384	525
South	Angola, Botswana, Djibouti, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Swaziland, Zambia, Zimbabwe	6301	73	35	37,818	519
East	Burundi, Kenya, Rwanda, Tanzania, Uganda	1707	79	81	17,750	225

2.2 Population Growth

Figure 1 shows that the population of each of the five regions in SSA has doubled over the last three decades. However, there has not been much difference in growth rates between the regions, except for a slightly higher rate in the East. Consequently the regions have maintained their relative positions over the last three decades, as far as total population is concerned.

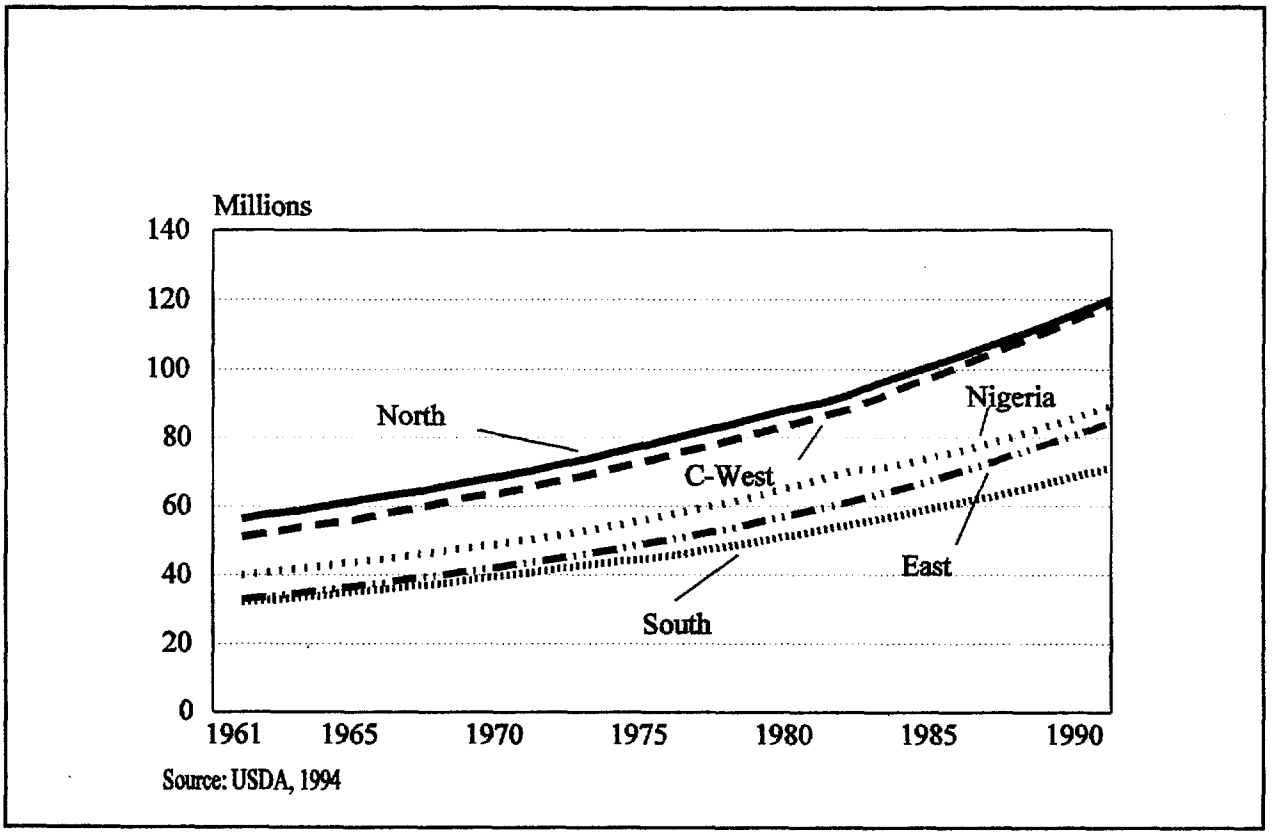


Figure 1: Population in Sub-Saharan Africa, by Region, 1961 - 91.

2.3 Record of Economic Development

As indicated earlier, economic stagnation, even decline, has characterized most African countries over the last two decades. Figure 2 shows that the growth of Gross Domestic Product (GDP) has exceeded population growth only in the South region. In all other regions real per capita GDP declined during the 1970s and 1980s. The poor performance of African economies was due to the poor performance of the agricultural sectors. Figure 3 shows that total output has more than doubled over the last three decades.

Because of relatively high population growth, the trend in per capita agricultural production, a more critical indicator of agricultural growth than growth in total production, has declined as shown in Figure 4. The index of per capita agricultural production, declined sharply from the early 1970s to the late 1980s. The downward trend agricultural productivity stabilized in the 1980s. In fact recent evidence has pointed to some increase in agricultural productivity in the late 1980s and 1990s (Block, 1994). From Figure 4, it is clear that the respectable growth in per capita GDP in the South region that is shown in Figure 2 is due to growth in the non-agricultural sector.

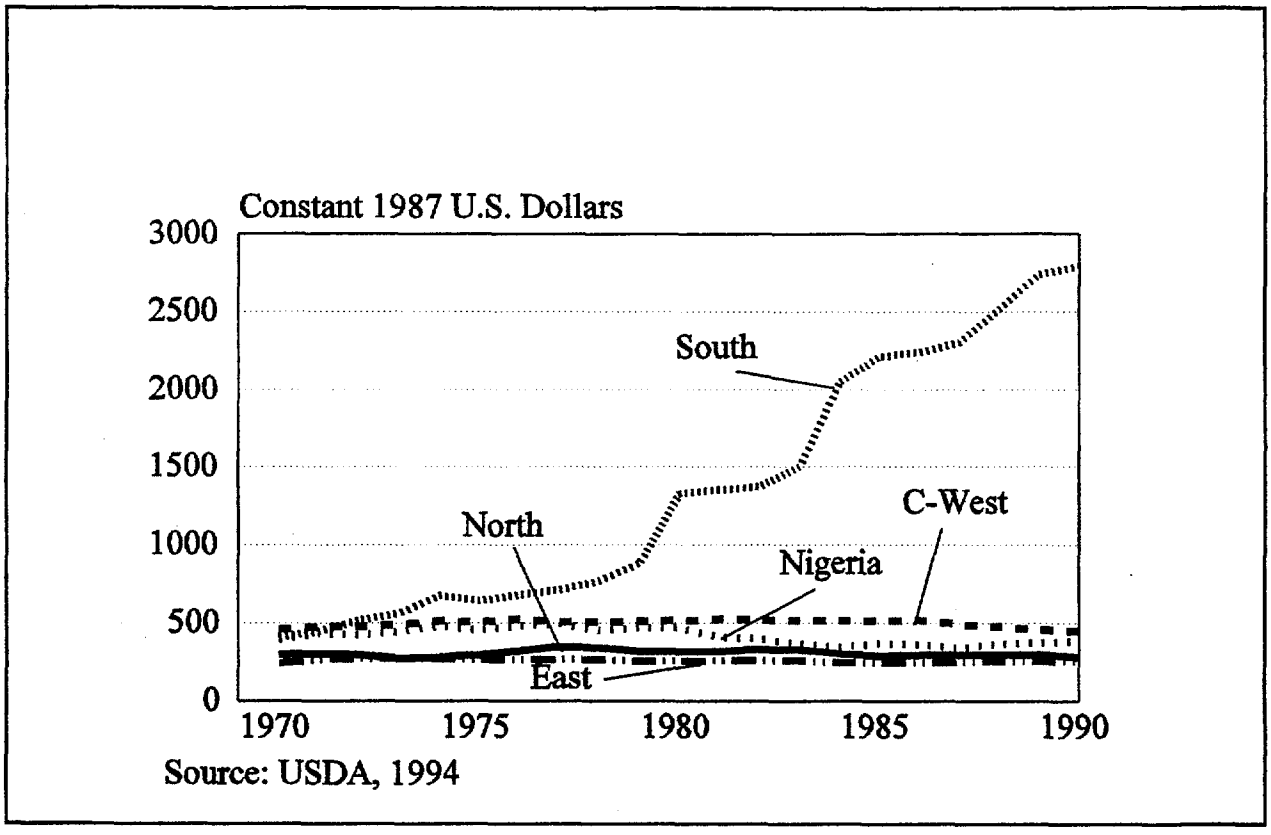


Figure 2: Trend in Per Capita Gross Domestic Production in SSA, by Region, 1970 - 1990

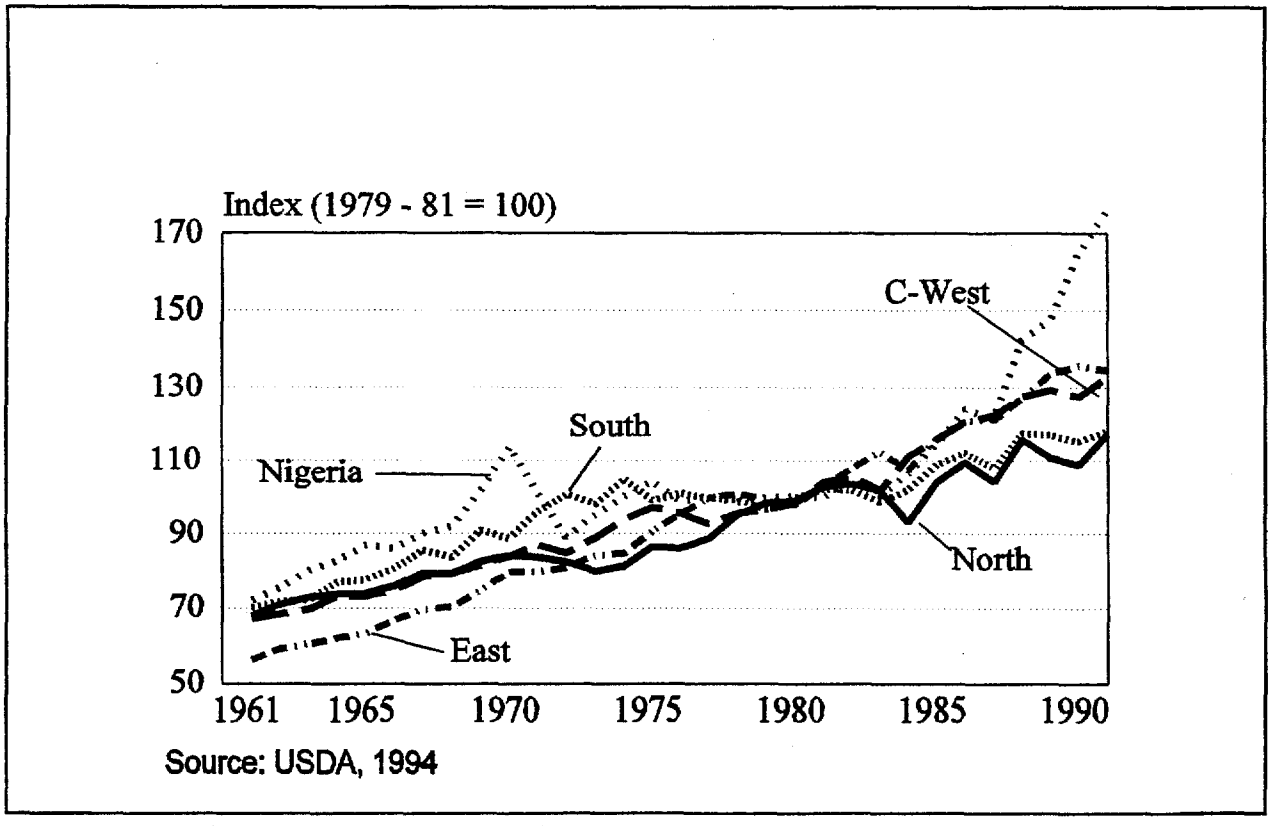


Figure 3: Trend in Average Total Agricultural Output in SSA, by Region, 1961 - 1990.

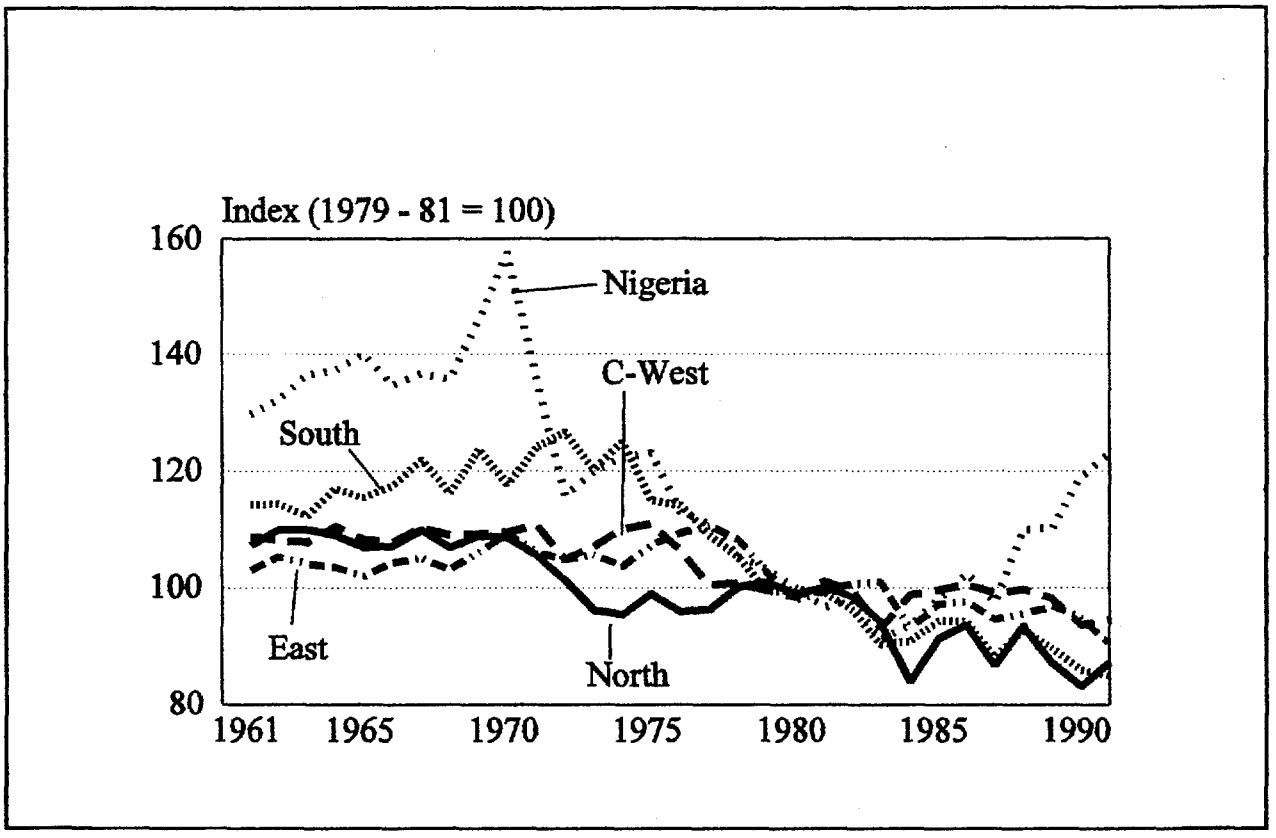
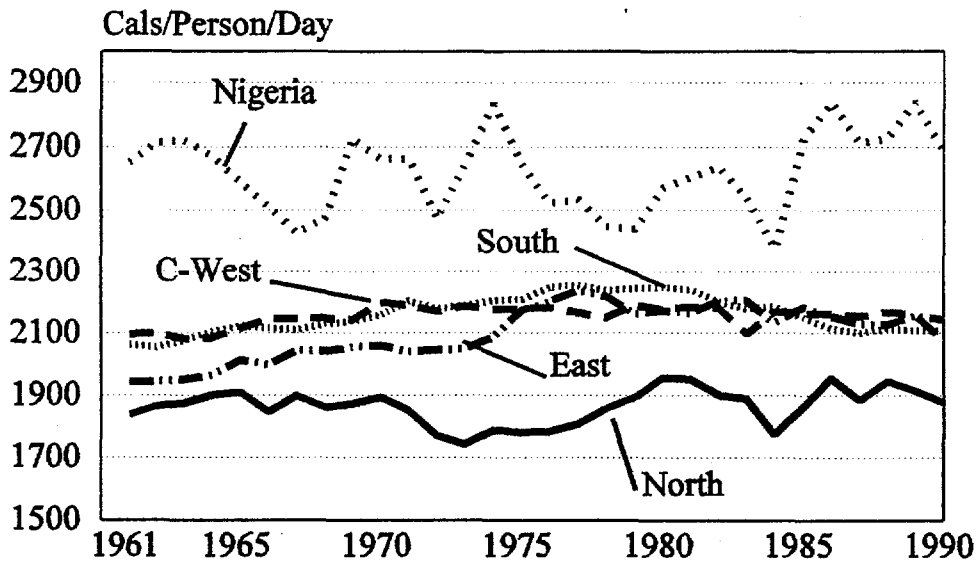


Figure 4: Trend in Average Per Capita Agricultural Output in SSA, by Region, 1961 - 1990.

2.4 Food and Nutrition

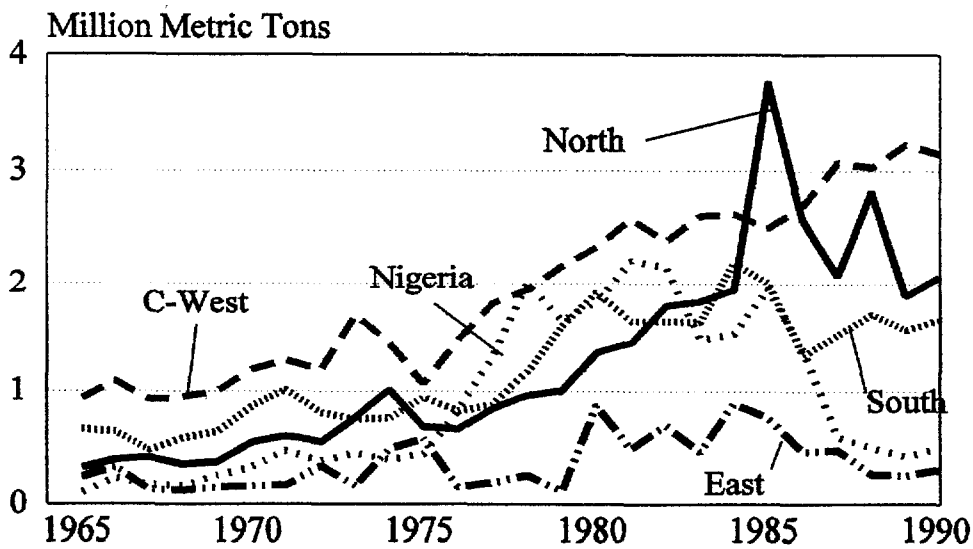
Although per capita agricultural output and food production have declined over the last three decades, three of the regions in SSA (Central-West, East and South) have managed to have a slight upward trend in per capita calorie consumption, while the other two have maintained their average level of consumption (Figure 5)[3]. This has been made possible by a massive growth of cereal imports. Total cereal imports have more than doubled since the 1960s (Figure 6). Food aid has been an important component of total food imports in some regions, especially the North region, which consists of the countries in Semi-arid SSA, and in which food aid has accounted for half to two-thirds of total cereal imports in most years (Figure 7). The trend in protein intake has followed that of calorie intake (Figure 8).

[3] The trends in Figure 5, of course hide a wide variation between the countries. For example, Zaire has seen its per capita daily calorie consumption drop from about 2180 in the 1960s to about 2040 at present, Central African Republic from 2250 to about 1900; while Guinea Bissau has seen it's grow from about 1650 to about 2150, and Gabon from about 2100 to about 2600.



Source: USDA,1994

Figure 5: Trend in calorie consumption in the different regions of Sub-Saharan Africa, 1961 - 1991.



Source: World Bank, 1993

Figure 6: Annual imports of cereals into different regions of Sub-Saharan Africa

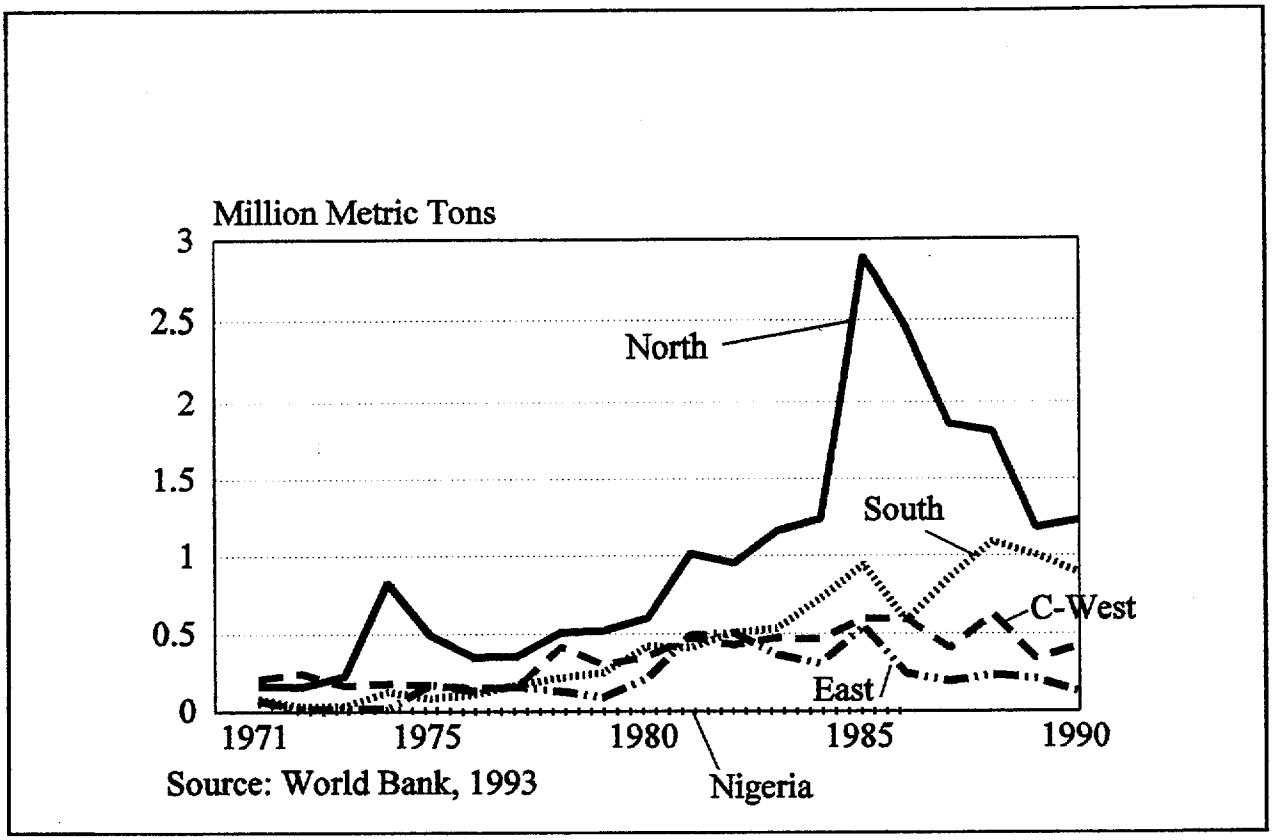


Figure 7: Trend in annual imports of cereals as food aid into different regions of Sub-Saharan Africa

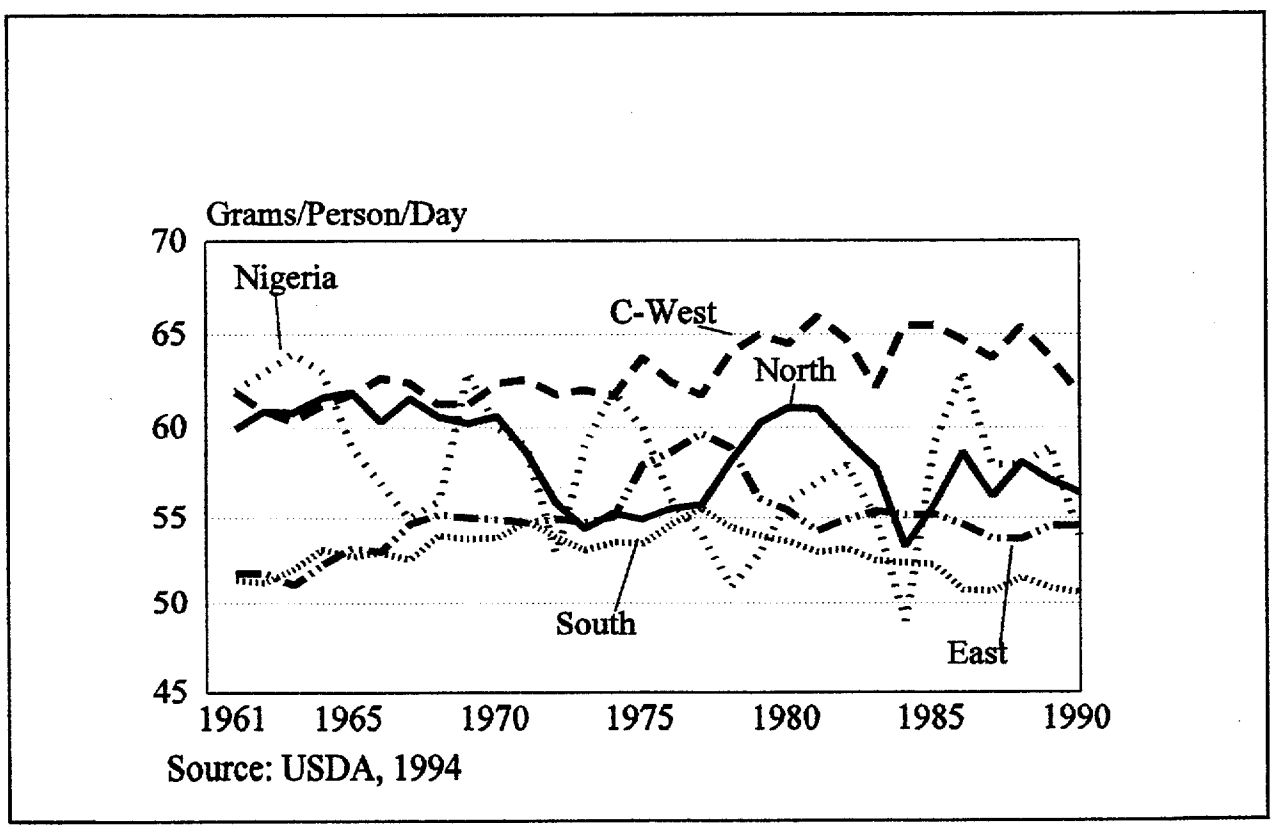


Figure 8: Trend in daily protein consumption in different regions of Sub-Saharan Africa

2.5 Use of Purchased Inputs

Probably, the biggest constraints on increased agricultural productivity in SSA are poor soil fertility and weed competition (IITA, 1988, Carr 1989). The soils are very susceptible to degradation, and there is a tendency for soil productivity to decline rapidly with repeated cultivation (Nye and Greenland, 1960, Lal, 1987, Kang, 1993).

One of the major factors in the green revolution in Asia, was the significant increase in the use of purchased inputs. Figure 9 shows that there has been a steady rise in fertilizer use over the last 3 decades in all the regions of SSA. However, the increases could hardly be considered as significant in the Central-West and the Northern regions. The level of fertilizer use, even in the high potential East and South, is still much below average levels in Asia and Latin America. This low level of fertilizer use is due to the low profitability of its use in most farming systems, as a result of the relative high cost of the input due to high transport and other transaction costs. With the reduction in fertilizer subsidies, as a result of structural adjustment programs, its use is becoming even less profitable, threatening to cause a reversal in gains already made [4].

The rate of tractor use has not changed much in the regions, except for the south where there was a doubling in the rate or tractor use between the early 1960s and the late 1970s. Since then, there has been hardly any increase. In the other regions there has been hardly any change over the three decades (Figure 10). The cost, inappropriateness in most of the upland areas of the humid and sub-humid tropics in terms of destruction of the soil, and relative unprofitability of such systems has constrained the growth of tractor use in SSA.

2.6 Infrastructure Development.

Rural infrastructure, comprising rural roads, markets, irrigation systems, water supply, health and educational facilities, are basic to quality of life in rural areas, and are important facilitators of economic development (Ahmed and Donovan, 1992). Many types of infrastructure have critical roles to play in any agricultural development strategy for Africa (Cleaver, 1993). However, a detailed review of all aspects or rural infrastructure is outside the scope of this paper, so emphasis is put on rural transport and irrigation systems. These are fundamental factors that influenced the success of the green revolution in Asia.

Compared to levels in other developing countries, the rural transport system in most of the regions of SSA is grossly inadequate. Table 2 shows that there are about 620,000 Km of rural roads in SSA, with an average density of 53 Km/1000 Km^2. The lowest coverage is in the North region which has an average of only 14 Km/1000 Km2, while the best coverage is in Nigeria. These present densities are much lower than those in other developing countries, and lower than required given the existing population densities in the countries.

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[4] See as an example case of improved maize varieties in the Northern Guinea Savanna of Nigeria (Smith et. al. 1994)

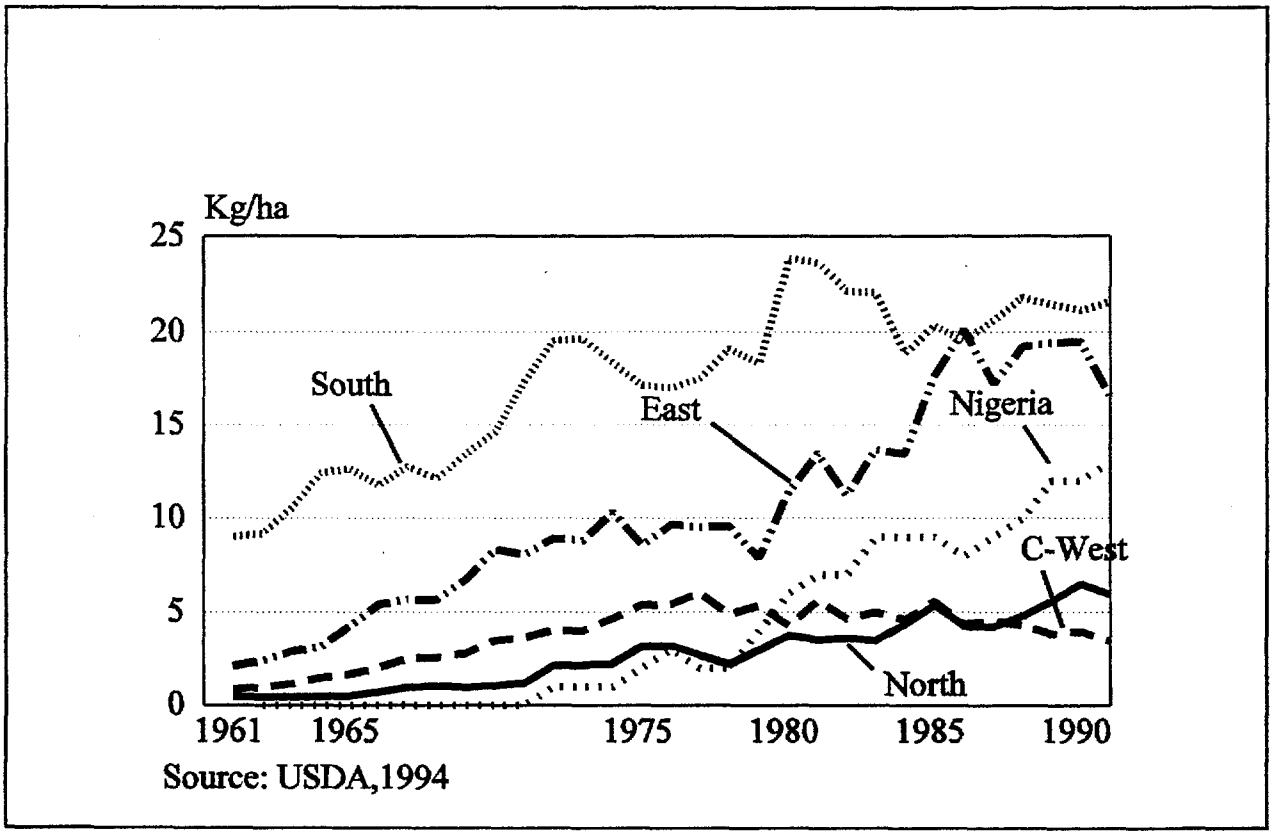

Figure 9:Trend in average fertilizer use in different regions in Sub-Saharan Africa

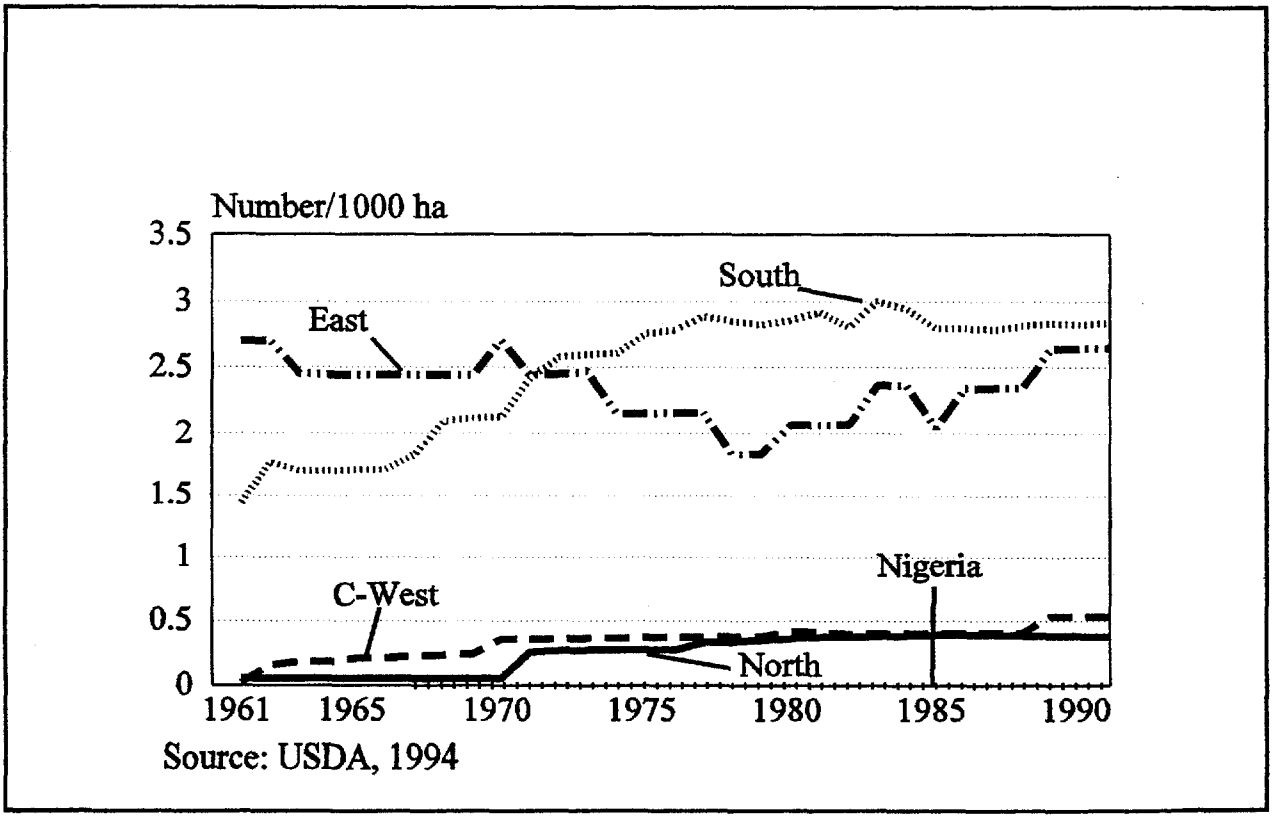

Figure 10: Tractor use in different regions of Sub-Saharan Africa.

Table 2: Rural Road Network in Regions of SSA

Region	Total (Km)	Density (Km /1000 Km^2)	
		Existing	Required [a]
Nigeria	89,900	99	728
C-West	189,125	42	231
North	95,091	14	190
South	154,862	45	237
East	95,868	77	542
SSA	624,846	53	374

[a] Density required to achieve a overage equivalent to that of India in 1950. Where population density in a region is less than that of India in 1950, the required road density is adjusted downwards in proportion to the present population density of the region.

Source: Heggie (1992)

To achieve a road density equivalent to that in India at the start of the green revolution, SSA countries should have an average density of 374 Km/1000 Km^2, roughly seven times what exists today. Densities should range from 190 in the North to 728 in Nigeria. Another major problem with the existing network is its poor state of repairs. It is estimated that half of the rural road network in SSA requires substantial rehabilitation (Riverson et. al., 1991).

Available statistics show that only about 6% of the arable and permanent crop land in SSA is irrigated. compared with an average of 25% for India and 47% for China (WRI, 1993). For SSA only 4% of the crop land is irrigated, with the highest percentages in Mali (9.75%), Sudan (14.6%), Mauritius (16%), and Madagascar (29%). Table 3 shows the area under irrigation in each region of SSA, compared with the area that should be under irrigation if SSA were to have the same level of irrigation as India. The figures show that the North and South regions should have 2 - 3 times the area that is presently under irrigation, while the other regions should have 11- 25 times what they presently have.

2.7 Reasons for Lack of Agricultural Development in SSA

Why have most countries in of SSA, failed to achieve significant agricultural growth during the last two decades ?. Analysts agree that although the situation is complex, one of the most important reasons is that improved technology has not been adopted on a significant scale. Most of the agricultural growth has come from area expansion, not yield increases (World Bank, 1989). Improved technology offered to farmers has not been appropriate, given the factor endowments of the majority of Africa's small scale farmers (Matlon and Spencer, 1984). The situation was exacerbated in many countries by inappropriate government macro-economic as well as sectoral policies.

Table 3: Irrigation Network in Regions of SSA

Region	Total (1000 ha)[a]	
	Existing	Required [b]
Nigeria	175	3578
C-West	153	3736
North	1162	2871
South	558	1649
East	148	1664
SSA		

[a] Area with a level of water control roughly equivalent to the average in Asia.

[b] Cropland that needs to be properly irrigated to bring the regional percentage to the level in India in 1991.

Accelerated growth in the agricultural sector is essential for economic recovery in African countries. Strategies for renewed growth in the agricultural sector and economic recovery should entail two basic components. Investments in raising the stock of available technologies, which addresses the needs for sustainable practices, input efficient varieties, and inputs that are less resource-intensive, less market-dependent and therefore more accessible to farmers. An appropriate macroeconomic and sector policy environment must be created which restores incentives to the agricultural sector, minimizes unit costs in domestic marketing systems, and ensures competitiveness of agricultural tradables in domestic, regional and international markets (Spencer and Badiane, 1994).

III - PROSPECTS FOR INCREASED FOOD PRODUCTION

This chapter looks forward to the year 2020, examining the prospects for increased food production in SSA. First the prospects if recent trends continue, are examined. Then the possibilities of accelerating the pace of agricultural development by creating the enabling conditions for widespread use of "green revolution" technologies currently on the shelf, or being produced by research institutions, are examined. In the third section, alternative types of technologies needed to fuel broad based agricultural development in the future are described, and the potential impact of adopting a broad based development strategy examined.

3.1 Prospects For Food Production by 2020, if Existing Trends Continue

Rosegrant et al. (forthcoming) provide an overview of the likely world food supply and demand situation to the year 2020, using the IFPRI International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), which is a representation of a global competitive market for crops and livestock. It is currently specified as a set of 17 commodities and 35 country or regional sub-models, five of which are for SSA. Each sub-model has a particular structure within which

supply, demand and prices for some categories of agricultural commodities are determined. The 35 sub-models are linked through trade. IMPACT uses a set of supply and demand elasticities, incorporated into a series of linear and non-linear equations to approximate the underlying production and demand functions, and sectoral growth multipliers to determine the intersectoral impact of changes in income in agricultural and non-agricultural sectors.

Baseline projections for the five zones of SSA, if present trends continue, are shown in Table 4. They clearly indicate, as shown by other projections (e.g. FAO, 1993, and World Bank, 1993b), a rapid growth of food imports, particularly cereals. For example imports of Wheat would increase from about 5.1million metric tons in 1990 to about 12.9 million metric tons, that of standard quality rice from 2.5 to 6 million metric tons, and of other grains from 1.1 to 6.4 million metric tons.

Rosegrant et. al. consider several alternative scenarios in order to explore how world food trends would be influenced by underlying assumptions in the model. They explore the potential effect of alternative growth in income and population, alternative dietary transitions, alternative rates of growth in productivity due to changes in the rate of investment in agricultural research and natural resource management, and full trade liberalization. As far as SSA is concerned, the results confirm that the prospects cannot be improved by policies applied at the global level. Since it is very doubtful that SSA will be able to finance the food imports implied in all the projections, even with foreign assistance, SSA must devise focussed intervention schemes that directly tackle its food production problems. Some alternatives are explored in this paper.

3.2 Accelerating the Pace of Agricultural Development: Using Existing "Green Revolution" Technologies in High Potential Areas

It is good policy for SSA countries to exploit existing technologies as much as possible in order to increase the pace of agricultural development, and consequently, the pace of economic development in the near future. It has been shown that the infrastructure and other conditions in SSA regions today are very different from those in Asia, and that adoption of intensive green revolution technologies has been very low. The question that arises is whether, and to what extent the enabling conditions that existed at the start of the green revolution in Asia and Latin America, can be created in SSA countries within the next 2-3 decades. If they can be created by then, research institutions will be justified in continuing to develop green revolution type technologies. If not, new strategies should be put in place now, that would lead to production of more appropriate technologies.

In an earlier paper (Spencer, 1995), it has been shown that Nigeria, as well as the countries in the West-Central Africa zone would not be able to create the fundamental enabling conditions, i.e. put the required rural road network and irrigation systems in place, to allow widespread use of existing green revolution technologies by 2020. In this section the effect on food supplies, of trying to create the enabling infrastructure and other conditions for widespread use of green revolution technologies in the so-called high potential zones of SSA (the South and East), are examined, using the IMPACT model.

Table 4 IMPACT model projections of the net trade position (1000 mt) for regions in SSA, if present trends continue.

Item	Nigeria		C-West		North		South		East		SSA	
	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020
Beef	-6	-171	-167	-650	53	-169	69	-49	86	-469.	35	-1508
Pig Meat	0	-16	-9	-103	0	-3	-17	-113	0	-83.	-26	-318
Sheep Meat	-2	-80	-8	-56	13	-175	-4	-30	1	-164.	0	-505
Poultry Meat	-77	-255	-69	-239	-9	-102	34	4	31	-49.	-90	-641
Eggs	-1	1	4	-35	0	-21	3	-4	1	-103.	7	-162
Wheat	-201	-460	-1355	-3302	-1774	-4226	-1408	-3495	-413	-1339.	-5151	-12882
Maize	1	425	-65	241	0	-207	-255	-778	79	-2422.	-240	-2741
Other Grains	-61	270	-444	-1144	-231	-3124	-343	-1122	-13	-1296.	-1092	-6461
Roots & Tubers	0	-302	47	41	-8	-97	-15	-119	1	-19.	25	-496
High quality indica rice	-108	-255	-70	-185	-29	-72	-62	-151	-33	-103.	-302	-766
Standard Rice	-34	-766	-1018	-1899	-419	-1149	-763	-1617	-265	-914.	-2499	-6345
Soybeans	2	1	1	0	0	37	-3	-127	2	0	2	-89

In order to bring the rural road network to a level equivalent to that of India in the early 1950s, by the year 2010, in the high potential South and East Zones, 766,000 Km of rural roads would need to be constructed[5]. This implies a total investment of $38,290 million, or an annual investment of about $5,380 million. The investment would put in place the rural road network that would allow effective input and output marketing. In addition, the countries in the two regions would need to increase their annual expenditure on other transportation infrastructure (vehicles, etc.), and fertilizer use which would need to increase to about 70 Kg/ha from the present level of around 20 Kg/ha.

The incremental investment above, may be expected to cause average maize and wheat yields to increase from their levels in the base run of IMPACT, for the years 1995 to 2010, so that they are about the same as those in India from 2010 to 2020. The effect of these increase on food supplies in SSA is shown in Table 5. There is not much change in the net trade position for wheat, but maize production increases substantially, from a deficit of 2.7 to a surplus of 4 million metric tons. Because of reductions in world market prices, there is a slight worsening in the net trade position for almost all commodities, especially in the three regions that do not benefit from the increased investment.

As indicated earlier irrigated agriculture has played an important role in the success of agricultural production in Asia. The region with the greatest extent of irrigated land is the North (Table 3). It is also the region with the greatest need, and the possibly the greatest potential for irrigation development in SSA. As is shown in Table 3, the North region would need to increase the area under irrigation by roughly 150% to bring irrigation coverage to an equivalent level to India in the 1950s. This would require a total investment of $ 4270 million, or an annual investment of $ 600 million, between now and 2010[6]. It is expected that such investment will allow rice yields in the North region to increase gradually so that so that they get to the same level as that of India by 2010, remaining at the India level therafter[7]. The cumulative effect of the investment in rural roads in the South and East, and irrigation investment in the North as predicted using IMPACT are shown in Table 6. Imports of standard quality rice are projected to decline by about 6.4 to obout 3.5 million metric tons in 2020.

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[5] Although it is impossible to say that the green revolution would not have taken place in Asia and Latin America without the levels of irrigation and rural transport infrastructure that existed in most of the countries in the 1950's, it is true that much of a "green revolution" has not occurred in countries with combined levels of irrigation and rural transport infrastructure significantly less than those in the green revolution countries. The levels in India are therefore used as a standard for what African countries may need to do to create the enabling conditions for a green revolution using technologies similar to those that fueled the green revolution in Asia.

[6] Capital cost of developing new irrigated area is assumed to be the same as the average in Asia, i.e. S3,500 per ha. The average in Africa is actually closer to $12,000 per ha. Annual capital expenditure is calculated using a discount rate of 12%. In this analysis irrigated rice area is assumed to double by 2010, and treble by 2020.

[7] Recent experience with the rehabilitation of the irrigation syatem in the Office du Niger in Mali has demonstrated it it is possible to achieve Asian yield levels over large areas in Africa.

Table 5. IMPACT model projections of the net trade position (1000 mt) for regions in SSA by 2020, after investments rural roads and fertilizer in the South and East regions.

Item	Nigeria	C-West	North	South	East	SSA
Beef	-172	-651	-171	-50	-471	-1515
Pig Meat	-16	-104	-3	-114	-84	-321
Sheep Meat	-80	-56	-176	-30	-164	-506
Poultry Meat	-255	-240	-103	4	-49	-643
Eggs	1	-35	-21	-4	-103	-162
Wheat	-462	-3307	-4238	-3195	-1155	-12357
Maize	357	111	-307	6506	-2636	4031
Other Grains	231	-1155	-3178	-1126	-1305	-6533
Roots & Tubers	-387	-38	-99	-119	-23	-666
High quality indica rice	-255	-185	-72	-151	-103	-766
Standard Rice	-767	-1901	-1149	-1618	-914	-6349
Soybeans	0	0	37	-127	0	90

3.3 Broad based development in all regions using "new" sustainable technology

In this section an alternative strategy is explored - increasing the investment in national and international agricultural research and extension systems, so that new "sustainable technology will be developed, and used on a widespread basis in SSA. Some of the essential characteristics that such new agricultural production technologies must have are as follows (Spencer, 1995):

a) Intensive production systems are needed. However, such systems must also result in significant increases in seasonal labor productivity, because there is evidence that this is the principal scarce factor of production in SSA, although it will become less so as population densities increase. The systems must be profitable given constrained resources of the small farmers, including the riskiness of the technologies.

Table 6 IMPACT model pojections of the net trade position (1000 mt) for regions in SSA by 2020, after investments in rural roads and fertilizers in the South and East regions, and irrigation and fertilizers in the North region.

Item	Nigeria	C-West	North	South	East	SSA
Beef	-172	-651	-171	-50	-471	-1515
Pig Meat	-16	-104	-3	-114	-84	-321
Sheep Meat	-80	-56	-176	-30	-164	-506
Poultry Meat	-255	-240	-103	4	-49	-643
Eggs	1	-35	-21	-4	-103	-162
Wheat	-462	-3308	-4240	-3196	-1155	-12359
Maize	356	111	-307	6503	-2637	4026
Other Grains	227	-1157	-3187	-1127	-1307	-6551
Roots & Tubers	-393	-51	-100	-121	-25	-690
High quality indica rice	-255	-185	-72	-151	-103	-766
Standard Rice	-773	-1942	1724	-1644	-920	-3555
Soybeans	0	0	37	-127	0	90

b) New technologies must rely minimally on purchased inputs that are heavily dependent on rural transport infrastructure. Cropping systems need to rely heavily on internal sources of inputs for soil fertility maintenance and enhancement, such as nitrogen-fixing and mycorrhiza associations and crop residue use. Low doses of chemical fertilizers will be much more profitable under such conditions.

c) Because of declining land-labor ratios and the resulting pressures on the natural resource base and because of the tendency of soils to degrade very fast under intensive cultivation, new production systems must not only be productive, they must be sustainable, i.e. they must not degrade the natural resource on which they depend. The following factors have been enumerated as necessary for sustainable food crop production in the IITA countries (IITA, 1988):

- The soil must be kept covered at all times by crops or vegetative mulch
- Organic matter must be maintained in the topsoil
- Soil compaction must be prevented or corrected preferably by biological rather than mechanical means
- Deep and shallow rooted crop species should be intercropped
- Fertilizer should be used judiciously so as not to worsen the already tenuous soil nutrient balance

- Integrated pest management systems should be used, in particular biological control systems for insect pests, and vegetation management systems for weeds.

d) Concentration should be on rainfed systems, since sufficient irrigated land is not likely to be available to allow widespread reliance on irrigation. In this context rainfed systems are defined to include improved inland valley systems with little or no water control, in which dryland crops are grown either as intercrops or sequentially with wetland crops such as rice.

e) Input efficient modern crop varieties are needed that are disease and pest resistant as well as stress tolerant. They must fit easily into the farmers intercropping systems which should be maintained to assure sustainability of the systems. Modern varieties (MVs) must meet local post harvest requirements in terms of taste and cooking qualities, so that they can satisfy farmers household as well as any domestic urban market or export needs. Furthermore, such varieties must be infrastructure efficient, i.e. they should not rely heavily on services such as modern and specialized storage or seed multiplication systems, which will be out of the reach of most countries in the next two decades.

Available statistics show that agricultural research personnel in SSA increased by an average of 6.8% annually between the early 1960's and late 1980's, while agricultural research expenditures increased annually by 4.7% during the same period (Anderson, Pardey and Roseboom, 1994). However, the growth rates have slowed down significantly in recent years. More importantly there has been a decrease in expenditure per researcher. Although the decline is partly due to a substitution of less expensive national researchers for expatriates, it also reflects a decline in the operational budget available to researchers in NARS, thus decreasing their ability to carry out the necessary research. Also, only about 0.5% of agricultural GDP is invested in agricultural research in the region, compared to a global average of 0.7% and 2% in more-developed countries.

In this analysis it is assumed that agicultural research and extension expenditure will increase from present levels to 2% of 1990 agriculture GDP, equivalent to $ 1163 million annually. Five countries (Cape Verde, Botswana, Namibia, Swaziland and Mauritius) have already attained this level of expenditure (Pardey, et. al., 1995). Although adequate funding for NARS and extension systems in SSA in the future will not on its own guarantee that they will develop and disseminate the technologies needed for sustained agricultural growth in the near future, we assume that other steps will be taken, so that the rate of growth of all crop yields will increase gradually from 1995 onwards so thet they are double the levels in the base model of IMPACT after 2010.

The results in Table 7 show that there is a substantial change in the net trade position for all commodities. Instead of the massive imports projected in Table 4, substantial surpluses are generated for all commodites in all regions, except for eggs, wheat and rice.

4.5 Conclusion

Food production in SSA can be increased using existing green revolution technology if there is significant increase in investment in rural roads and irrigations systems, as well as in the use of higher levels of fertilizer use. In an earlier publication it has been shown that it would be difficult to make the necessary investments in the Humid and Sub-humid Tropics of SSA (Spencer, 1994).

Table 7 IMPACT model pojections of the net trade position (1000 mt) for regions in SSA by 2020, increased investment in agricultural research and extension.

Item	Nigeria	C-West	North	South	East	SSA
Beef	160	-405	658	426	287	1126
Pig Meat	188	81	22	30	-21	300
Sheep Meat	74	53	353	87	-52	515
Poultry Meat	-65	0	85	263	109	392
Eggs	1	-35	-21	-4	-104	-163
Wheat	-312	-3260	-3519	-3313	-1223	-11627
Maize	2075	2753	2048	4672	2189	13737
Other Grains	10474	767	5848	-392	563	17260
Roots & Tubers	4857	27418	4614	11352	22307	70548
High quality indica rice	-255	-185	-72	-151	-103	-766
Standard Rice	-344	734	-741	-184	-686	-1221
Soybeans	36	22	45	42	24	169

The analysis in this paper has shown that even with an incremental annual capital investment of $5980 million, equivalent to about 10% of SSA agriculture GDP, in so-called high potential zones of SSA, in order to create the enabling conditions to allow green revolution technologies to be used, the food gap in SSA is not likely to be closed by 2020, not to mention the equity and distributional issues that would arise from such a lopsided development strategy.

On the contrary, a broad-based development strategy that focusses on investment in agricultural research and extension systems may lead to the a closure of the food production gap. African countries and their donors should concentrate on implementing the broad-based development strategy. Even if the necessary investment can be made, Are adequate research institutions in place, are physical and human resources adequate, are research and extension agendas correctly focussed, and are research methodologies adequate to produce these technologies? These are all questions that need to be addressed now, if the broad based strategy is to have any chance of success.

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