Chapter 4

Extension Services for Equitable Growth: The Green Revolution in Sub-Saharan Africa

Introduction

Development microeconomics has shown that the market mechanism cannot always guarantee the optimal choice for profit maximization under the circumstances of imperfect information, high risk, and high transaction cost. These types of phenomena can be broadly observed in the least developed countries.

On the other hand, globalization is sometimes assumed to be an automatic process in which economic resources are mobilized globally through the international market mechanism and advanced information technology. However, some countries that have no comparative advantage cannot attract foreign direct investment, and people who have little access to advanced information technologies become estranged from the global circulation of knowledge. As seen in Sub-Saharan Africa (referred to as Africa hereafter), poor economies tend to be left behind from the benefits of globalization.

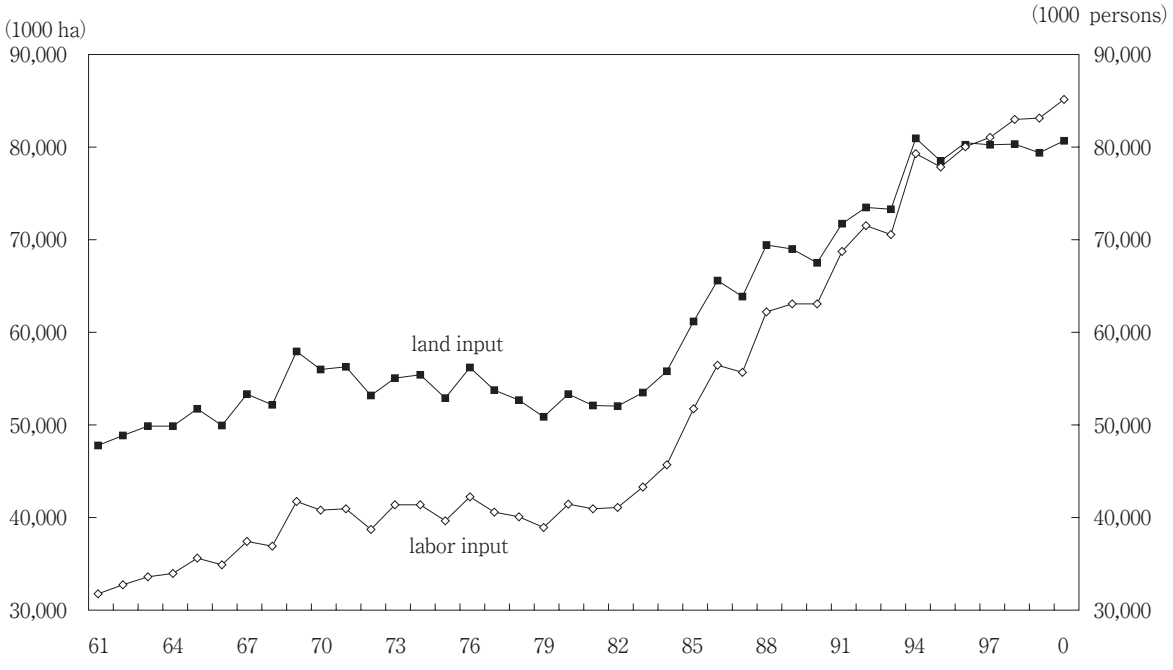
Extensionist, who brings new ideas and technologies to the peripheries of society in developing countries, is expected to function as walking transmitter of globalization. For people trapped by a vacuum of developmental tools, which include small-scale farmers in developing countries, extensionist is practically the only channel to get them.

This chapter begins by explaining the high demand for modern technology in African agriculture. This demand can be met by agricultural extension services, and development with equity can be promoted through their contributions.

4.1 African Economies and Agriculture

During the years 1980-2000, the average annual growth rate of aggregate African GDP

Figure 1 Inputs of Land and Labor for Cereal Production in Sub-Saharan Africa



Source: FAOSTAT [2002].

Table 1 Changes in the Figures Related to Cereal Production(1960-2000) (%)

	Cereal Production	Population	Labor input	Land input	Land productivity
Sub-Saharan Africa	135.3	187.6	167.6	69.4	38.9
(South Africa excluded)	141.7	191.5	175.9	82.2	32.7
Developing Asia	211.3	116.1	64.5	12.4	176.9
Latin America & Caribbean	191.3	131.3	-0.3	29.5	124.9

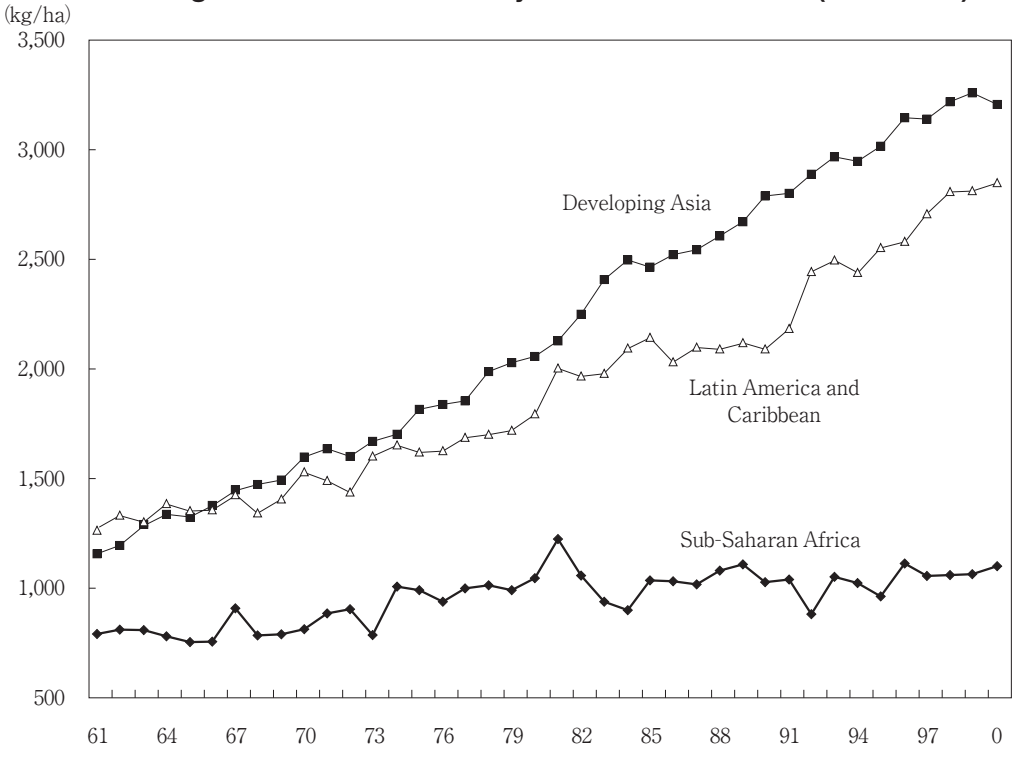
Source: FAOSTAT [2002].

was 2.19%[1]. Because the average annual rate of population growth was 2.82% in the same period, the per capita GDP of African people shrunk at a rate of -0.61% per year. By contrast, per capita GDP in India was growing at an annual rate of 3.64% and in China the rate was 8.61% in the same period. China and India tend to dominate the average figures for developing countries due to their large populations and production figures. As a result, Africa has increasingly fallen behind the average figure for developing countries and marginalized in the world.

4.1.1 Ricardian Trap

While Africa's economic performance has deteriorated, its form of food production has changed from the 1980s. Figure 1 shows the cultivated area and labor input[2] for cereal production in Africa. The land area for cereal production expanded rapidly from the early 1980s, and reached 80 million hectares in the middle of the 1990s, but then stagnated. A 135% increase of cereal production in Africa from 1961 to 2000 was brought about mainly by the increase of land input; however, it could not keep pace with population growth (see Table 1). The land productivity for cereal production in Africa grew at a small aver-

Figure 2 Land Productivity of Cereal Production(1961-2000)



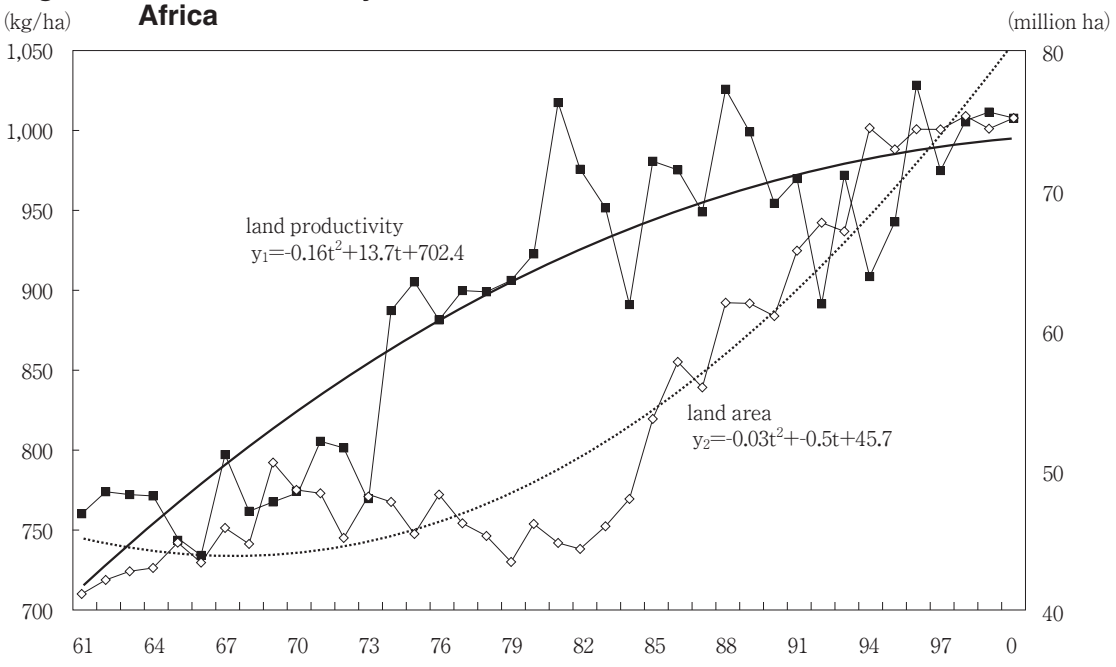
Source: FAOSTAT [2002].

age annual figure of 0.86% during that period, and at only at 0.09% from 1980.

The cereal yield per land unit area in Africa is extremely low. It was 1,116 kg/ha (1,009 kg/ha if South Africa excluded) in 2000, compared to 3,207 kg/ha in developing Asia, 2,860 kg/ha in Latin America, while the world average for the same year was 3,070 kg/ha. The gaps in cereal yields between Africa and other regions have been enlarged through the differences of the speed of land productivity improvements (see Figure 2).

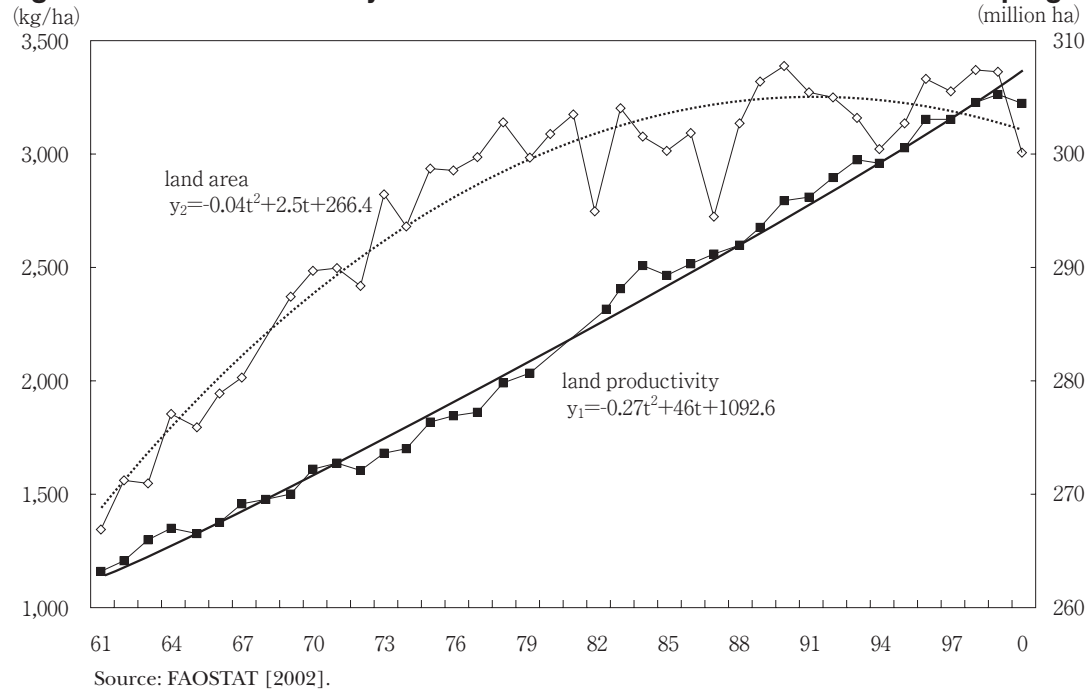
Considering that the rapid enhancement of agricultural productivity with modern

Figure 3 Land Productivity and Area of the Cereal Production in Sub-Saharan Africa



Source: FAOSTAT [2002].

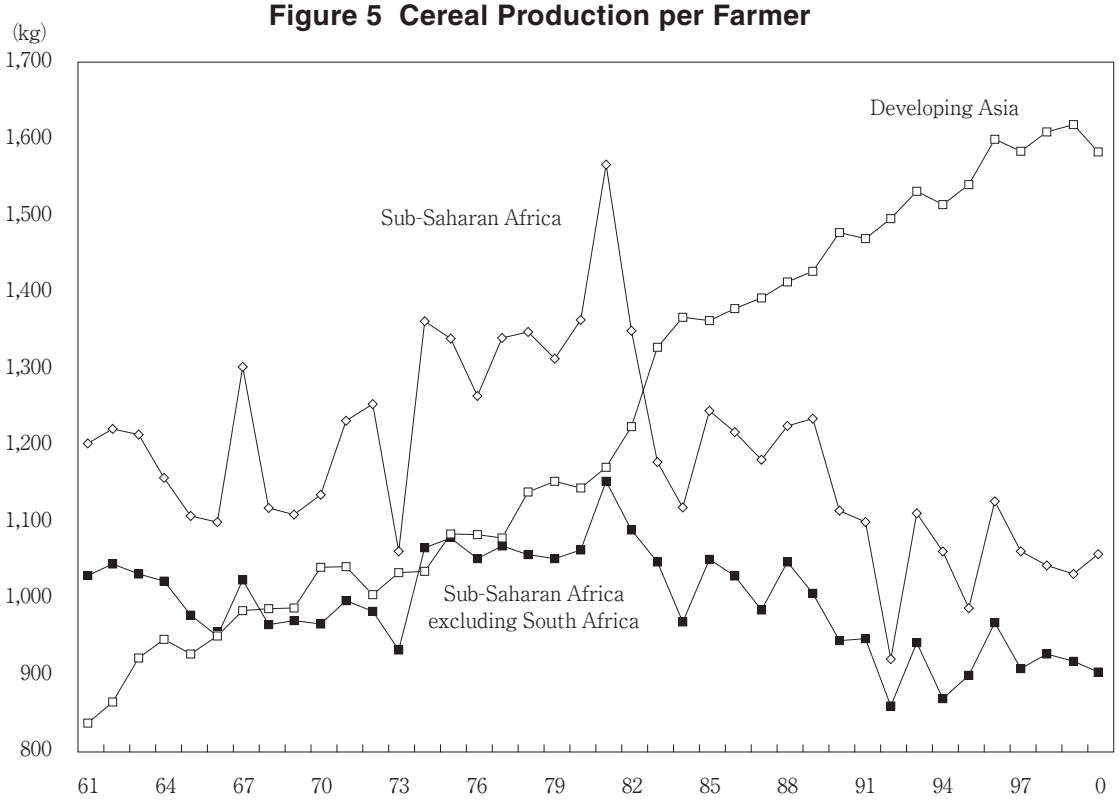
Figure 4 Land Productivity and Area of the Cereal Production in Developing Asia



Source: FAOSTAT [2002].

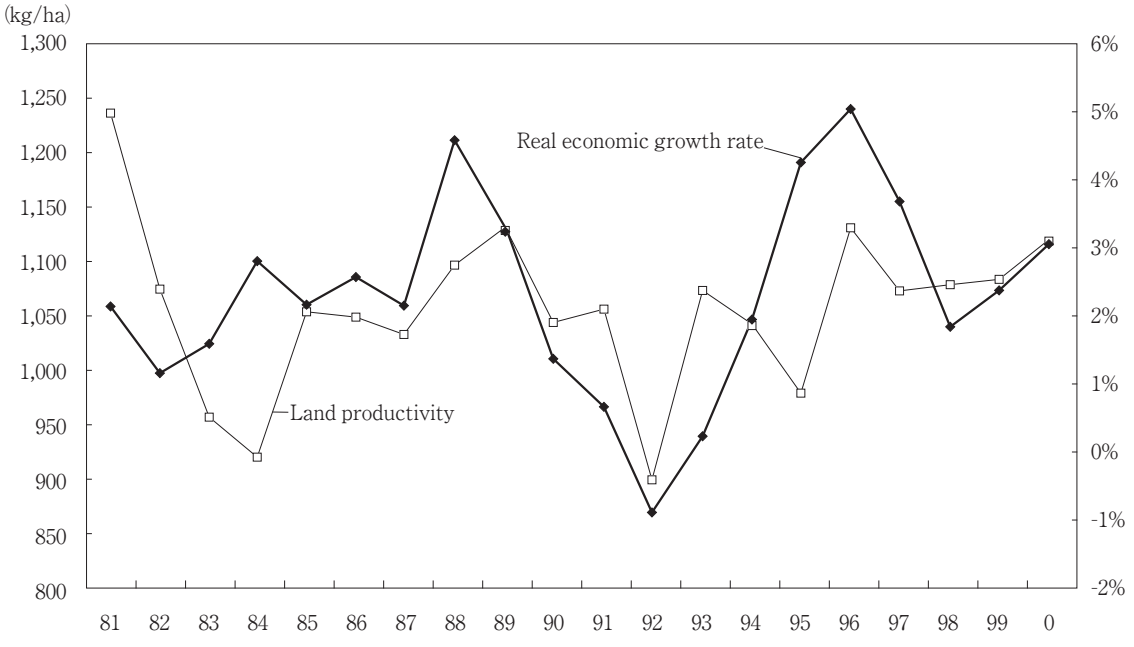
technology paves the way for 'industrial revolution' and then sustainable development, as indicated by economic history and neo-classical economics, it can be said that African economy is still in the pre-industrial revolution age.

Figure 5 Cereal Production per Farmer



Source: FAOSTAT [2002].

Figure 6 Real Economic Growth Rate and the Land Productivity of Cereal in Sub-Saharan Africa



Sources: World Bank [1996-2002a] [1992-2000b], IMF [1996-2002], EIU [2002], FAOSTAT [2002].

As shown in Figure 3, the rate of increase of land productivity for cereal in Africa has been quite slow and diminishing, while the expansion of land input has accelerated. This extensive pattern is completely opposite to the intensive development observed for Asian cereal production (see Figure 4).

The development pattern of African food production can be understood along the idea in classical economics that economic growth will be restricted by land constraints, or what is known as a 'Ricardian Trap.' On the other hand, the Asian pattern runs along the neo-classical idea that agricultural productivity should increase with technical input to attain an optimal growth path.

As shown in Figure 5, cereal production volume per farmer in Africa has decreased as a result of the pattern of extensive development. Land productivity ceased to improve, and then total production stagnated, approaching a non-growing 'stationary state' in the late 1990s.

In the Ricardian Trap, the African economy stopped growing as well (see Figure 6). The poverty problem in Africa was left to become more serious year by year, under its population pressure.

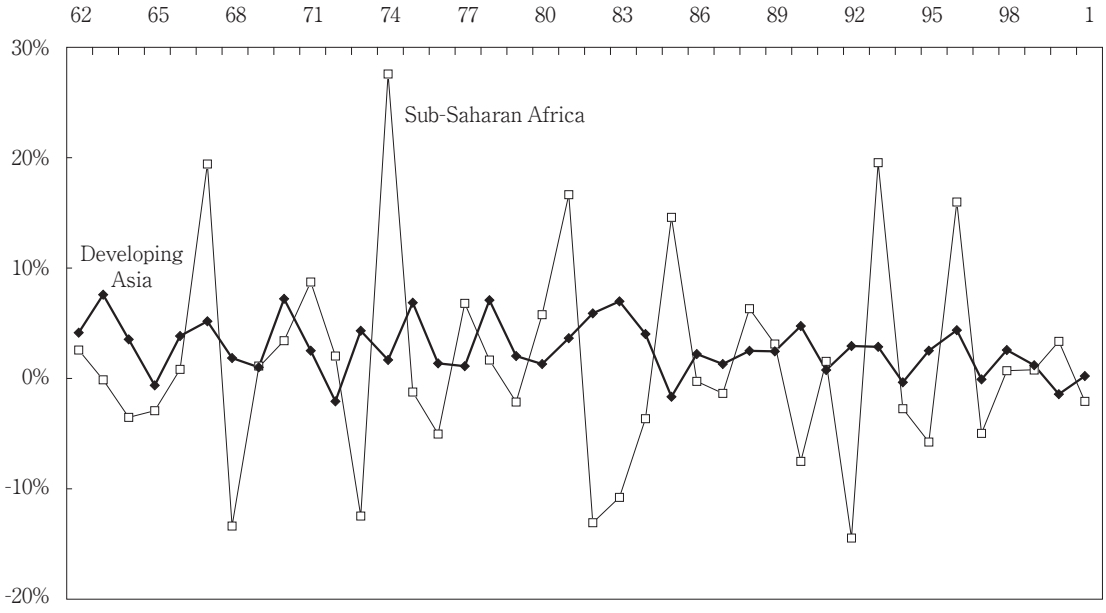
4.1.2 Unstable Production

In addition to its extensive form of cereal production, African agriculture is also characterized by instability. Figure 7 shows yearly changes of cereal yields in developing Asia and Africa. The violent fluctuations in Africa stand in great contrast to the stable growth in Asia.

The results of the regressions in Table 2 indicate that the following year's production level can be anticipated with high probability either from the current level or from a time trend in China and in Asia generally, but that it is almost impossible in Zimbabwe to make such predictions.

Significant fluctuations and instability of production make a business risky; therefore agriculture is a quite risky business in Africa. Accordingly, the investment decisions of farmers are depressed and land productivity can hardly be expected to increase. Farmers will prefer to diversify their income as insurance, at the sacrifice of specialization on agriculture. Because these behaviors are quite rational, the vicious circle cannot be removed without external intervention.

Figure 7 Changes in Cereal Yield(Developing Asia and Sub-Saharan Africa)



Source: FAOSTAT [2002].

Table 2 Coeffients of the Regressions on Cereal Yield

	Sub-Saharan Africa		Developing Asia	
	Lag variable	Time Trend	Lag variable	Time trend
	0.717	0.008	0.995	0.027
	(6.55)	(7.95)	(83.06)	(51.25)
R^2	0.531	0.618	0.995	0.985
	Zimbabwe		China	
	Lag variable	Time trend	Lag variable	Time trend
	0.037	0.004	0.982	0.034
	(0.23)	(0.85)	(55.75)	(29.22)
R^2	0.001	0.018	0.988	0.956

Note: Lag variable is b in $Y_t = a+bY_{t-1}$, time trend is b' in $LN(Y_t) = a'+b't$, and Y_t is the cereal yield per unit area in t year. t-value is in parentheses.

4.1.3 Expanding Food Import

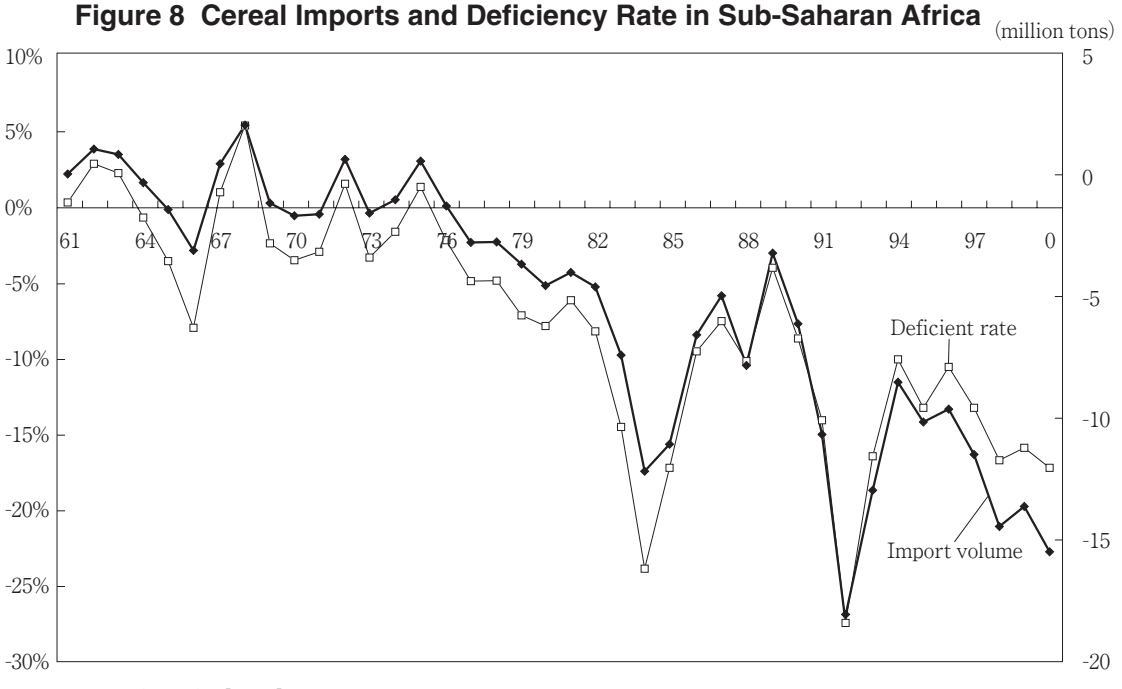
In the absence of intensive development, the cereal production sector is supposed to absorb nearly 50% of the total labor force in Africa, and its labor input volume is still increasing[3]. It is estimated that the labor input for cereal grew at an annual average rate of 4.19% from 1980 to 2000, but Africa has nevertheless fallen into food deficiency.

Figure 8 shows Africa's cereal imports and their percentage of domestic supply. Africa has been a net importer from the late 1970s, and the volume has expanded rapidly; it now exceeds that of China. Cereal imports in the drought periods of 1983-4 and 1992-3 were enormous, but the food deficiency in Africa must be recognized as a chronic structural problem of the African economy. Even in 1997, when there was normal rainfall in general, the cereal deficiency was 17 kg per capita (19 kg excluding South Africa), nearly ten times the Chinese figure. The cereal trade deficit burdens Africa as a whole with 1% of total GDP; the figure is 9% in Eritrea, and 10% in Sierra Leone. Based on the current level of cereal yield, Africa would not be able to attain the world average cereal production of 358 kg per capita (1997) even if every single African gave up his or her occupation and engaged in cereal production. The only hope lies in proper intervention to improve land productivity.

4.2 The Agricultural Revolution and Extension Services

The potential of the African economy is severely constrained by its limited capacity for food production. Subsistence farmers, which

Figure 8 Cereal Imports and Deficiency Rate in Sub-Saharan Africa



Source: FAOSTAT [2002].

make up the majority of African people, remain in poverty even in high-growth countries like Botswana[4]. Fundamentally, the poor economic performances and serious poverty in Africa can be attributed considerably to the extensive form of food production, i.e., the low-input, low-yield agriculture.

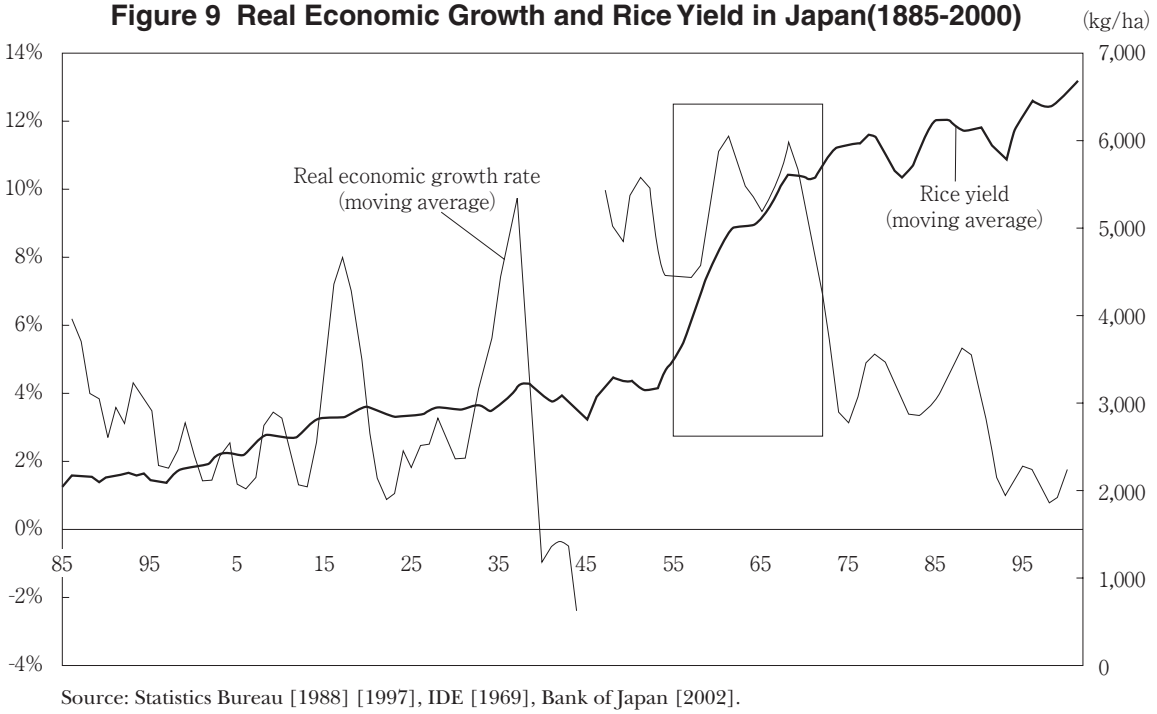
4.2.1 The Japanese Experience

However, the extensive agriculture seen in Africa today was common to all the developed countries before the modern agricultural revolution, and the developing countries in Asia and Latin America before the Green Revolution. Figure 9 shows real economic growth and rice yields in Japan from 1885. While with paddy field cultivation, a relatively good climate, and fertile soil conditions, 2 t/ha was achieved even in the 19th century, the speed of improvement in rice yields was 0.81% as an annual average before the Second World War. This is as slow as cereal yields in Africa, which was 0.86% on average from 1960 to 2000. However, the rice yield level in Japan grew rapidly up to 6 t/ha during the high-growth period that lasted for almost 20 years from the late 1950s to the early 1970s (marked by a square in Figure 9). During those years, the annual average rate of improvement of the rice yield was 2.48%, which was as high as in other Asian countries during the Green Revolution. The double-digit growth rates in the Japanese economy were made possible in the meantime by the intensive development of food production, based on the fast and steady progress in the land productivity of staple foods.

As a result, the share of agricultural employment in the total labor force decreased from over 60% in the 19th century to 9.4% in 1980, and the urbanization of Japanese society proceeded rapidly, with a large number of workers moving from rural districts to be employed in the emerging industries. At the same time, the improvements in agricultural productivity allowed farmers' incomes to keep up with their counterparts in the manufacturing sector. And the income distribution among industries and between urban and rural areas was improved.

In carrying out the modern agricultural revolution mentioned above, the government played a pivotal role in Japan. Intentional pol-

Figure 9 Real Economic Growth and Rice Yield in Japan(1885-2000)



Source: Statistics Bureau [1988] [1997], IDE [1969], Bank of Japan [2002].

icies started in the 1880s to increase rice production using technological innovation, soon after the Meiji Restoration. However, it was in the 1930s that a nationwide network of agricultural research institutes and extension system was completed in the public sector (Tanaka [1998]). Peasants' movement, which had forced the government to recognize the need to improve their living standards, largely promoted this process. Until the end of the 1930s, the number of extension services was raised over 14,000 for 6 millions farms attaining national coverage, and artificially improved varieties had diffused on more than 30% of the total cultivated area, replacing traditional ones (Kiyokawa [1995: 53]). Figure 10 shows the diffusion of improved rice varieties in Aomori prefecture before the Second World War, as an example.

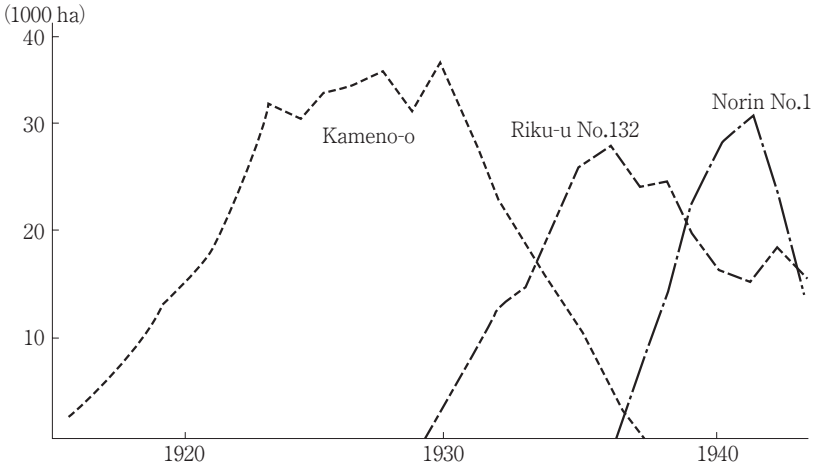
After the end of the war, these improved varieties were themselves quickly replaced by new varieties, exemplified by the Norin series, which were developed in the national research institutes. The rapid diffusion of modern varieties equipped with cold-weather resistance in the northern parts of Japan was the most impressive part of this wave, which transformed those districts into granaries. While the land reform and the democratization of the social system under the foreign occupation in the immediate postwar years definitely promoted further progress in Japan's agricultural revolution, the well-established extension system built by the new government played an indispensable role in diffusing the new varieties and technologies at the grassroots level. A total of 1,586 diffusion stations were established, covering all rural districts keeping the number of extension services to a rate of 500 farms per staff.

These efforts were accompanied by infrastructure building. The accelerated development of the manufacturing sector is a well-known part of Japanese history after the Second World War, but even greater public investment was poured into the agriculture sector. During the period from 1955 to 1975, 49.2% of industrial development expenditures from the national budget were spent on agriculture, forestry, and fishery on annual average, far exceeding the 18.0% for manufacturing and mining and the 11.2% for transportation and communication (Statistics Bureau, Government of Japan [1988]).

4.2.2 Extension Service as a Public Good

The importance of the public sector in bringing about the modern agricultural rev-

Figure 10 Diffusion of Improved Rice Varieties(Aomori, Japan)



Source: Reprinted from Kiyokawa [1995: 54].

olution can be verified in countries other than Japan. In the modernized agriculture, its technologies are developed in national centers and diffused to production sites, instead of being inherited from former generations. This radical transformation requires huge costs and institutions, which cannot be financed by the private sector nor spontaneously created by the market mechanism. The extension system by its very nature, as an intentional diffusion using public money, never targets the perfect-information state that would be a prerequisite for the market mechanism.

In fact, all developed countries have established their own types of contrivance for agricultural modernization. In the United Kingdom, the pioneer of the modern agricultural revolution, facilities for agricultural research and extension were privately initiated as with the industrial revolution, but were later nationalized under the central government. In Germany, the pioneer in establishing public apparatuses for the agricultural revolution, agricultural schools under state governments are functioning as centers for technological development and extension. The German style was imported into the United State, where a dual federal-state system was built, with land-grant universities in each state functioning as centers of research and extension (Ruttan [2001: 208-211]). In the case of developing countries, in addition to the inputs from the colonial era, full-scale extension systems were created in the central governments after the Second World War with assistance from donors. China independently developed an agricultural research and extension system and succeeded in creating hybrid-rice varieties in the 1970s. These varieties became pivotal components of the agricultural revolution there (Tajima [1989]).

Public intervention is essential for agricultural revolutions. Its functions range widely, from the development of agricultural science to building extension systems, infrastructure building, securing agricultural inputs, and arrangement of agricultural finance, etc. Among them, extension services have a special significance as human contacts carried out with the purpose of channeling profitable technologies to the grassroots. Such services can contribute greatly to development with equity, and they do not neglect small peasants in deep rural areas.

4.3 Green Revolution in Africa?

As mentioned in Section 1, Africa has seen little intensive development in agriculture and is severely lacking in food production capacity. While the adoption rate of modern cereal varieties has increased in very recent years, the expected profits have not yet materialized (see Figure 2). More than half of the modern varieties introduced to African fields were made by crossing local varieties with others created in international agricultural research institutes (Evenson [2002]), therefore, it can be said that African farmers will become connected to the global community through the diffusion of modern varieties. Such connections must be strengthened before food production in Africa begins to grow.

4.3.1 Diffusion Model

A number of empirical works on modern agricultural technology diffusion in African countries indicate that there are several determinants of whether farmers adopt it (for example, Adesina and Zinnah [1993], Adesina and Baidu-Forson [1995], Adugna [1997], Mbata [1997], Negatu and Parikh [1999], Doss and Morris [2001], Ndjeunga and Bantilan [2002]). These works employed the Probit model (or Tobit model) to measure the influence of various factors on the adoption of modern varieties or chemical fertilizers. They looked at the characteristics of the individual farmer, locality, and targeted variety, with the frequency of contact with extension services, and gained very instructive information. Ac-

cording to these works, the extension variable has a strong influence in many cases along with other important factors.

The diffusion theory in economics has progressed from the classical one, which said that new products would be adopted at a speed determined by their profitability on a time-axis shaping logistic curve, to the current Probit approach that analyzes various determinants of adoption, as mentioned above. The later implies that the adoption rate will go up if the determinants are improved. With regard to locality, for example, if unstable rainfall prevents farmers from adopting modern varieties, adoption will take place along the deployment of irrigation schemes. And with regard to the characteristics of farmers, if their knowledge level influences adoption, expansion of extension services will raise the rate. Accordingly, the diffusion of modern technologies will accelerate as policy efforts are energetically made to improve the situations surrounding farmers.

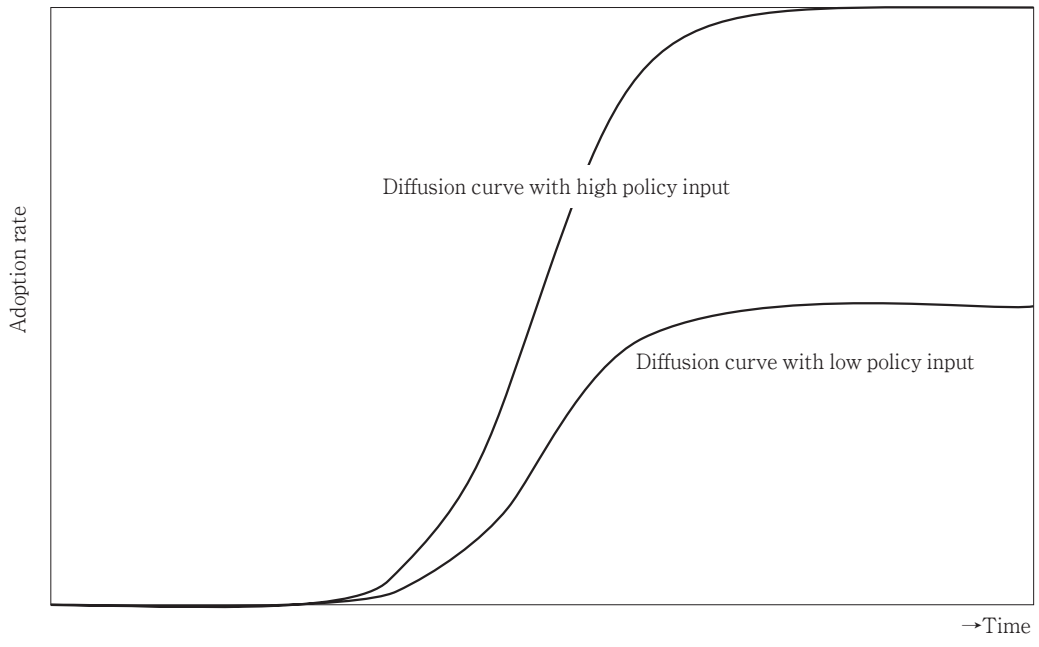
The dynamics of diffusion should be measured by looking at time and area expansion. Therefore, some determinants explored by Probit analysis can be translated into 'variables' that will change with policy input. In the unfavorable situations of African rural areas, policy efforts are needed to accelerate the diffusion of high-yield varieties; those policies must be given the highest priority on the list of development issues.

4.3.2 NERICA

In 1994, the West Africa Rice Development Association (WARDA) finally succeeded in a hybridization project between Asian rice (*Oryza sativa*) and African rice (*Oryza glaberima*), with financing from the Japanese government. The newly created varieties were named 'New Rice for Africa' (NERICA). NERICA is a ideal combination of the characteristics of both parents: a high and stable yield (as high as 2.5 t/ha at low input and 5 t/ha with a minimum increase in fertilizer use), early maturity (90-100 days), drought tolerance, resistance to diseases, responsiveness to mineral fertilization, high protein content, and a taste and aroma favored by local people (WARDA [2001]).

In Africa, eight countries produce rice as a major crop: Comoros, Cote d'Ivoire, Guinée, Guiné-Bissau, Madagascar, Mauritania, Liberia, and Sierra-Leone. Mali, Nigeria,

Figure 11 Diffusion Curve



Tchad, Sénégal, Tanzania, Ghana, and Gambia produce more than 10 kg of rice per person. However, no country is self-sufficient, and more than 30% of total rice consumption is imported, at a cost of over 1 billion dollars in 2000.

NERICA began to diffuse in West Africa from 1996, and is now produced in Cote d'Ivoire, Ghana, Guinée, and Togo under the supervision of national extension agencies and an international NGO involved in extension, namely Sasakawa Global 2000 in Guinée.

The Japanese government, which will hold the third Tokyo International Conference on African Development (TICAD III) in September 2003, has a strong desire to diffuse NERICA for alleviating poverty in Africa, in collaboration with an international consortium[5]. The recognition of the importance of agriculture, and especially the food production sector, has been enhanced by this work. In this context, extension services are indispensable. They are real arms which can bring new technical inputs to production sites in distant rural area, monitor their performance and collect information.

Conclusion

In order to vitalize the African economy and alleviate poverty there, subsistence farmers must be set as the main targets of development policy and development cooperation. Extension services are the most reliable, and almost only apparatus that can reach them. They reduce the barriers of 'imperfect information' to farmers, and can lower transaction costs if they assist in the circulation of needed input. Farmers will be largely rescued from high-risk states through the technologies that these services bring in.

It is not impossible to overcome the unfavorable conditions in African agriculture, but will require international cooperation utilizing proper technologies. This requirement comes from the reality of African rural communities. Therefore, extension services are expected to play a major role in attaining globalization with equity.

(Katsumi HIRANO)

Notes:

1. These calculations here were based on 41 countries for which GDP time-series are available for this period (World Bank [1996-2002a][1992-2000b], IMF [1996-2002]). Those 41 countries accounted for 99% of total GDP in Africa and 95% of its total population.
2. Labor input was estimated from:
   [economic active population in agriculture] x [cereal production area / arable and permanent crop area]based on the assumption that the amount of labor input by crop is roughly proportional to the land area assigned to each crop.
3. This does not necessarily mean that the number of full-time cereal producers is growing, but that many people embarked on food cereal production in addition to their own businesses. While inter-cropping, including for food crops, was historically prevalent over the continent, many fieldwork and studies have reported that food cereal production was expanding as a survival strategy in the economic plight after the 1980s. It took various forms including a shortening of the cycle of shifting cultivation, expansion to marginal lands, and "urban agriculture" (Cromwell [1992], Ikeno [1996], Shimada [1996], Yoshida [1999], et al.).
4. Botswana recorded one of the highest economic growths in the world, 8.99% as a yearly average, during 1980-2000. 46% of its GDP comes from the mineral sector, sustained by diamonds, which employs just 0.9% of total labor; 45% of the people make their livelihood through agriculture. The cereal yield in Botswana is as low as the African average and is unstable. The Gini coefficient of the country was 54.21 in 1986 (Deininger and Lyn [1996]).
5. It is called the 'NERICA Consortium'. It is composed of national agricultural research and extension organizations in participating African countries, Japan, UNDP, the World Bank, the African Development Bank, the Rockefeller Foundation, USAID, and NGOs including Sasakawa Global 2000 (WARDA [2002]).

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