

Green Revolution in India and Its Significance in Economic Development: Implications for Sub-Saharan Africa

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Abstract

In recent years India is experiencing a rapid economic growth, especially after the 1990s when India started to liberalize its economy in a full scale. However, the author emphasizes the critical importance of the preceded 1980s when Indian agricultural sector registered a high growth rate. The Green Revolution in India started in the late 1960s and with its success India attained food self-sufficiency within a decade. However, this first 'wave' of the Green Revolution was largely confined in wheat crop and in northern India such as Punjab, resulting in a limited contribution to overall economic development of the country. On the contrary, the agricultural growth in the 1980s (the second 'wave' of the Green Revolution) involved almost all the crops including rice and covered the whole country, it enabled to raise rural income and alleviate rural poverty substantially. Such a rise of rural India as a 'market' for non-agricultural products and services was an important pre-requisite for the rapid economic growth based on non-agricultural sectors' development in India after the 1990s. The 1980s was a critical decade for South Asia and Sub-Saharan Africa to make a great divergence in the economic development thereafter. The implication for Sub-Saharan Africa is that raising income in rural areas through productivity growth of the agricultural sector, especially the staple food sector, is essential for the success of modern economic growth through industrialization.

Introduction

As one of the so-called BRICs, India is experiencing a rapid economic development and growth in recent years, especially after the 1990s when India started to liberalize its economy in a full scale. With no doubt, a series of economic liberalization policies implemented after 1991 in India largely contributed to the accelerated growth in the country until the present day. However, this paper will focus more on the role of the Indian agricultural sector in its history of overall economic development process. To mention at first the major conclusion of the paper, we consider that agricultural growth should be preceded the modern economic growth which is based on industrialization. As described later in detail, we emphasize the existence of domestic market for

non-agricultural products and services as an important pre-requisite for the success of industrialization. By agricultural development through productivity growth such as the Green Revolution, rural income can be raised and rural poverty be alleviated. Therefore the Green Revolution can contribute to the overall economic development through creating a market in rural areas for non-agricultural products and services.

In the case of India, the Green Revolution at first started in the late 1960s. With the success of it, India attained food self-sufficiency within a decade by the end of the 1970s (the first 'wave' of the Green Revolution). However, because it confined only to wheat crop and in northern India such as Punjab, it failed to raise income in the vast rural areas of the country. The second 'wave' of the Green Revolution, however, reached India finally in the 1980s. Since it involved almost all the crops including rice (which is a very important staple food in eastern and southern India) and it covered the whole country, it was able to contribute to raise rural income and alleviate rural poverty in the whole country. Thus the second Green Revolution in the 1980s was essential for the history of Indian economic development.

This paper composes as followings. In the section I, we will reflect the process of the agricultural development in India after its independence in 1947. In particular, the process of the first and the second waves of the Green Revolution and their impacts will be delineated in detail. In the section II, the role of the Green Revolution in India on its history of economic development will be presented. In the section III, the implications of the Indian experience for the contemporary Sub-Saharan Africa will be discussed, taking into consideration the similarities and differences between the two regions. Finally, we will summarize the argument and conclude.

I. The Green Revolutions in India

Before focusing on the agricultural sector development in India, let us first look at briefly the overall economic development process of the country since independence in 1947 until the present day. Figure 1 illustrates the economic growth rates (three-year moving averages) of India in order to eliminate year to year fluctuations.

It is found from the figure that India suffered a relatively low economic growth rates around 3.5 percent per annum until the late 1970s, with a large fluctuations due to the influence of the agricultural sector growth which largely depended on the monsoon situation. Indian economy then experienced some improvement in the 1980s because of the government's liberalization policies (but not in a full-scale) under the Rajiv Gandhi regime and a relatively high growth rate attained by the agricultural sector in the decade. And finally, after the full-scale economic liberalization in 1991 the economic growth rates in India accelerated to a very high level (usually more than 6 percent, and

even more than 8 percent after the mid-2000s) until recently. It is notable at the same time that the agricultural sector growth started to clearly lag behind the GDP growth since the 1990s, which indicates that the Indian economy was plunged into a new developmental stage after the 1990s where widening disparity between agricultural and non-agricultural (or between rural and urban) sectors is one of the major problems for the economy. Now let us look into the agricultural sector development in India by dividing the whole period from the independence to the present time into several periods.

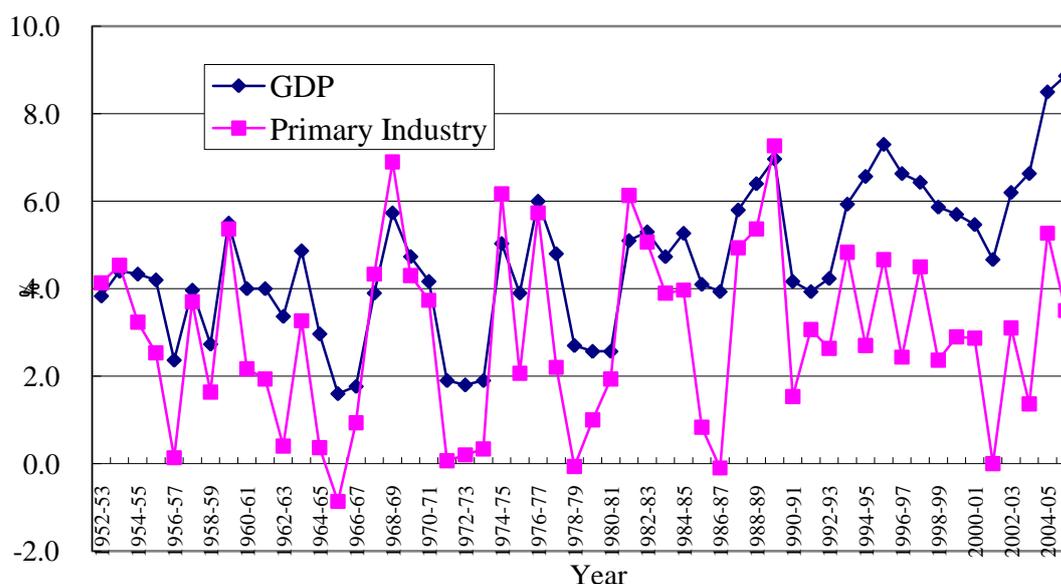


Figure 1 Economic Growth Rates in India (Three Year Moving Averages)

1. Until the mid-1960s

It is well known that the agricultural sector of British colonial India, especially the crop sector, was totally stagnant or even a negative growth was recorded in the entire first half of the 20th century (Blyn, 1966; Kurosaki 1999). This pattern, however, was reversed at the independence in 1947. The foodgrains (which is defined in India as cereals plus pulses) production registered a high growth in India at 4.13 percent during 1951-52 to 1960-61 on average (Kurosaki, 1999). Both the sown area expansion and the crop yield increase were contributed to the growth. However, as shown in Figure 1, the growth rate of the agricultural sector was decelerated during the period. The priority of the government's agricultural policy was primarily given to institutional reforms such as the land reform and the promotion of farmers' cooperatives. As a 'socialist' nation India strongly promoted a heavy industrialization, especially after the second Five Year Plan (1956-57 to 1960-61), leaving the agricultural sector relatively neglected.

Severe two years' consecutive droughts attacked India in the mid-1960s. Agriculture recorded

a large negative growth and India faced a serious food problem. Since the share of the agricultural sector in GDP was still very high at about 50 percent, the slump of agriculture hit the economy as a whole and even the political regime itself. India was obliged to import as much as 10 million tons of food (mainly wheat) for the two years (Figure 2).

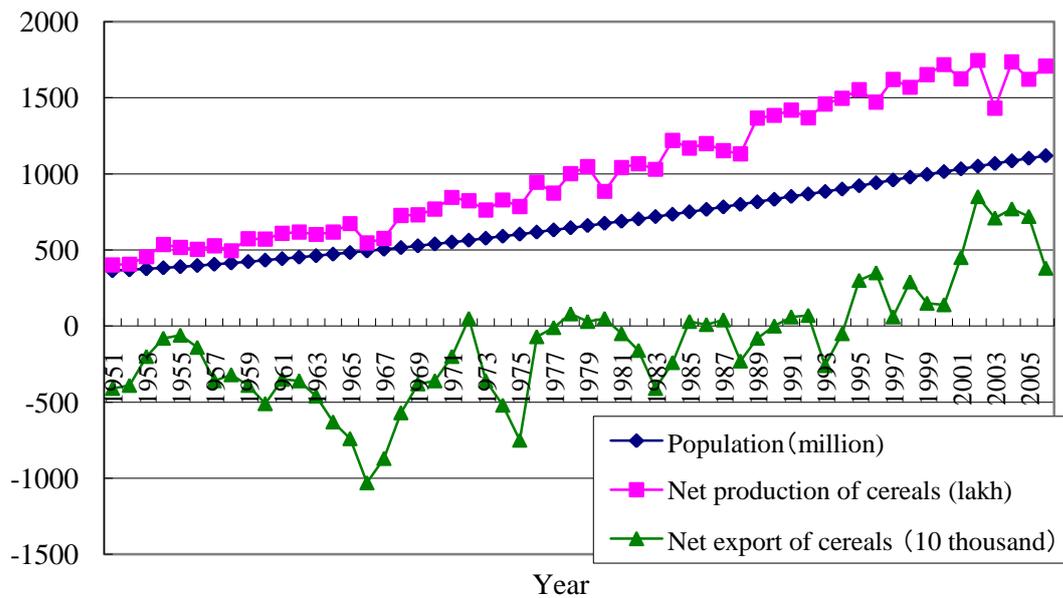


Figure 2 Population and Cereal Production & Trade in India

2. From the mid-1960s to the end of the 1970s

The serious economic and political crisis which India faced in the mid-1960s triggered the big conversion of agricultural policy of the government; i.e. it emphasized technological innovation and started to introduce new agricultural technologies from abroad. And it was a fortunate coincidence for India that the mid-1960s was the time when new seed-fertilizer technologies started to diffuse in the tropical developing world. In particular, it was luckily found that the wheat HYVs (Mexican semi-dwarf wheat varieties) developed in CIMMYT in Mexico were quite suitable for the climate conditions in the northern India such as Punjab¹. And the most important factor which promoted the dissemination of the new technologies was the diffusion of private tube-wells which exploit groundwater.

Thus the new seed-fertilizer technologies, especially for the wheat crop, started to disseminate very rapidly in northern India and within a decade or so India attained food self-sufficiency except for some drought years (Figure 2). It can be called the first 'wave' of the Green Revolution in India. However, Indian economy as a whole had to experience a bitter 'lost decade' during the mid-1960s to the mid-1970s mainly due to the shortage of foreign exchange for the import-substituting industrial sectors (Ohno, 1999). It was because India had to continue to import a large amount of

food for several years and it also had to import chemical fertilizers (and agricultural machineries) for the development of agriculture. In sum, India had to pay a huge cost for the sake of the negligence of agriculture at the time until the mid-1960s, which is considered to be a typical case of the ‘Ricardian trap’ in economic development (Hayami, 1997).

The first wave of the Green Revolution in India had another limitation from the viewpoint of overall economic development in the country. Because the diffusion of the Green Revolution was confined to wheat crop and in northern India such as Punjab, Haryana and the western part of Uttar Pradesh, it could not raise rural income and alleviate rural poverty in a wider area. Rural India continued to be poor except some particular spots.

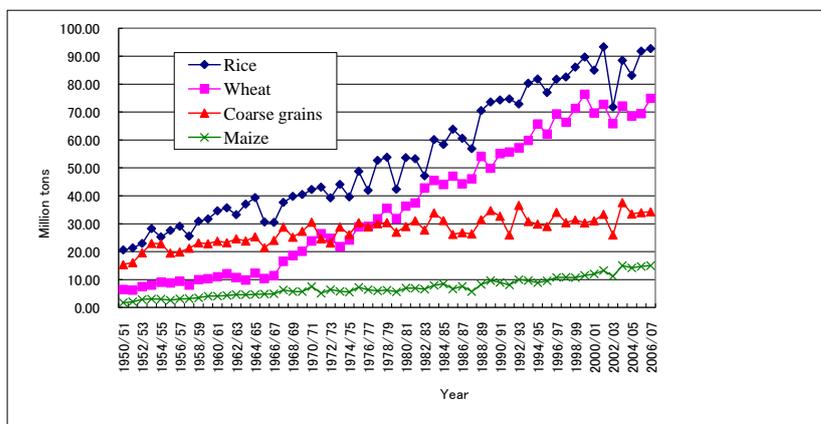


Figure 3 Production Trend of Major Cereals in India

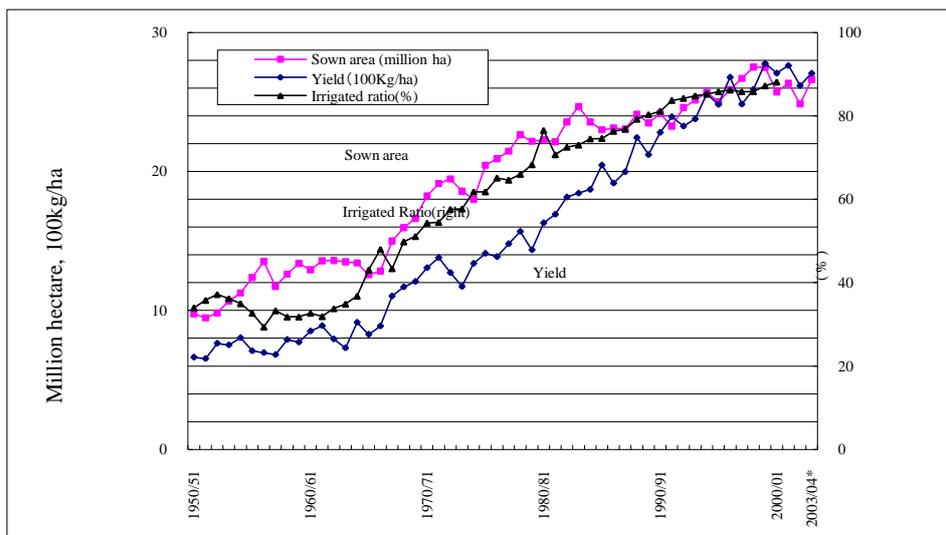


Figure 4 Sown Area, Yield and Irrigated Ratio of Wheat Production in India

Source. Government of India, *Agricultural Statistics at a Glance 2004*.

As a result of the rapid production growth of wheat, which was a minor crop in India at the time of independence, however, the production of wheat exceeded that of the coarse cereals (such as *jowar*, *bajra*, *ragi* and maize) by the end of the 1970s in India (Figure 3, Figure 4).

3. During the 1980s

The decade of the 1980s witnessed a very favorable growth rates in the agricultural sector, including almost all the regions of the country and almost all the important crop sectors (Table 1). The rapid increase of rice production during the 1980s, which is an important staple food in eastern and southern India, was especially essential for the development of hitherto poverty-struck rural areas in India (Figure 5).

The most important factor behind the overall rapid growth of the agricultural sector in India was a widespread diffusion of private tube-wells (especially small-scale shallow tube-wells). The diffusion of tube-wells in formerly rain-fed areas (or unreliably irrigated areas by government canals) enabled to grow HYV wheat instead of *rabi* crops such as pulses in the dry season (*rabi* season), and in the monsoon season (*kharif* season) the yield of rice was increased substantially by switching the varieties from traditional to modern types (HYVs). Thus the highly productive rice-wheat cropping pattern was established in a wide area of rural India, especially in the Gangetic Basin. Furthermore, in some places with a plenty of rainfall such as West Bengal², double cropping of HYV rice was widely disseminated.

There had been a controversy in India among economists regarding the reason why new agricultural technologies were not accepted for long in eastern India, in sharp contrast with northern and some other parts of India. It was argued by some Marxist economists that the ‘semi-feudal mode of production’ system in eastern India (represented by agrarian structure with small numbers of big landlord and large numbers of indebted poor sharecroppers) was ultimately attributed to it (Bhaduri, 1973). Against this argument, however, Newberry (1974) tried to refute it from the theoretical viewpoint and Bardhan and Rudra (1978) did so empirically.

Table 1 Growth Rate of Crop Production in India

	1950~60	1960~70	1970~80	1980~90	1990~96
Rice	4.53	2.12	1.73	4.08	1.60
Wheat	5.79	7.73	4.15	4.29	3.64
Coarse grains	3.76	1.67	0.55	0.71	-0.99
Maize	7.84	3.90	0.64	3.20	1.30
Total	4.45	3.10	2.07	3.38	1.81
Pulses	3.80	-0.47	-1.18	2.45	-0.07
Total Foodgrains	4.35	2.63	1.76	3.31	1.66
Oilseeds	3.05	2.41	1.34	6.01	4.16
Sugarcane	5.62	2.54	2.27	4.38	3.72
Cotton	4.54	2.03	2.69	3.23	4.51
Jute/Mesta	5.60	0.32	2.13	1.28	2.18

Note. The data are three year moving averages.

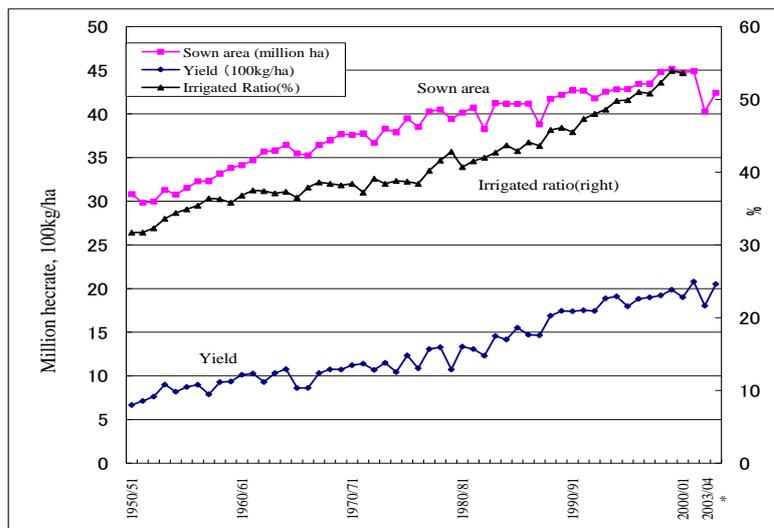


Figure 5 Sown Area, Yield and Irrigated Ratio of Rice Production in India

Source. Government of India, *Agricultural Statistics at a Glance 2004*.

Note. Yield of rice in India is in terms of milled rice.

However, if we investigate the factors which critically determine the diffusion of the new seed-fertilizer technologies, it is evident that one of the key factors was the diffusion of private tube-wells. Therefore the key question is why especially in the eastern India the introduction of private tube-wells was delayed until the 1980s. One of the answers may be the shortage of capital in the hand of farmers to purchase private tube-wells, because in eastern India there were in general only small-scale poor farmers. In other words, it can be hypothesized that after the 1980s the real price of tube-wells declined so that even the relatively poor farmers in eastern India could purchase tube-wells. Another factor may be the delay of rural electrification in eastern India, because irrigation cost is much cheaper by electric tube-wells than diesel-driven tube-wells³.

On the other hand, extreme land fragmentation in eastern India with a lack of successful land consolidation program was often attributed to the delay of the diffusion of tube-wells (Bardhan, 1984). However, the experiences in eastern India in the 1980s suggested that this hypothesis was totally wrong; i.e. tube-wells did rapidly diffuse even under the extreme land fragmentation. And under the land fragmentation the water sales market (groundwater market) for irrigation was widely emerged and developed⁴.

In sum, rural India witnessed a widespread agricultural development in the 1980s due mainly to the diffusion of private tube-wells (Figure 6). Especially the most important thing was that rice production, which was the main staple food in eastern and southern India, increased rapidly and

contributed to raising rural income and alleviating poverty. The real wages of agricultural laborers in India had started to rise and also rural poverty started to decline for the first time in the long history of the country.

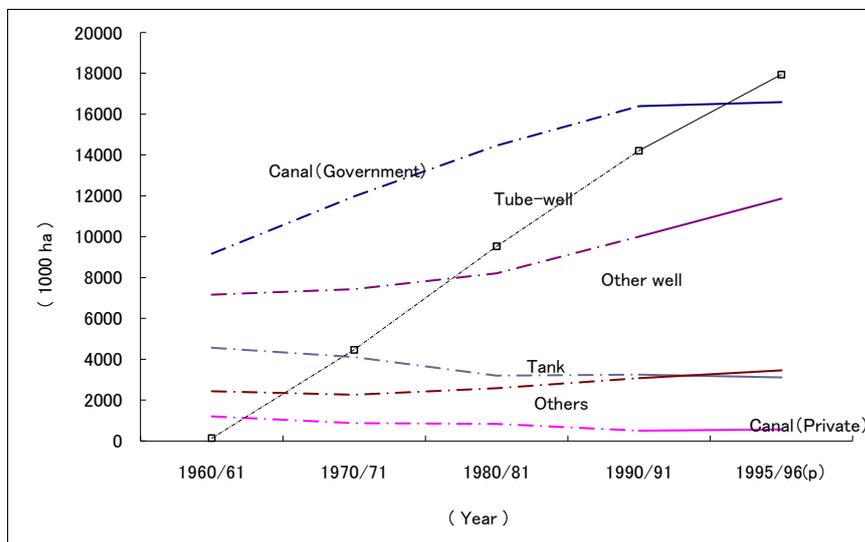


Figure 6 Net Irrigated Area by Source of Irrigation in India

Source. Until 1990/91: Water and Related Statistics 1994, Statistics Directorate, Irrigation Management Organization, Central Water Commission, p.81, Regarding the year 1995/95, Fertilizer statistics 1998/99.

If we look at the indicator of per capita per day calorie intake by the data of FAO (FAO, 1995), both South Asia and Sub-Saharan Africa were almost at the same level at 2100 calorie/day until the late 1970s, but after the 1980s whereas Sub-Saharan Africa stagnated at the same level, South Asia began to rise continuously to the level of approximately 2300 calorie/day by the end of the 1980s (Figure 7). Therefore, it can be stressed here that the 1980s was the critical period for South Asia and Sub-Saharan Africa to make a great divergence in the economic development thereafter.

Lastly, it should be noted that in India not only rice and wheat increased their yield levels dramatically during the period of the Green Revolution (Figure 4, Figure 5), but also coarse cereals accomplished a continuous and substantial increase of their yield (Figure 8). According to Figure 8, the average yield of coarse cereals increased from less than 500 kg/ha in the 1950s to more than 1000 kg/ha in recent years, although sown area experienced a rapid decrease from the beginning of the 1970s due to the continuous decline of demand for human consumption. At present, as indicated in Figure 9, although demand for coarse cereals for human consumption became minimal except some spots (rural and urban Karnataka, rural Maharashtra, rural Gujarat and rural Rajasthan), demand for animal feed is increasing, especially in the case of maize and *jowar* (sorghum).

図 2.4 1人当たり食糧供給量(1日当たりカロリー), 開発途上国, 1951-92年

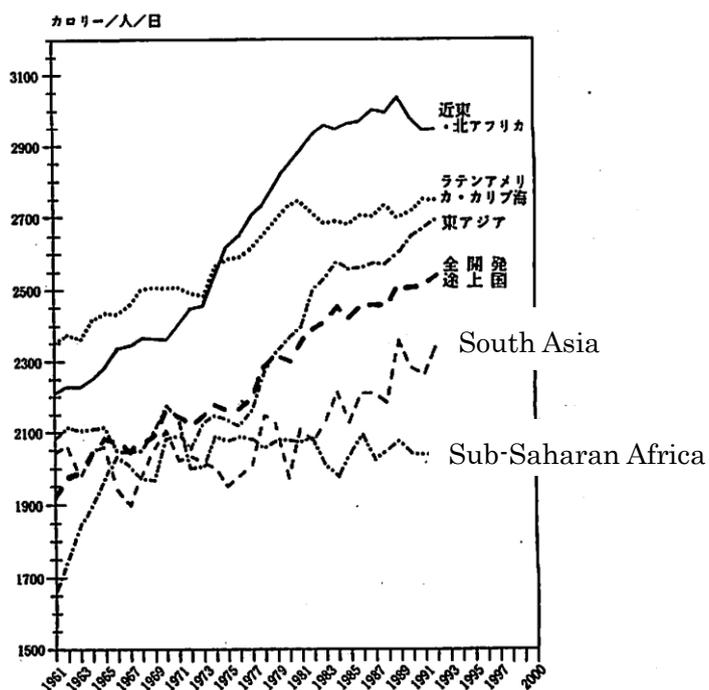


Figure 7 Per Capita Calorie Intake of Developing Areas

Source. FAO, 1995.

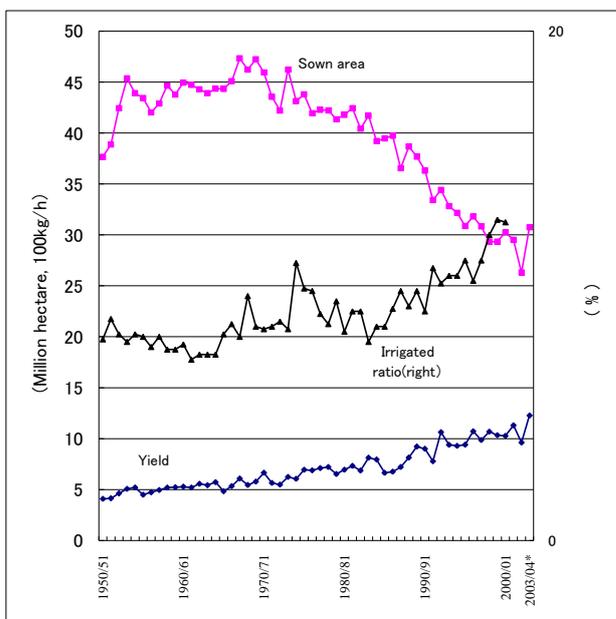


Figure 8 Sown Area, Yield and Irrigated Ratio of Coarse Cereal Production in India

Source. Government of India, *Agricultural Statistics at a Glance 2004*.

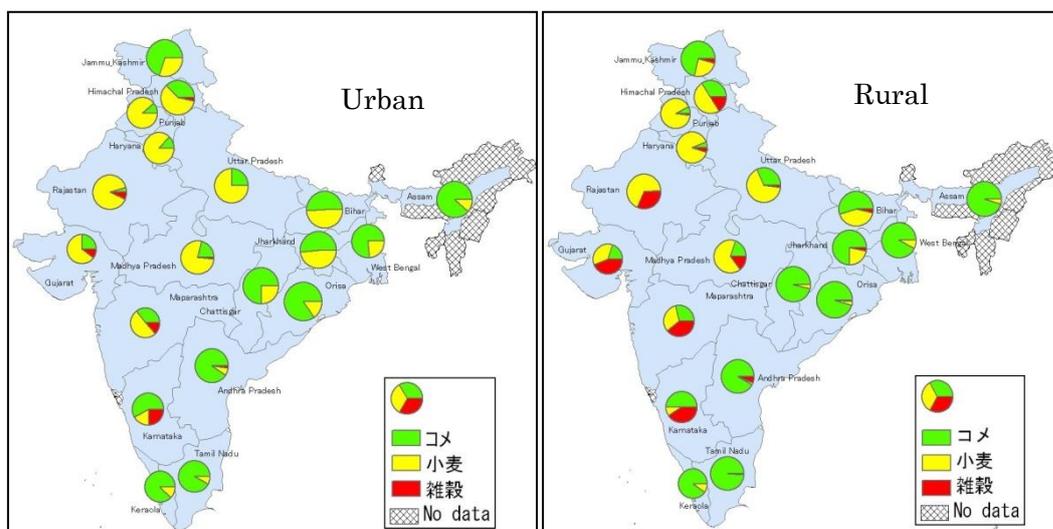


Figure 9 Per Capita Consumption of Cereals and Its Composition in India

Source. National Sample Survey Organization, 2006.

4. After the 1990s

Indian economy was plunged into a new developmental stage after the 1990s. First, the critical period for the preparation of full-scale non-agricultural sector development was over until the end of the 1980s, when broad-based agricultural development based on the second Green Revolution was happened. Second, however, since India turned to the stage when per capita human consumption of foodgrains (especially for staple food such as rice and wheat) started to decline, agricultural growth rate will not be very high because foodgrains sector is large within the agricultural sector, even if high-valued agricultural commodities (such as livestock, vegetable, fruits) will increase relatively rapidly. Third, it means that widening disparity between agricultural and non-agricultural (or between rural and urban) sectors will be a serious problem for the economy.

Because of the limited space, let us point out only some key facts and issues which Indian agriculture faced after the 1990s in the following.

- 1) The agricultural sector growth rate declined to 2.5 percent per annum on average after the 1990s. The 'fatigue' of agricultural sector and rural economy is becoming a serious social problem, especially compared to the rapid growth of non-agricultural sectors mainly in urban areas. Although the government is setting the growth rate target of agricultural sector at 4 percent, it may be quite difficult to realize it.
- 2) Because of the declined per capita consumption for cereals (especially for rice) and also because of the failure of food management policies of the government, India became a major exporter of rice (very recently wheat also) since the mid-1990s to the world market (Figure 2), particularly to Bangladesh and Sub-Saharan Africa. The export of rice (and

wheat) was strongly associated with an excess buffer stock of rice (and wheat) accumulated in the government sector (Food Corporation of India), and India experienced two peak periods of extremely excess stock; i.e. the first one was in the mid-1990s and the second one was at the beginning of the 2000s.

- 3) Subsidies for agricultural inputs such as chemical fertilizer, irrigation (canal) and electricity (for electric pump sets such as tube-wells) has been rapidly increased since the 1980s until the present day. Agricultural subsidies are now very big fiscal burden for the government, especially for the state government. The subsidies are given mainly to the advanced agricultural areas and also to the wealthy farmers in particular. Therefore, the necessary public investment for agriculture and for rural areas is neglected, which causes the disparity between advanced rural areas and backward rural areas fixed.

II. Role of the Green Revolutions in Economic Development

Now let us summarize the role of the Green Revolution in India, especially the second Green Revolution during the 1980s, on overall economic development process of the country.

The most important lesson we learned is that agricultural growth should be preceded the modern economic growth based on industrialization. The reasons are as follows.

At the beginning of economic development the agricultural sector is 'large'. A large share of population depend their livelihood on agriculture and related activities. They are poor and the share of their household expenditures for food and beverages (Engel's coefficient) is usually very high; around 70 percent. Under such a situation, even if the government tries to promote industrialization (especially heavy industrialization) with neglecting the agricultural sector, it tends to fail because of the lack of the market for non-agricultural sectors. Note that export-oriented industrialization is more difficult and entrepreneurs should at first depend on the domestic market which is more familiar to them before going to exploit export market. In this sense, the existence of the domestic market for their products is essential when promoting industrialization. Because the majority of people live in rural areas at this stage of economic development, the key is how to raise income and alleviate poverty in widespread rural areas. Thus the development of agricultural sector, especially staple food sector, should come first because majority of rural population depend their livelihood on it. If raising income of rural population is the key, the agricultural growth should be led by productivity growth, rather than by 'horizontal' expansion of farmland.

Actually, as we had seen before in this paper, India had to pay a huge cost for the negligence of agricultural sector before the mid-1960s, in the form of the 'lost decade' from the mid-1960s to the mid-1970s.

In conclusion, the second Green Revolution in India during the 1980s was able to play a critical role in preparing a wide market in rural areas for non-agricultural products and services, which became the basis of the rapid economic growth based on non-agricultural sector development in the country after the 1990s. The author emphasizes here the 'final demand effects' of the agricultural development in the 1980s, although the author does not deny the existence and the importance of 'backward and forward linkage effects' of it too.

III. Implications for Sub-Saharan Africa

What are the implications of the experience of India for the development of Sub-Saharan Africa? In terms of the living standard of ordinary people, the two regions made a great divergence in the 1980s when India started to escape from the hitherto low-level equilibrium. If the major argument so far of this paper is summarized, the critical difference between the two regions was the performance of the agricultural sector during the 1980s. During that decade, India accomplished a nationwide development of the agricultural sector due to the spread of the second Green Revolution while the agricultural sector was more or less stagnated in Sub-Saharan Africa. Actually the growth rate of agriculture in Sub-Saharan Africa during the 1980s was less than 2 percent, which lagged behind even the population growth rate. Per capita food production was thereby decreased and food import (rice and wheat) started to rise rapidly from the 1980s. And per capita calorie intake is still stagnating in Sub-Saharan Africa at around 2100 calorie/day. To be worse, while the population growth rate largely decelerated in India to nearly 1.5 percent per annum in recent years, Sub-Saharan Africa is still suffering from the 'population explosion' at about 2.5 percent per annum. Note that the major reason why India came to the last stage of the so-called demographic transition (the stage in which birth rate started to decline substantially) was the successful transition of the economy from agriculture-based to non-agriculture-based.

The most important implication of the experience of India for Sub-Saharan Africa, therefore, is to raise rural income to 'a certain level' and alleviate poverty in rural areas, thus to make rural areas a big market for non-agricultural products and services. If it is realized, Sub-Saharan Africa can most probably proceed to the next step of economic development based on industrialization. And in order to raise rural income to a certain level, the agricultural sector, especially the staple food production sector, should be developed by productivity growth (not by horizontal expansion of farmland, as experienced in most of the regions in Sub-Saharan Africa so far). The other method such as introducing cottage industry in rural areas, for example, cannot be universal enough for raising rural income in everywhere. The key question is thus how to introduce the Green Revolution in the context of the existing natural and socio-economic environment in Sub-Saharan Africa.

However, several critical disadvantages can be pointed out for the introduction of the Green Revolution in the area.

First, the staple food crops are much diversified in Sub-Saharan Africa, and rice and wheat occupy a very small share in the total staple food (Table 2). Since there is relatively a small backlog of new technologies in the world for root crops and coarse cereals other than maize, it may be quite difficult to raise productivity of the major staple food crops in Sub-Saharan Africa.

Table 2 Crop-wise Demand and Supply in Sub-Saharan Africa in 2000

Crop	Demand (million ton)	Production (million ton)	Net import (million ton)	Ratio of net import in total demand (%)
Cassava	106.5	106.8	0.3	0.4
Sweet Potato	43.8	35.7	2.1	5.6
Maize	37.8	32.6	2.4	6.9
Other Cereals	35.0	43.7	0.1	0.2
Wheat	13.6	4.6	9.0	66.2
Rice	12.0	6.7	5.3	44.2

Source. De Fraiture, 2005.

Second, most of the Sub-Saharan agriculture is depending on rainfall. The irrigated ratio of farmland is only less than 4 percent (60,000 hectare is irrigated out of the total 1,580,000 hectare). Irrigation is the most important pre-requisite not only for the diffusion of the new seed-fertilizer technology but also for the introduction of rice and wheat itself. From the irrigated land which is less than 4 percent, half of the rice production and one third of the wheat production are at present produced in Sub-Saharan Africa as a whole. Moreover, approximately 60 percent of the irrigated land is concentrated in only three countries; South Africa, Sudan and Madagascar. Therefore, 55 percent of irrigated rice production is concentrated in Nigeria and Madagascar, and 75 percent of irrigated wheat production is concentrated in South Africa and Ethiopia (Riddle et al, 2006).

Third, the share of urban population is already higher in Sub-Saharan Africa than in South Asia including India. In other words, a large-scale rural-urban migration has been started in Sub-Saharan Africa before attaining substantial increase in agricultural productivity and also before creating sufficient non-agricultural job opportunities in urban areas. Therefore the poverty of urban population is a more serious problem in Sub-Saharan Africa than in India. In addition, as the Green Revolution technology is basically labor intensive, it may not be suitable for rural Sub-Saharan Africa where labor is a scarce resource.

Fourth, the demand for staple food is usually different between rural and urban areas in Sub-Saharan Africa. Urban population prefers rice and wheat whereas rural people are continuously depending on traditional staple foods other than rice and wheat in general. Therefore, even if farmers

try to increase their staple food production there will not be much demand for it in urban areas, so that there is not much incentive for farmers to increase their traditional staple food. This is the main reason why Sub-Saharan Africa as a whole has basically been able to keep self-sufficiency in the traditional staple foods while high percentages of rice and wheat have been imported mainly for urban population (Table 2).

There is not much room for increasing wheat production in Sub-Saharan Africa. However, situation is different in the case of rice. West Africa has a long history and experiences in rice production and there remains a lot of unutilized swamped land there. There is a good prospect to increase rice production in West Africa for commercial sales to urban areas (Sakurai, 2006).

Summary and Conclusions

In recent years India is experiencing a rapid economic growth, especially after the 1990s when it started to liberalize its economy in a full scale. However, the author emphasizes the critical importance of the preceded 1980s when Indian agricultural sector registered a high growth rate. The Green Revolution in India started in the late 1960s and with its success India attained food self-sufficiency within a decade. However, this first wave of the Green Revolution was largely confined in wheat crop and in northern India, resulting in a limited contribution to overall economic development of the country. On the contrary, the agricultural growth in the 1980s involved almost all the crops including rice and covered the whole country, it enabled to raise rural income and alleviate rural poverty substantially. Such a rise of rural India as a market for non-agricultural products and services was an important pre-requisite for the rapid economic growth based on non-agricultural sectors' development in India after the 1990s. The 1980s was a critical decade for South Asia and Sub-Saharan Africa to make a great divergence in the economic development thereafter. The implication for Sub-Saharan Africa is that raising income in rural areas through productivity growth of agricultural sector, especially the staple food sector, is essential for the success of economic development through industrialization.

However, the actual situations which Sub-Saharan Africa faces at present are much more challenging, if various disadvantages are taken into consideration. Disadvantages of contemporary Sub-Saharan Africa include; diversified staple food in which rice and wheat has only a minor share, scarcity of irrigated land, labor shortage in rural areas, difference in staple food between rural and urban areas and so on.

The Green Revolution which India and other Asian countries experienced in the past is much needed in Sub-Saharan Africa now for the long term economic development. It is forecasted, however, that imports of rice and wheat will continue to be increased, especially in urban areas.

Wheat production cannot be increased in Sub-Saharan Africa due to lack of suitable land, but in the case of rice, West Africa has a long history of its production and there are much room for increased production in a wide unutilized swamped land for sales to urban areas. If the Green Revolution will be possible in Sub-Saharan Africa in the near future, rice is the most prospective crop.

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¹ In addition to the favorable climate conditions, there were other important socio-economic conditions for the rapid diffusion of the new agricultural technologies in north India such as Punjab; i.e. the areas were newly settled areas by medium-sized farmers after construction of the canal irrigation network in the British colonial era; and land consolidation program was successfully implemented in the areas after independence which solved the problem of land fragmentation; and finally and most importantly, private tube-wells were introduced for irrigation in the areas which solved the problem of unreliable irrigation water distribution from the government canals.

After the first wave of the Green Revolution the cropping pattern was changed as follows. In the dry season (*rabi* season), pulses (or the mixed cropping of pulses with wheat) were substituted by wheat. And in the monsoon season (*kharif* season), coarse cereals such as *jowar* (sorghum) and *bajra* (pearl millet) were substituted by rice albeit the process was lagged behind the diffusion of wheat in the *rabi* season for several years.

² Double cropping of HYV rice (*aman* in the *kharif* season and *boro* in the *rabi* season) was widely expanded in the neighboring country of Bangladesh too.

³ However, under the situation without rural electrification, tube-wells were rapidly diffused in rural Bangladesh during the 1980s.

⁴ See, for example, Kahnert and Levine (1993), Pant (1992), Fujita, Kundu and Jaim (2003). See also Fujita (2010) regarding Bangladesh.