The role of intermediate factor markets in Asia's Green Revolution: Lessons for Africa?

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Introduction

This study reviews the extent to which lessons from Asia's green revolution experience can be relevant for Africa today (hereon Africa refers to sub-Saharan Africa, excluding South Africa), especially in terms of the role of the development of intermediate factor markets (in terms of purchased inputs like improved seeds and fertilizers). It is well known that the green revolution spurred economic growth in much of Asia, reducing rural poverty significantly in the process. It did so primarily because the bulk of rural smallholder farmers were able to profitably access intermediate inputs such as improved seed that were scale neutral and added little to production risk, in addition to other complementary inputs such as fertilizer, irrigation and farm credit. The dramatic spread of these technology inputs was made possible in great part by direct state interventions in input delivery systems, price incentive policies, and rural infrastructure investments.

Africa missed this first green revolution for two main reasons. First, relative to Asia at the time, population densities were much lower in Africa, the state of physical and financial infrastructure was weak, there was little irrigated land, markets were far less developed, and governments were for the most part disinterested in an agricultural-led growth strategy. Second, the principal green revolution cereals, wheat and rice, are not as widely grown in Africa. Instead, a variety of cereals and root crops are grown across many different parts of the continent and under very diverse agro-ecological and climatic conditions.

Thirty years later, many of these underlying conditions have not changed, but others have. For instance, population densities in Africa have increased, in some parts rising to levels similar to those of Asia before the green revolution. The potential for genetic improvements of Africa's principal crops (maize, cassava, millet and sorghum) has also changed dramatically, increasing the possibilities for agricultural intensification. There have been advances in natural resource management (NRM) techniques that are appropriate for dealing with Africa's fragile and diverse agro-climatic conditions. And finally, the political players have also changed. African governments and donors are today increasingly focusing their attention on stimulating growth through smallholder agriculture.

This paper briefly reviews and contrasts the agricultural experience in Africa and Asia over recent decades and draws lessons about relevant policies for future agricultural growth strategies in Africa. Drawing on the experience of India is especially useful given its dramatic agricultural output response during the Green Revolution following an appropriate mix of public investments in agricultural R&D and extension, rural infrastructure, irrigation, and in the development of its seed and fertilizer markets.

Agricultural performance and sources of growth

The successful impact of India's Green Revolution (GR) is evident in the phenomenal growth in agricultural output over the past 30 years. In fact growth in agricultural production has consistently outpaced population growth, as measured by the growth in per capita agricultural production (table 1). Contributing to this were the large gains in land productivity, which grew at a rate of about 3 percent per year between 1967 and 1995 (Rosegrant and Hazell). Labor productivity on the other hand grew slower, at a rate of about 1.7 percent, indicating that farmers were generally adopting land-saving or labor using technology inputs. The key factors that were

found to have contributed the most to agricultural productivity growth in India include research and extension, and public investments in roads and irrigation (Evenson, Pray and Rosegrant; Fan, Hazell and Thorat).

In stark contrast to the experience of the Indian sub-continent, Africa experienced a much slower growth trend over this period in terms of per capita agriculture production (table 1). Growth was driven more by land area expansion. Total factor productivity only grew modestly, an average annual rate of about 0.54% between 1963 and 1988 (Block).

India's green revolution experience

India's experience with the green revolution (GR) can be described in terms of the sequence of public investments that preceded the GR, and policy interventions in intermediate factor and product markets during the GR. Significant public investments that occurred prior to, or during, the GR created the right incentives for the rapid adoption of new technologies and productivity growth (Rosegrant and Hazell; Bhalla and Singh). For example, between 1970 and 1990, public expenditures in rural areas increased five fold, growing at a rate of about 13 percent per year in the 1970s alone (Fan, Hazell and Thorat). This level of investments of this magnitude was a clear sign of the broad political commitment, at both the federal and state government level, to accelerate agricultural income growth in rural areas.

The primary focus areas at this time included roads, irrigation, and rural electrification. An important feature of these investments was the steady growth in irrigation investments such that by the 1990s the area under irrigation had more than doubled (table 2). Investments in the wide network of rural roads and transportation systems was also a priority that resulted in the road density increasing from 2,614 km per 1,000 sq km in 1970 to 5,704 in 1995 (Rosegrant and Hazell), and contributing to lower transportation costs and greater market integration. Another

key investment was the electrification of rural areas, which ultimately helped expand the use of irrigation systems. By 1995, almost 90% of the rural areas had access to electricity, albeit at subsidized rates (Fan, Hazell and Thorat).

Although many of these initial investments did not directly affect food production – they laid the basic foundation for a GR. It was not until the late 1960s that attention shifted more towards expanding the domestic supply of wheat and rice to satisfy food-self-sufficiency goals. To increase domestic food production, public policy focused on making intermediate factor inputs easily available, accessible, and affordable to farmers, and subsidies thus became a big part of this. Initial efforts were focused in the high potential areas, followed later in the 1980s by investments in the low potential and mostly rain-fed areas.

Although public investments were a key foundation, it was the public policy interventions that played a prominent role in: a) providing incentives for adopting modern factor inputs (improved seeds, fertilizer, and credit); and b) ensuring that small farms participated. Incentives for adoption included market policy interventions designed to ensure stable and profitable input/output price ratios for all farmers, by guaranteeing procurement of output and subsidizing factor inputs.

Though a central marketing system and a pricing regime, the government worked to ensure incentives for both farmers and consumers by imposing pan-territorial and pan-seasonal minimum price guarantees to wheat and rice farmers, controlling the movement of grain between surplus and deficit areas, creating buffer stocks, and ensuring low food prices (Smith and Urey). In spite of the heavy handed nature of government interventions, the public marketing system still permitted the private sector free entry. For example, the private seed and fertilizer sectors helped complement and improve the efficient distribution of these inputs to farmers. An important incentive for the private sector was that there were profits to be had from investing in

wholesale trade, processing and transportation given high population densities and good infrastructure.

Besides intervening in the procurement of grains, the use of subsidies on inputs like fertilizer and irrigation increased the incentive for farmers to adopt improved technologies, even at a time when overvalued exchange rate policies were generally biased against agriculture (Smith and Urey). The payoff from fertilizer subsidies were quite significant during the early stages of the GR, such that a dollar spent on the subsidy contributed to agricultural GDP by as much as 5 times the money spent on the fertilizer subsidies (Fan, Thorat and Rao). Under such conditions, fertilizer application rates increased from 7.2 kg/ha to 23 kg/ha between the 1960s and 1970s (table 2).

Although market interventions and subsidies can be a cost effective vehicle to encourage farmers to initially adopt a package of technologies, they are not justifiable as their use rises well above their socially optimal levels. Over time, they drain the treasury and encourage overuse that is detrimental to the environment (Gulati and Narayannan; Rosegrant and Hazell).

Because fertilizer use depends on adequate access to rural credit and finance, and to ensure that millions of small farmers could access it, the Indian government intervened forcefully in the banking sector. It required banks to operate in rural areas and certain priority sectors, such as in agriculture and cottage industries, and regulated many of the bank's operational aspects in the rural areas (Smith and Urey).

In summary, the combination of the three factor inputs: irrigation, high yield varieties, and fertilizers, contributed to the phenomenal growth witnessed throughout the GR period. But perhaps even more importantly, the sequencing and combined effect of public investments in infrastructure (roads, power and irrigation), as well as research and extension, followed later by

marketing policy interventions to stimulate technology adoption, played a catalytic role. And further still, the initial focus on high potential areas proved vital as an engine of growth.

The Lessons for Africa

Compared to India, Africa faces a far greater diversity in agro-ecologies, farming systems and agronomic constraints, implying that a multitude of different technology solutions are required rather than single technology packages that were appropriate for vast and homogenous cropping areas in India. For example, only about 1 to 2 percent of the total cultivated area in Africa is under rice cultivation while root crop based systems are grown on 35 percent of the land (Dixon, Gulliver and Gibbon).

Wide differences also exist in terms of rural population density. For example, on each hectare of agricultural land, 3.8 persons can be found in India compared to 0.4 persons in Africa (table 1). Although this varies widely across countries, with Uganda having as many as 2 persons per hectare and comparable to India in the 1960s.

One of the typical problems that Africa faces as a consequence of its sparse rural population densities is that its labor markets are weak, and combined with seasonal labor bottlenecks makes the adoption of labor-using technologies (such as the GR technologies of India) less profitable. Yet another challenge is that low population densities imply higher per capita costs for investing in and maintaining basic rural infrastructure and services. At the same time, options for expanding irrigation are also costly. One estimate places the average costs of medium- to large-scale irrigation in Africa at about US$8,300 per hectare, which is over three times what it costs in South Asia (Rosegrant and Perez). As a result, irrigation remains very low in Africa, covering a mere 3.7 percent of agricultural area in the 1990s (up from 2.6 percent in

the 1960s, see table 4). Road density is also very low, averaging about 63km per 1,000 square km, which is about 40 times less than the density India had in 1970 (Spencer).

The high public costs of launching GRs in Africa helps explain why so few have occurred, and why those that did were often 'boom and bust' revolutions. Most African governments have not yet made the same commitment to agricultural growth and rural poverty reduction that India's government made in the 1960s. As a result, public investment in agriculture and the rural sector has remained low. Even today, African countries spend less than 5% of total government spending on agriculture, compared to 14% in Asia (table 2). In Uganda, for example, large gains are still to be had from investing in agricultural R&D and rural feeder roads (Fan, Zhang and Rao), yet the government continues to allocate only 0.5 percent of total government spending to the agricultural sector, compared to India's 27 percent in 1980 (table 2). And where sufficient investment has been made to launch a GR, the investment has not been sustained over time. Zimbabwe is a classic example. At independence and throughout the 1980s, the country experienced a smallholder GR in maize and sorghum production due to heavy government investments in physical infrastructure (roads and storage facilities), procurement, and input subsidies and delivery services. Unfortunately, the government bureaucracy overextended itself by monopolizing grain trade altogether and failing to manage growing inefficiencies and corruption within the system itself (Mosley). In Uganda, the development and widespread diffusion of improved varieties among traditional staples (maize and cassava) are especially noteworthy, tripling yields in the case of cassava (Mosley). However, rural economies remain backward under conditions of poor infrastructure, and access to credit and finance.

Policy conclusions

Africa clearly faces a different set of challenges in launching an agricultural revolution than India and other Asian countries did some three decades ago. Africa has far less irrigation potential, and its diverse and rainfed farming systems will require different and much more site specific technology solutions to raise their productivity. The poor state of Africa's rural infrastructure adds to the cost and difficulty of supplying key inputs and services to many African farmers, limits physical access to markets, and discourages growth of private trade and markets. But like India in the 1960s, Africa faces severe national food crises and is becoming increasingly dependent on foreign assistance to meet its food needs. As with India in the 1960s, there is a growing commitment to agricultural development and food security in Africa, as exemplified by the goals of the newly emergent and African led initiative called the New Economic Program for African Development (NEPAD). But what must Africa do to launch its own agricultural revolution?

First, the experience from India and Asia clearly suggests that large amounts of investments will be required in such fundamentals as rural infrastructure, irrigation and agricultural research and extension to overcome the appalling current low state of these structures in Africa. Given the scale of the problem, few African countries will be able to marshal the resources required by themselves, and in fact many have had to cut such basic investments under the financial stringencies of structural adjustment programs (Fan and Rao). Nor have development agencies been willing to invest in these fundamentals in Africa (although they did in Asia in earlier years).

Second, Africa will need to develop technologies that are appropriate for a wide array of diverse, rainfed farming systems. Although irrigated agriculture should be developed where

feasible, this will never amount to a large share of Africa's agriculture. The challenge of raising productivity in rainfed farming systems is much greater, especially as many are constrained by low and risky rainfall, fragile soils and poor market access. Most African farmers will need technologies that are not dependent on high use of purchased inputs like fertilizers, such as natural resource management technologies, at least for the next decade or two until rural infrastructure can be built up. Biotechnology offers considerable potential for improving crop performance and livestock performance under Africa's often harsh conditions, but this potential can only be exploited once pending biosafety regulation and intellectual property issues have been resolved, and if much more public money is invested in this kind of research.

Third, fertilizer use must be increased in Africa. Given its high cost and current difficulties in distributing it with poor infrastructure and market development, there may well be justification for an initial fertilizer subsidy, as in India in the early years of their GR. But unlike India, any such subsidy needs to be established with its own sunset clause to ensure that it does not eventually become a financial burden once its usefulness has been fulfilled. Africa will also need effective rural financial services for agriculture, and this will require greater attention to the development of banking for small and medium sized farms, not just microfinance which has captured the most attention in recent years.

Finally, Africa faces much more competitive world agricultural markets than was typical of the time Asia had its GR. Not only are there many low cost competitors around the world, even for many of Africa's traditional export crops, but quality standards have risen and are key to accessing higher value markets. Many OECD countries are also effectively dumping subsidized products in African markets. Within this environment, Africa must transform its marketing institutions to enable its farmers and processors to compete. The WTO trade negotiations will have very important implications for African agriculture, but many of the

needed market reforms must begin at home, especially those related to marketing costs and recognizing and rewarding higher standards and quality products.

References

Block, S. (1994) "A new view of agricultural productivity in sub-Saharan Africa", *American Journal of Agricultural Economics* 76(6):19-24

Dixon, J. A. Gulliver and D. Gibbon (2001), *Farming systems and poverty: improving Farmers' livelihoods in a changing world*. FAO and World Bank, Rome and Washington, DC.

Evenson, R.E., C. E. Pray, and M. W. Rosegrant (1999), "Agricultural Research and Productivity Growth in India" *Research Report 109*, IFPRI, Wash. DC

Fan, S., P. Hazell and S. Thorat (1999) " Linkages between government spending, growth, and poverty in rural India" *Research Report No.110*, IFPRI, Wash. DC

Fan, S. S. Thorat and N. Rao (2003), "Investments, subsidies and pro-poor growth in rural India", draft paper, IFPRI, Wash. DC

Fan, S. X. Zhang and N. Rao (2003), "Public Expenditure, Growth and Poverty Reduction in Rural Uganda", draft paper, IFPRI, Wash. DC

Gulati, A. and S. Narayanan (2003) *The Subsidy Syndrome in Indian Agriculture*, Oxford University Press, Oxford, UK

Mosley, P. (2003) *A painful ascent: the green revolution in Africa"*, London: Routledge,

Rosegrant and Hazell (2000) *Transforming the rural Asian economy: the unfinished revolution*, Oxford University Press

Spencer, D. 1994. "Infrastructure and Technology Constraints to Agricultural Development in The Humid and Subhumid Tropics of Africa". EPTD Paper No. 3. IFPRI, Wash. DC

Table 1. Agricultural production growth and input use

	1961-70	1971-80	1981-90	1991-00
Growth indexes (1961=100)				
Per Cap Ag Production: India	94	95	106	120
Sub-Saharan Africa	102	95	85	87
Cereals area expansion: India	104	111	112	109
Sub-Saharan Africa	109	113	130	175
Fertilizer use (application rate, kg/ha)				
India	7.2	23.4	54.6	90.6
Sub-Sahara Africa	2.5	5.7	8.7	9.1
Uganda	1.1	0.8	0.1	0.4
Irrigation use (percent of arable and permanent crop land)				
India	16.9	21.2	25.8	32.3
Sub-Sahara Africa	2.6	3.0	3.5	3.7
Rural Population Density (persons per hectare of total agricultural area)				
India	2.30	2.73	3.22	3.79
Sub-Sahara Africa	0.23	0.28	0.35	0.42
Uganda	1.18	1.40	1.62	2.06

Source: FAOSTAT, 2003. Note: Sub-Saharan Africa excludes South Africa here.

Table 2. Agricultural spending in 1980 and 1998

	Agricultural expenditure (1995 int'l dollars, billions)		Percentage of agricultural GDP (%)		Composition of total expenditure (%)	
	1980	1998	1980	1998	1980	1998
India	44.5	43.52	11.9	7.8	27.8	14.5
Sub-Sahara Africa [c]	3.56	3.77	8.8	8.5	6.3	4.9
Uganda [d]	0.03	0.02	0.4	0.2	1.4	0.5

Source: Data from various tables in Fan and Rao (2003).

[c] This is a total across the following countries: Botswana, Burkina Faso, Cameroon, Ivory Coast, Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, Togo, Uganda, Zambia, and Zimbabwe. North African countries in Fan and Rao (2003) were removed. Percent of agricultural GDP is a simple average across the sample of countries.

[d] Data in the 1980 column for Uganda is for 1990.