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Zimbabwe's Green Revolution: Preconditions for Replication in Africa

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I. BACKGROUND

Africa is staggering under the weight of its horrendous failure in food and agriculture, the sector that employs two out of every three people on the continent. After thirty-five years of independence, the region faces a growing food production gap, a loss of world market shares of many of its agricultural exports and pervasive rural poverty. Three fourths of the wheat consumed in Africa is imported, and rice imports (mostly from Asia) are running at $600 million per year. Because Africa's population will increase by roughly 100 million over the next six to seven years, African governments are under intense pressure to increase food supplies from domestic production, commercial imports and food aid. Some countries with idle land can meet the annual three to five percent growth in food demand by expanding the area under cultivation. However, land-short economies (such as Burundi, Kenya, Malawi, and Senegal) will have to increase crop yields, import food or face the consequences of higher food prices and possibly food riots. The central policy question for these land-short economies is: What can be done to bring about a sharp and sustained increase in crop yields - i.e., a Green Revolution - through improved crop varieties, fertilizer and better agronomic practices. The success of Asia's Green Revolution explains why so many donors and scientists are keen on drawing lessons from Asia for Africa (Winrock, 1991).

But Asia's Green Revolution is not a reliable compass for Africa. Africa should turn inward and study its own experience. After many false starts, a maize-based Green Revolution is emerging in Africa. Africa's maize-based Green Revolution in Zimbabwe, Malawi, Zambia, Kenya, and Ghana, provides a laboratory for examining how African nations have solved some of the basic scientific and institutional preconditions for a Green Revolution. These are important issues to examine because most countries in Africa are currently at an earlier stage of scientific and institutional development than India and Pakistan were on the eve of Asia's Green Revolution in the mid sixties.

The purpose of this paper is to analyze Zimbabwe's Green Revolution and discuss the preconditions for replicating Zimbabwe's success in other nations in Africa. Zimbabwe's Green Revolution is defined and analyzed in terms of increasing maize production, not in terms of access to food and food distribution. These food access issues are of critical importance but they are beyond the scope of this paper.[1]

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[1]These issues are addressed in Rukuni and Eicher (1988) and Cliffe (1988).

Zimbabwe's experience demands scrutiny because it is one of the most publicized agricultural success stories on the continent. White maize accounts for around half the calories in the average diet.[2] Zimbabwe has generated a reliable maize surplus and exported maize for 19 of 21 years over the 1970-91 period. Zimbabwe's achievement is of added importance because it is a homegrown production success from start to finish. It has been spearheaded by indigenous farm organizations, a public national agricultural research system unmatched in Africa, institutional innovations, and fueled by the synergy between white and black farmers and farm organizations. Foreign aid has been a footnote in Zimbabwe's success story.[3]

We begin by examining Africa's experience in increasing crop yields over the last 70 years, starting with the rice riots in Sierra Leone in 1918/19, followed by an analysis of Nigeria's Green Revolution experience of the 1970s and the development of a Green Revolution hybrid sorghum variety in the Sudan. Then we analyze Zimbabwe's maize-based Green Revolution and discuss the preconditions for replication.

II. AFRICA'S QUEST FOR A GREEN REVOLUTION: COLONIAL INSIGHTS

The British Colonial Experience

After the Berlin Conference was convened by Western powers in 1885 to carve up Africa, the continent was colonized in two decades. By 1912, colonialism was in control throughout sub-Saharan Africa (Pakenham, 1991). During the early 1900s, colonial administrators concentrated on imposing law and order, collecting taxes and developing international trade linkages. The colonial powers devoted little attention to stepping up food production because population densities were low and land was readily available to expand food production. But this laissez-faire attitude toward food production was challenged by a severe drought in Sierra Leone and other parts of West Africa in 1918/19. In fact, the food shortages and rice riots in 1919 and 1920 spurred the British Governor of Sierra Leone to attempt to solve

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[2]Maize consumption in the maize belt of Eastern and Southern Africa (Kenya, Zimbabwe, Malawi, Zambia) is about 100 kg. per year - about the same as in the original homeland of maize - Mexico, Guatemala and Honduras (CIMMYT, 1981; Byerlee and Heisey, 1993a).

[3]In 1991, Zimbabwe, a nation of 10 million people, had an average per capita G.N.P. of $650, a life expectancy of 60 years, near universal primary education and a high, but declining rate of population growth (World Bank, 1993).

the rice crisis by replacing the traditional West African rainfed rice production system[4] with Asia's wet rice system, in which rice is grown under flooding and irrigation. In a dispatch to the Colonial office in London in 1920, the Governor noted his previous experience as a colonial officer in Asia, and concluded that irrigation "lends itself to progress and power" because "all the great Empires of antiquity developed their civilizations in the basins of great rivers" (Richards, 1986, p. 7).

The Governor also requested the assistance of a rice expert from India to teach Sierra Leonean farmers how to grow irrigated rice. However, the Indian expert was impressed with the low labor requirements of producing rainfed rice in Sierra Leone, where farmers simply cleared land, burned the brush, scattered seed and relied on rainfall for moisture. Instead of promoting the Asian irrigated rice system, the Indian expert urged the British colonial service to hire veteran Sierra Leonean farmers as itinerant extension workers to promote and diffuse rainfed rice practices. The Colonial Department of Agriculture accepted this counsel and opened a Rice Research Station in Sierra Leone in the 1930s, and focused on screening, testing, and diffusing the best local rainfed rice varieties to farmers.

Interest in irrigated rice cultivation was revived by the outbreak of World War II because Freetown, the capital of Sierra Leone, was a major base for the allied war effort. In 1941, the British colonial service introduced an emergency program to construct several irrigated rice schemes in Sierra Leone. But these schemes were abandoned because of numerous technical problems, and in 1944, the Department of Agriculture resumed its promotion of rainfed rice cultivation practices.

The lesson that flows from Sierra Leone's experience is that even though its rainfed rice systems were low yielding, the returns per hour of family labor were generally higher in rainfed than irrigated rice production. Because land was virtually free and labor was relatively expensive in Sierra Leone and other West African countries during the colonial period, it is understandable why rainfed rice accounted for around 95 percent of the land under rice cultivation in West Africa at independence in 1960, while only 5 percent was grown under Asian style, labor-intensive irrigated systems.

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[4]Rainfed cultivation refers to a farming system that relies on rainfall for water rather than irrigation or flooding.

The French Colonial Experience

Great Britain was not the only colonial power obsessed with replacing rainfed with irrigated rice and making the transition from 'primitive' to 'progressive' agriculture. In the 1920s, the French Colonial Service had a magnificent obsession to grow cotton and rice under irrigation in West Africa in order to increase cotton exports to France and reduce the dependency on imports from the United States. The French developed a bold plan to develop a largely uninhabited two million acre site in the middle of Mali in West Africa. The scheme was called the Office du Niger Project because it drew its water from the central delta of the Niger river that snakes its way through Mali and a dozen other countries in West Africa. In 1930, a French public corporation was established to carry out the site work, including the construction of dams and canals capable of irrigating several hundred thousand acres. Because the proposed irrigation site was virtually uninhabited, the French recruited settlers from the heavily populated neighboring countries of Upper Volta (now Burkina Faso) and the Sudan. It was assumed that the settlers would create an "island of prosperity" by producing cotton as their cash crop and rice as their subsistence crop. But subsistence farmers from neighboring countries were reluctant to migrate to the Project in Mali, and adopt the labor-intensive techniques and discipline required for irrigated cultivation. As a result, the French resorted to compulsory recruitment of settlers. However, after 30 years of experimentation, only one hundred thousand of the two million acres in the project were under cultivation, far below the capacity of the dams and canals (de Wilde, 1967, pp. 244-300). After investing $160 million, the French quietly turned the "poisoned gift"[5] over to the government of Mali in 1962, two years after independence.

The failure of irrigated rice farming systems in West Africa highlights some of the pitfalls in borrowing farm production models from other continents. Irrigated farming is currently flourishing in the Punjab of India where land prices are high. But as long as land is free or relatively cheap, as it is in many countries in Africa, farmers will not invest their labor in felling trees, removing stumps, and levelling land for growing rice under irrigation. They can generally earn higher returns per hour of their labor in low-yielding rainfed rice production systems or in off farm work such as trading and rural small scale industries. Nevertheless, because of increasing population densities, growing land scarcity and rising land values, irrigation

[5]A French agronomist with four decades of experience in West Africa coined this phrase to describe many white elephant projects on the continent.

and flooding represent the pathway to increasing rice production in many African countries in the 21st century.

III. GREEN REVOLUTION EXPERIMENTS SINCE INDEPENDENCE

Nigeria's Crash Programs

Nigeria embarked on its independence in 1960 with a reliable food surplus, a booming agricultural export economy and a set of research institutions and trained agriculturalists that were the pride of West Africa. With a reliable food surplus, it is easy to understand why Nigeria's first Development Plan (1962-68) concentrated on increasing large-scale manufacturing and export crop production and devoted secondary attention to increasing food production. But a combination of rapid population growth and a severe drought in the late 1960s led to a food crisis around 1970, forcing Nigeria to import food. Flush with oil revenues, Nigeria launched three crash programs in the 1970s with one common aim: to create a Green Revolution as quickly as possible.

General Gowan launched a National Accelerated Food Production Program (NAFPP) in 1972. The aim of the crash program was to achieve national self-sufficiency in six food crops by using improved food production technology that was assumed to be on the shelf - i.e., technology that was ready and awaiting diffusion to farmers. But in practice, improved food production technologies were not readily available for local ecologies and consumer tastes (Okigbo, 1982, p. 320). The Accelerated Food Production Program failed to generate a marked improvement in available food supplies and a reduction of food prices and imports. Nigeria's first Green Revolution campaign never really got off the ground and it was scrapped after three years.

Nigeria's second grandiose food production scheme was dubbed Operation Feed the Nation (OFN) in 1976 by the head of state, General Olusegun Obasanjo. This crash program was personally spearheaded by Obasanjo, an agribusiness tycoon, and endorsed by other high-ranking military officers who had become "soldier-farmers." Operation Feed the Nation employed a military chain of command which turned out to be an exercise in paper shuffling. It was scrapped in three years (1976-79) because it "did not contribute significantly to increased food production, to a drop in food prices, or to the reduction of mounting food imports" (Okigbo, 1982, p. 320). Nevertheless, Obasanjo has been lionized by many U.S. organizations for his role as a progressive farmer and spokesman for agriculture in African development circles.

Nigeria's third food production scheme was launched by a civilian ruler - President Shagari in 1980 and it was officially called the Green Revolution Campaign. The Federal Minister of Agriculture proclaimed that a basic objective of the Campaign was to make Nigeria "self-sufficient in food." But the overall rate of growth of food production declined from 1980 to 1983. In 1983, General Buhari toppled President Shagari. General Buhari was barely in office two years when he was overthrown by General Ibrahim Babangida in a coup d'etat. Soon after taking office, Babangida banned the importation of wheat, rice and corn in order to stimulate local production. However, because of Nigeria's porous borders, substantial quantities of wheat and rice were smuggled into the country until the government lifted the ban in 1993. National food self-sufficiency remains an elusive goal.

Nigeria's Green Revolution campaigns have failed to generate a sharp increase in food production. Nigeria's military and civilian rulers formed task forces and issued directives, but they failed to develop a consistent policy package, economic incentives and a long term approach to strengthening farmer support institutions that are essential components in Green Revolution production campaigns. Instead, each successive Nigerian leader approached the chronic food-production problem with simplistic battle plans to win the war on food production in three to four years. The bottom line is that Nigeria's annual agricultural growth rate of 1.7 percent from 1965-80, was swamped by its annual population growth rate of 3.2 percent (World Bank, 1992, pp. 220 and 268).[6]

At the beginning of the oil boom in the early 1970s, many Nigerian intellectuals and businessmen thought that Nigeria was poised to become an industrial giant, i.e., the Brazil of Africa, within a decade or two. It was assumed that a Green Revolution could be put in place in less than a decade. But after squandering $100 billion of petroleum revenues during the seventies and eighties, Nigeria neither has a competitive industrial sector nor a modern agriculture. Two-thirds of its people are "parked" in the agricultural sector, rural institutions are

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[6]However, Nigeria's agricultural growth rate of 1.7 percent over the past 20-30 years is respectable when it is compared with the long term agricultural growth rates of presently industrialized countries. For example, the agricultural growth rate for the U.S. and Japan over the 1880-1980 period was 1.6 percent (Hayami and Ruttan, 1985). The critical difference between Africa today and the industrial countries from 1850-1900, is the sharp difference in population growth rates. The current annual population growth rate in Africa is about 3.0 percent. By contrast, the average population growth rates in European countries during the 1850-1900 period were as follows: Great Britain, 1.1; Denmark, 1.1; France, 0.2 and U.S.S.R., 1.4 percent (Dovring, 1964, p. 82).

in disarray and agricultural policies change like the sand dunes in the Sahara. After much bravado from soldier-farmers such as General Obasanjo about the role of agribusinesses in feeding Nigeria, it is clear that small-scale family farms, with five to ten acres of land, are the foundation of Nigeria's agricultural future.

Several stark lessons emerge from Nigeria's attempts to create instant Green Revolutions. The most important factor that has undercut agricultural development is political instability. The second lesson is the time frame required to fulfill the required preconditions for a Green Revolution. Nigeria's petroleum boom of the 1970s generated ample government revenue and foreign exchange earnings that could have been used to develop the preconditions for a Green Revolution - roads, rural infrastructure, and agricultural institutions - over a period of several decades. Instead of laying out a medium term Green Revolution plan and "staying the course" for 10 to 15 years like India and Indonesia did in the late 1960s and throughout the 1970s, Nigerian leaders, military and civilian, introduced a series of crash food production programs with the aim of achieving an instant Green Revolution in three to five years. The third lesson is a tale of macroeconomic mismanagement and a drive to industrialize with a backward agriculture. The government virtually abandoned agriculture in the 1970s and used its foreign exchange earnings from petroleum to import billions of dollars of food each year, develop a $3 billion iron and steel complex and construct a new federal capital at Abuja.

Hybrid Sorghum in The Sudan

Superlatives are appropriate when describing Sudan's potential as an agricultural powerhouse in Africa. Sudan, the largest country on the continent, is sparsely populated and has only about 10 percent of its arable land is under cultivation. This explains why the Sudan is often referred to as the potential "bread basket" for the Middle East. Sorghum is the nutritional backbone of the country; it is grown in a semi-arid region in the central part of the country that is comparable to the sorghum belt in Texas and Kansas. Sorghum is used for making unleavened bread, thick porridge, a soft drink and a local beer. The stalks are used as building material for houses and the leftovers as animal feed or fuel.

When the Sudan gained independence in 1956, it had a world-class cotton research program, but a weak research base on food crops. This was understandable because large scale, mechanized farms, using local varieties were producing enough sorghum for local needs and export markets in the Middle East. The Sudanese owners of the mechanized farms simply

planted local varieties of sorghum on virgin land for several years until the soil was exhausted by wind erosion. Farmers would then move to another virgin area and open up more land.

In 1952, Sudan initiated a modest program of research on sorghum which subsequently moved through three trial and error phases, each about a decade in length. The first phase covering the 1950s (1952-1961), could be described as a "technology transfer" gamble. The Central Rainlands Research Station was set up at Tozi in 1952 to carry out research on mechanized cultivation of food crops such as sorghum. The dream was to multiply Texas sorghum seed in the Sudan and release it to extension workers and farmers. It was assumed that the semi-arid ecosystem in Central Sudan was "similar" to that in Texas and Kansas. But U.S. sorghum varieties did not flourish in central Sudan because of unforeseen differences between the soil temperature, and disease and insect pressures in the Sudan and in Texas and Kansas.

Since the direct transfer of U.S. sorghum seed to farmers in the Sudan was unsuccessful, Sudanese researchers initiated a program of crossing imported and local varieties in the 1960s. However, this approach did not generate a high yielding hybrid sorghum variety. Sorghum research was accelerated in the 1970s with financial assistance from the Ford Foundation and scientific counsel from the Arid Lands Agricultural Development Program, headquartered in Lebanon. In 1977, the government hired its first full-time sorghum breeder (an expatriate) to lead an intensified research effort. In 1979, an Ethiopian plant breeder assumed the leadership of the research program. After four years of intensive testing of several hundred experimental varieties, one hybrid, Hageen Dura-I,[7] was found to out-yield the best local variety by 50 percent (Ejeta, 1988). In addition to its higher yield, HD-I had yield stability across micro environments and good grain quality for consumers.

The release of HD-1 in 1983 was the culmination of three decades of trial and error research. Since HD-1 is a hybrid, farmers must purchase new seed every year. Because of the lack of a reliable public or private seed company and political unrest, the spread of HD-1 has been limited. Unlike Asia where imported wheat and rice varieties provided the "missing link" in getting agriculture moving in the sixties and seventies, Sudan's experience reminds scientists and donors that a Green Revolution variety such as HD-I needs to be supported by basic farmer support institutions such as a public or private seed distribution system.

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[7]Arabic translation of Hybrid Sorghum No. 1.

The attempts of Nigeria and the Sudan to create a Green Revolution drive home the basic point that food crop revolutions cannot be achieved through short run military-type campaigns. This experience also illustrates that even if a high yielding variety such as hybrid sorghum is developed, the new technology requires a favorable macroeconomic environment for agriculture and efficient public and private farmer support organizations (e.g. seed distribution systems) in order to diffuse the technology and turn it into commercial success.

IV. ZIMBABWE'S GREEN REVOLUTION

The First Green Revolution, Commercial Farms, 1960-80

In 1890, Cecil Rhodes dispatched a pioneer column from South Africa to colonize Zimbabwe, but after failing to find gold deposits on a par with those in South Africa, the European settlers turned to farming.[8] The settler farmers subsequently gained control over prime agricultural land through the passage of a series of Land Ordinances that "guaranteed white economic dominance and black poverty during the 90 year colonial period" (Herbst, 1990). The colonial strategy of confiscating land and depressing the profitability of small scale farms, and the wages of farm workers and migrant laborers, has been pursued historically by large scale farmers, in collaboration with the state, in many countries in Latin America and Africa.[9]

The political preconditions for Zimbabwe's Green Revolution were first addressed in the 1920s when European farmers formed local farmer associations. These associations expanded and evolved into provincial farmer associations. During World War II, the government secured the cooperation of commercial farmers in increasing food production in exchange for the passage of the Licensing Act of 1942. This Act made it mandatory for all commercial farmers

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[8]The Southern Rhodesia Order of 1898 led to the designation of Native reserves. Subsequently, "high potential" land was seized by European settlers. The Land Apportionment Act of 1930 legalized the segregation of land between European settlers and Africans. At independence in 1980, roughly half the arable land in the country was controlled by 5,000 commercial (large scale) farmers and the other half by roughly 700,000 communal (smallholder) farmers.

[9]The following mechanisms have been used to protect large scale farms and depress the earnings of small scale farms, tenants and workers: (1) confiscation of prime agricultural land for use by large scale farms, (2) differential taxation via hut, head or poll taxes, which had to be paid in cash, in kind or labor services, (3) restricted access to markets for certain crops, (4) labor market interventions, e.g. pass laws, and (5) confining public agricultural services (e.g. credit, research, extension) to serve large scale farms (Binswanger and Deininger, 1993).

and ranchers to buy a license from the newly-formed Rhodesian National Farmers Union (RNFU). The passage of the Licensing Act of 1942 has been described as a "stroke of organizational brilliance" because it assured the Union a sound financial base (dues from farmers and ranchers) which allowed "white farmers to undertake research and lobbying exercises of enormous sophistication and expense" (Herbst, 1990, p. 40). The RNFU was subsequently renamed the Commercial Farmers Union (CFU). The CFU currently has a salaried staff of 120 and it occupies a ten story building in downtown Harare (Bratton, 1991). The CFU is led by a farmer-president who leaves his farm to work full time at the CFU headquarters during his term of office. In retrospect, the process that Zimbabwe's commercial farmers used to acquire political power is a rerun of the Japanese experience.[10]

The technical and institutional preconditions for Zimbabwe's first Green Revolution were developed through public and private investments in the four prime movers of agricultural development from 1920-1950:

- New technology that is produced by long term public and private investments in agricultural research;
- Human capital and managerial skills that are produced by investments in schools, training centers and on-the-job experience;
- Biological capital investments (e.g. improving livestock herds, planting, spraying, pruning and maintaining cocoa and coffee trees) and physical capital investments in infrastructure, such as small dams, irrigation, and roads;
- Investments in farmer support institutions such as marketing, credit, fertilizer and seed distribution systems.

The prime movers laid the foundation for the first Green Revolution by commercial farmers who increased maize, cotton and tobacco yields and production from 1950 to 1980 (Blackie, 1987; 1989). For example, although research on cotton pests was launched in the 1920s,

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[10]In 1881, the Japanese government invited successful farmers (called veteran farmers) to Tokyo to establish a new organization, the Agricultural Society of Japan, modeled after the Royal Agricultural Society of England. The purpose of the new organization was to disseminate technical information to Japanese farmers. In 1894, the National Agricultural Association was established to mobilize farmers as a political force. All farmers in Japan were required by law to join the Association and pay membership fees. Thus the seeds of agrarian political power in Japan were rooted in compulsory membership of farmers in the National Agricultural Association (Hayami and Yamada, 1991). Zimbabwe followed this same course of action when the government and the farmers cooperated in securing the passage of the Licensing Act of 1942.

effective control over insects, pests and cotton diseases was not achieved until the 1950s. Research on hybrid maize was initiated by H.C. Arnold at the Harare research station in 1932 but it took 17 years to develop and release the first hybrid maize variety to commercial farmers in 1949. However, the first hybrid (SR-1) was not biologically stable so maize researchers continued their trials until 1960 when they hit the jackpot with SR-52, a high-yielding hybrid that increased maize yields by 46 percent (with fertilizer, and improved agronomic practices) over Southern Cross, the best local (open pollinated) variety (Weinmann, 1975; Mudimu, 1989). Alan Rattray, the Zimbabwean maize breeder who developed SR-52, reports that commercial farmers quickly adopted the new variety and, within eight years, (1960-68), two-thirds of the maize acreage of commercial farmers was planted to SR-52 (Rattray, 1969, p. 10).[11]

Without question, SR-52 hybrid maize is the most famous Green Revolution food crop variety in Africa. SR-52 is a long season (150 day) variety that was ideally suited to the commercial farmers of Zimbabwe who lived on fertile land with "Iowa-type" growing conditions. Two crucial political developments of the 1950s and 1960s contributed to the rapid adoption of SR-52 maize in Zimbabwe and in neighboring Zambia (Howard, et al., 1992). The first was Great Britain's decision in 1953 to establish a regional political Federation, consisting of Northern Rhodesia (now Zambia), Southern Rhodesia (now Zimbabwe) and Nyasaland (now Malawi). The Federation only lasted ten years, (1953-63), but during its brief operation, it encouraged industrial and agricultural specialization, including research, and it facilitated an exchange of scientific findings, including the new hybrid maize varieties. For example, when Zimbabwe released SR-52 in 1960, it was renamed Z752 by scientists in neighboring Zambia and adopted by many commercial farmers. But surprisingly, SR-52 was not widely adopted by commercial farmers in Malawi (Smale and Heisey, forthcoming).

The second major political event was Southern Rhodesia's Unilateral Declaration of Independence (UDI) from Great Britain in 1965. The Declaration triggered a bitter 15 year Civil War and it was countered by U.N.-led sanctions to curb Rhodesia's exports, especially tobacco, the leading agricultural export. The immediate effect of sanctions was a drop in tobacco prices and a scramble by white farmers to diversify their farming operations. Many commercial farmers shifted from tobacco to the new short season hybrid maize varieties - R200,

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[11]About 20 percent of the smallholders (mostly those in high rainfall areas) adopted SR-52 by 1965 (Mashingaidze, forthcoming). However, smallholders in marginal (low rainfall) areas required a shorter (120-130 day) maize variety.

R201 - as soon as they were released in the early seventies because they were well suited to the sandy soils where tobacco had been grown previously.[12] Although sanctions reduced the relative profitability of tobacco in Zimbabwe, they opened up international markets for Malawian tobacco estates. This new export opportunity may explain why Malawian commercial farmers were slow (relative to Zambian farmers) in adopting SR-52 maize seed from Zimbabwe (Smale, 1993).

The 1965-79 Civil War accelerated the process of agricultural diversification by "forcing" Zimbabwean commercial farmers to shift from tobacco to maize, cotton, wheat, soyabeans and coffee (Blackie, 1987).[13] For example, in 1985 only 4,000 tons of wheat were grown, meeting only 4 percent of domestic consumption requirements. Because of the loss of foreign exchange earnings from tobacco, the government tried to reduce foreign exchange outlays on wheat imports by offering subsidies to commercial farmers to invest in irrigation infrastructure to produce wheat. Since improved wheat varieties were on the shelf (Rattray, 1969), farmers quickly expanded irrigated wheat production and by the late seventies, Zimbabwe was producing all of its domestic wheat requirements.[14]

To summarize, the Green Revolution in the Third World actually started in Zimbabwe in 1960, five years before Asia's Green Revolution was launched in India in 1965. Zimbabwe's first Green Revolution in maize was implemented by commercial farmers from 1960-80 in the midst of a 15 year civil war and U.N. sanctions. However, even though the first Green Revolution helped feed the cities and earn foreign exchange, it was not replicated by smallholders. This

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[12]These varieties were developed from in-bred lines from South Africa (Rattray, 1988).

[13]Blackie (1987, p. 120) documents the impact of agricultural diversification by comparing the composition of marketed agricultural output in 1965 and 1980.

	1965		1980	
Commodity	Value Z$m	Percent	Value Z$m	Percent
Tobacco	67.6	52.6	97.4	19.8
Cotton	2.6	2.0	71.4	14.5
Maize	13.5	10.5	78.1	14.6
Wheat	0.3	0.2	22.2	4.5

[14]Today, Zimbabwe's national average wheat yield is around 6 tons per hectare, among the highest in the world (Morris, 1989).

explains why Zimbabwe's first Green Revolution never received the international press coverage of Asia's Green Revolution starting in 1965.

The Second Green Revolution, Smallholders, 1980-85

At Zimbabwe's independence in 1980, roughly 5,000 commercial farms controlled half the arable land and 700,000 smallholders (communal) farmers occupied the other half (Blackie, 1982). The second Green Revolution was spearheaded by smallholders who rapidly adopted hybrid maize varieties, fertilizer and doubled maize production in six years, 1980-86.[15] This unexpected success story is attributed to a combination of factors, including peace in the countryside which enabled many smallholders to bring land abandoned during the civil war back into cultivation, a backlog of short season hybrid maize varieties, increase in guaranteed maize producer prices, removal of the racial and institutional barriers to credit which allowed smallholders to gain access to seed and nitrogen fertilizer, and expansion of marketing services (e.g., grain buying points) in rural areas (Rohrbach, 1989).[16] Zimbabwe's second Green Revolution attracted international press coverage because it was led by smallholders and it occurred at a time when a million people died in the Ethiopian famine (1984-85). Zimbabwe's success story also garnered the Africa Leadership Prize for President Mugabe in 1988 and it helped make the case that smallholder farming was more efficient than state farms that were popular in many countries in Africa in the 1980s.

Zimbabwe's second Green Revolution was facilitated by several fundamental political decisions. At independence, the new government declared its political support for a smallholder road to development. Zimbabwe also honored the terms of the Lancaster House independence

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[15]About 1/3 of the increase in smallholder maize production came from bringing idle land back into cultivation and the remaining 2/3 from higher yields (Rohrbach, 1989).

[16]Since 1985 was an exceptionally good crop year and 1986 was a normal year in terms of rainfall and growing conditions, the 1980-86 period was used to delimit the second Green Revolution. In 1980, with slightly below normal rainfall (700mm) smallholders planted 931,000 ha. of maize, harvested 738,000 tons and delivered 89,000 tons of maize to the Grain Marketing Board (GMB). In 1985 with exceptionally good weather (943mm), smallholders planted 1,228,000 ha. of maize, harvested 1,877,000 tons and sold 819,000 tons of maize to the GMB. The average maize yield in 1980 was .79 tons/ha. compared with 1.53 tons/ha. in 1985. In short the 1980 crop year was slightly worse than normal in terms of growing conditions while 1985 was an exceptional year for growing maize. In 1986, a year with normal growing conditions, smallholders planted 1.1 million ha. of maize, produced 1,338,000 tons and sold 682,000 tons to the GMB (Jayne, et al, forthcoming).

agreement that stipulated that commercial farm land would be sold on a "willing buyer - willing seller" basis for a decade after independence. The decision of the new government to maintain a strong commercial farming community helped ensure a reliable food surplus while basic agricultural institutions (e.g., credit, research, extension) were reorganized to serve the majority of farmers - the black smallholders.

Zimbabwe's smallholder-led Green Revolution of the 1980s is partially attributed to the prime movers that had been developed by white commercial farmers over a period of many decades. The seed industry is a case in point. In 1940, a small group of commercial farmers established the Zimbabwe Seed Maize Association to produce certified maize seed under the supervision of the Ministry of Agriculture (Tattersfield and Havazvidi, forthcoming). In 1949, the Association distributed the first hybrid maize seed to commercial farmers. Today, around 160 farmers produce hybrid maize seed which is sold by the Seed Co-op Company of Zimbabwe at home and in a dozen countries throughout Africa. Zimbabwe's seed distribution system performed well in the 1980s and it is currently providing maize seed to small, medium and large scale farmers. Without question, Zimbabwe's seed supply system is the crown jewel of seed systems in Africa (Rusike, 1993).[17]

Agricultural research is another prime mover that smallholders were able to tap at independence. The new majority-ruled government inherited the finest public national agricultural research system in Africa. Kupfuma (1993) recently estimated that the annual internal rate of return on public investment in hybrid maize research was 43 percent from 1932 to 1990.[18] In the early eighties the extension service was in the enviable position of having a backlog of hybrid maize varieties "on the shelf" for small, medium and large scale farmers. No other country in Africa entered independence with such a strong indigenous research base.

Following independence, the Mugabe government directed the national agricultural research service to shift its orientation from serving commercial farmers to developing relevant technology for smallholders, especially those living in low rainfall areas where sorghum and millet were the dominant food staples. However, this shift in research mandate was hampered

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[17]Seed distribution has been a bottleneck in the Third World. Virtually all government seed companies in Africa have turned out to be white elephants. See Cromwell, et al, 1992.

[18]This means that every dollar invested in hybrid maize research over a period of 58 years, 1932-90, earned an average annual return of 43 cents. This rate is roughly three times higher than the minimum return (10-12%) that the World Bank usually uses as a cutoff on projects.

by a loss of experienced research officers[19] and a failure to provide adequate funds to finance the required field trials in the smallholder farming regions. Also, the budget of the national agricultural research system declined 25 percent in real (inflation-adjusted) terms from 1980 to 1990. These factors contributed to Zimbabwe's loss of its technological edge in agricultural research in little more than a decade of independence. The slow erosion of one of Zimbabwe's national treasures - its national public R&D system - has important implications for agricultural policy in the 1990s and beyond.

The expansion of government credit also contributed to the smallholder-led Green Revolution in the early 1980s, but this early achievement was undermined by the "scaling-up" problem and the powerful role that commercial farmers continue to play in dominating the government credit system (Chimedza, forthcoming). The main government credit agency, the Agricultural Finance Corporation (AFC), has its origins in the Land Bank of 1911 which had a mandate to serve white commercial farmers. In 1978, the AFC launched a Credit Scheme for smallscale commercial farmers. At independence, the government decided to expand credit to communal farmers, especially for farmers producing maize and cotton. However, credit was perceived as a magic wand, an entitlement and the AFC increased the number of loans to communal farmers from 18,000 in 1980/81 to 77,000 in 1985/86 (Table 1). The number was reduced to 30,000 in 1990/91 because of several problems. First, there were managerial and loan supervision problems in "scaling-up" the credit program from 18,000 to 77,000 loans. Second, recurrent droughts increased the risk of borrowing and the rate of default. Third, the delinquency rate was high, partially because of the speed in extending the loans and inadequate supervision. The AFC responded to these problems by becoming more selective and reducing the number of loans to smallholders.

After 13 years of independence, commercial farmers still monopolize subsidized government credit. Table 1 reveals that although the number of AFC (government) loans to commercial farmers declined significantly in the eighties, the total value of AFC loans to 1,133 commercial farmers in 1990/91 was more than seven times the total value of AFC loans to

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[19]After four years of independence, "nearly two-thirds of the mainly experienced cadre of European scientists left to be replaced by inexperienced African university graduates. This has seriously weakened the capacity of DR&SS to respond effectively in the short term to the new set of demands placed on the Department" (ISNAR, 1988, p. 15).

TABLE 1. ZIMBABWE: AGRICULTURAL FINANCE CORPORATION (AFC) LOANS BY TYPE OF FARMER, 1980/81 TO 1990/91

Year Ended March	Large Scale Commercial		Small Scale Commercial		Resettlement		Communal (Smallholder)		Grand Total	
	Number Granted	Value $M	Number Granted	Value $M	Number Granted	Value $M	Number Granted	Value $M	Number Granted	Value $M
1980/81	2 526	86.9	3 333	3.7	-	-	18 000	4.2	23 859	94.8
1981/82	2 103	88.8	3 649	4.6	911	0.5	30 150	10.1	36 813	104.0
1982/83	1 645	88.7	2 953	4.5	4 154	1.5	38 912	13.2	49 664	107.9
1983/84	1 400	110.2	3 052	8.1	19 874	10.6	50 036	23.4	74 362	152.3
1984/85	1 484	110.3	2 744	8.7	19 926	10.7	65 793	32.0	89 947	161.7
1985/86	1 308	113.0	2 569	11.5	13 866	8.5	77 526	38.9	95 269	171.9
1986/87	1 007	94.9	1 910	9.6	11 800	8.6	77 384	60.0	92 101	173.1
1987/88	990	111.2	1 542	6.8	11 217	9.0	69 885	49.4	83 634	176.4
1988/89	900	117.4	1 140	5.3	7 022	5.9	57 679	41.3	66 741	169.9
1989/90	969	136.3	844	4.5	5 193	5.9	43 846	33.4	50 852	180.1
1990/91	1 133	195.1	761	3.6	4 658	4.7	30 190	26.4	36 742	229.8

Source: AFC Annual Reports.

30,190 communal farmers. This raises the fundamental political question: Why should 1,133 commercial farmers receive more subsidized government credit than 30,190 communal farmers?

Zimbabwe's post independence development experience illustrates how difficult it is for a new government to restructure agricultural institutions that are serving commercial farmers and focus their energy and resources on serving hundreds of thousands of smallholders, especially those in marginal areas. In thirty years of Africa's independence, many donors have helped African governments design and implement farmer support projects (credit, extension, seed, fertilizer) that serve a few thousand smallholders. But most new governments have had great difficulty in acquiring the managerial capacity to replicate "successful" projects on a regional or national level. Zimbabwe's experience sheds further light on the complex managerial problems involved in restructuring farmer support institutions and scaling them up to serve the majority of farmers in a nation - i.e., the smallholders.[20]

Fueled by the second Green Revolution Zimbabwe was awash with maize by the mid eighties. This explains why an analysis of the second Green Revolution must go beyond production issues and also examine how the government managed its national food economy during several vastly different food policy scenarios, ranging from overflowing grain silos in the mid eighties, to the catastrophic drought of 1992. In 1985, a record crop of three million tons of maize was harvested, an amount equivalent to three years of domestic consumption. But the mounting cost of financing the government's maize reserve (2 million tons in 1985) brought about a reappraisal of the producer pricing policy and the level of government grain reserves. The government announced a policy decision to curb maize production for the 1985/86 crop year and to reduce the level of the grain reserve. The government encouraged commercial farmers to diversify into other activities such as oilseeds, game ranching and horticultural crops for export. Both commercial farmers and smallholders slowly reduced the area under maize cultivation in the late eighties. But some of the gains of the early eighties in terms of levelling the playing fields for smallholders were dissipated in the second half of the eighties. For

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[20]Yudelman, (1991, p. 41), reports that when the Sasakawa-Global 2000 food production program in Ghana scaled-up its credit program in the late eighties, the loan repayment rate fell sharply:

Year	Farmers Receiving Credit	Loan Repayment Rate
1987	1,644 farmers	95%
1988	15,737 farmers	77%
1989	78,218 farmers	39%

example, the government has reduced the number of temporary grain collection points in rural areas from 125 to 9.[21]

Although the government pointed to the drought as the main cause of food shortages and the 40 percent jump in food prices in 1992, closer examination reveals that the 1992 food crisis was exacerbated by several policy mistakes (Jayne and Rukuni, forthcoming). For example, the government initially ignored the advice of its Early Warning Committee to order grain from overseas and vacillated for four months before it reached agreement with South Africa and Mozambique to allow rail and truck convoys to move imported grain through the ports of Durban, Capetown, Beira and Maputo to Zimbabwe in 1992 and 1993.[22]

Based on the experience gained in managing the bumper maize harvest of 1985 and the 1992 drought, the Minister of Agriculture recently recommended a target of 936,000 tons of public grain reserves for 1993/94, equivalent to about one years' domestic consumption (Kangai, 1993). This is substantially higher than several economists have recommended.[23] But the Minister of Agriculture argues that the government has struck an appropriate balance by taking account of two contrasting experiences, the record maize crop of 1985 and the drought of 1992 (Kangai, 1993).

In summary, Zimbabwe's second Green Revolution is the story of smallholders doubling maize production from 1980 to 1986. But this success is not attributed to a single factor, such as higher prices, improved technology or greater access to credit. Zimbabwe's second Revolution, like its first, was achieved by fulfilling the same four basic preconditions: political, technological, institutional and economic. And, unlike Asia where irrigation was synonymous with the Green Revolution, in Zimbabwe, crop production is critically dependent on rainfall.[24] This explains why Zimbabwe's second Green Revolution was highly concentrated among smallholders in

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[21]Also fertilizer use declined in the late eighties. Fertilizer use by smallholders was as follows: 1980, 90,000 MT; 1985, 135,000 MT and 1990, 100,000 MT.

[22]Zimbabwe imported 1.2 millon tons of grain during the 1992 calendar year and 1.7 million tons during the marketing year, April 1992 - March 1993.

[23]Buccola and Sukume (1988) suggest a four month working stock would minimize storage costs and still allow enough time for grain imports to be ordered and delivered from overseas.

[24]About 5 percent of the cultivated land is under irrigation in Africa as compared with 40 percent in India and 60 percent in Indonesia.

higher rainfall areas. In fact, 75 percent of the increase in maize production from 1980-85 occurred in 18 (mainly in the maize belt in Mashonaland Province) of the 150 smallholder areas in the country (Amin, 1990; Jayne and Rukuni, 1993).

The bottom line is that Zimbabwe's second Green Revolution is a "qualified" success story that cannot be easily replicated by other nations in Africa. Beneath the surface of Zimbabwe's second Green Revolution is an untold story of cooperation, synergy and spillovers between white and black farmers, researchers, and farm support organizations (Rukuni and Eicher, forthcoming). At independence, Zimbabwe inherited a dual agrarian structure of white commercial farmers with political power and smallholders on the fringe of the political process. The new government made a political commitment to a smallholder road to development and it urged smallholders to set up their own farm organization. However, most African nations have an agricultural sector with little political clout and weak farm support organizations. Hence, even if other countries borrow or develop a new Green Revolution crop variety, they will have fulfilled only the technological precondition, one of the four generic preconditions for a Green Revolution. The three remaining preconditions, political, economic and institutional, are almost impossible for other African countries to fulfill in the short run. The history of aborted Green Revolution campaigns in Sierra Leone, Nigeria and the Sudan provides solid evidence of the need to address the four preconditions in a concerted manner over a number of decades.

V. THE QUEST FOR A THIRD GREEN REVOLUTION

Zimbabwe's socialist development strategy failed to deliver rapid economic growth in the 1980s. In fact, population growth outstripped economic growth in the 1980s, and the average Zimbabwean was worse off in 1990 than at independence in 1980. Major economic policy reforms are now underway in Zimbabwe. The central agricultural policy question of the 1990s is how to carry out policy and institutional reforms to accelerate agricultural growth and help reverse economic stagnation, moderate inflation and generate rural employment.

Zimbabwe's first Green Revolution was led by commercial farmers. The second Revolution was led by a minority of smallholders, mainly those in higher rainfall areas (Stack, forthcoming). The premier agricultural production challenge in Zimbabwe over the next 10 to 20 years is to assist smallholders in bringing about a third Green Revolution in favorable and unfavorable natural resource regions. However, it is an open question whether the government can master the complex issues involved in implementing a broad-based, smallholder development

strategy. Much will depend on the ability of the government to dispose of its heavily subsidized state farms and plantations, rekindle its dormant land reform program, rebuild its deteriorating public agricultural research system, generate improved technology for resource-poor regions, and strengthen its farmer support organizations to serve hundreds of thousands of smallholders. These are daunting tasks for the government, especially in light of the loss of some of its political legitimacy in recent years.[25]

Zimbabwe's third Green Revolution should focus initially on increasing maize yields and crop production in favorable areas because it is a proven strategy with low risk and it can generate both direct and indirect benefits. This is precisely what India did when it concentrated its administrative talent and resources (e.g., credit, irrigation) on 17 high potential districts in the mid sixties (Mellor, 1976). Expanded production in favorable areas can lead to lower maize prices which can indirectly benefit rural families in unfavorable areas who are net food buyers.[26] At the same time, parallel steps should be taken to develop better maize, sorghum and millet varieties and crop resource management practices for smallholders in resource-poor and low rainfall areas over the next 10-15 years (Bembridge, 1991; Blackie, forthcoming).[27] But even if a third Green Revolution is achieved, it will be unable by itself to eliminate rural poverty. The smallholder road to development is only applicable to rural households that have adequate land and resources (e.g. credit, draft animals, access to markets) to adopt new technology and employ most of their family labor in farming. Rural households without adequate land or access to credit to meet their household food security needs must be assisted by employment generation programs, food safety nets and investments in health and education to equip many rural people for eventual out-migration to the industrial-urban sector.[28] A

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[25]However, the government's efficient 1993 drought recovery program (25 kg. of free maize seed and a bag of fertilizer for each farmer) has been applauded by smallholders. As a result, many political analysts believe that the ruling party is likely to garner a bumper harvest of rural votes in the 1995 national election.

[26]Despite the folklore that most rural families in Africa are either self-sufficient in food or net food sellers, recent research has shown that from 15 to 73 percent of the rural households in Mali, Senegal, Rwanda and Zimbabwe were net food buyers (Weber et al., 1988).

[27]Maize is still more profitable than sorghum and millet in many low rainfall areas.

[28]See Lipton and Lipton (1993) for an analysis of restructuring institutions and creating rural livelihoods in South Africa.

recent study in South Asia reveals that the Green Revolution was incapable of solving rural poverty problems in the absence of economy-wide growth to generate jobs and facilitate rural to urban migration (Singh, 1990).[29]

IV. PRECONDITIONS FOR REPLICATION

Zimbabwe's first and second Green Revolutions were achieved by fulfilling the same four generic preconditions: political support for agriculture, technological and institutional innovations and a favorable macroeconomic policy environment.[30] These interlinked activities created a national system to develop new technology, adapt it to local ecosystems, diffuse it to farmers and manage a national food economy in times of abundance and scarcity.

1. Political leadership. The political preconditions for a sustainable Green Revolution are formidable and difficult to achieve in practice. The first is the development of political leadership that is committed to a unimodal (smallholder dominated) agrarian structure which is essential for ensuring that the benefits of increased agricultural productivity are broadly distributed throughout rural society instead of to a few thousand commercial farmers. Second, political leadership is crucial in facilitating the participation of farmers in the political process, including the ability to organize commodity groups, national farm organizations, cooperatives and "autonomous farmer-managed business enterprises" (Cleaver, 1993). Third, political leadership is required to take the hard decisions in mobilizing and reinvesting some of the agricultural surplus (taxes) back into the agricultural sector in the form of rural infrastructure, rural electrification, research, etc., in order to achieve a higher rate of growth of the agricultural sector in the future.

Zimbabwe's commercial farmers developed a powerful farm organization that made the case for agriculture (favorable producer prices, rural schools and roads and a strong national research service) in the political arena. This experience should be carefully studied by other countries in Africa and by donors. Without question, donors and international organizations

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[29]Singh recommends helping smallholders expand both crop and noncrop production such as dairying, small ruminants, fishing and forestry. He reports that one crossbred cow may do more to raise the standard of living of landless households than giving each of them two to four acres of irrigated land in most parts of India (Singh, 1990, p. 224).

[30]Favorable economic environment includes macroeconomic policies, microeconomic incentives for farmers and favorable markets (effective demand) at home and abroad.

should address the issue of political power and urge African governments to promote the formation of farm commodity groups, co-ops, and farmer associations, much like the American Farm Bureau, the Commercial Farmers Union of Zimbabwe and the powerful, farmer-dominated rice lobby of Japan. Until smallholders acquire greater political power to ensure that farming is a valued and rewarded activity, they will be reluctant to mobilize family labor for land improvements and other forms of accretionary capital formation.

2. Technological Innovation. A continuous stream of new technology from home or abroad comprise the second precondition for a Green Revolution. Each nation must master the complex process of developing a threshold level of indigenous scientific and managerial capacity to develop or borrow, adapt and diffuse improved technology to farmers. The ability of a nation to borrow scientific knowledge and technology from abroad requires the same type of scientific capacity that is required to invent new technology (Evenson, 1977). Zimbabwe created a scientific atmosphere where small teams of highly motivated and well-paid scientists[31] devoted their entire careers to research on one or two commodities. Zimbabwean researchers also developed the capacity to borrow technology from neighboring countries and the global research system.[32] Zimbabwe's favorable scientific atmosphere is illustrated by the fact that it had only four directors of its hybrid maize research program over a 56 year span, 1932 to 1988 (Eicher, 1990). Zimbabwe's unusual political and financial commitment to R&D provided the continuity of investigation that was essential for the development of a continuous stream of new maize varieties.

The quest by African nations for a Green Revolution should include the development of a minimum threshold of national scientific capacity to develop new technology as well as a capacity to borrow technology shamelessly from neighboring countries and the global research system. But the usefulness of imported technology will vary, depending on the commodity. For

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[31]Senior scientists were paid as much as the Secretary of Agriculture, the highest ranking civil servant in the Ministry.

[32]For example, because inbred and hybrid maize lines from the corn belt of the United States were found to be too quick maturing for the higher rainfall conditions in Zimbabwe, local researchers imported maize varieties from Central America and South Africa to use in their breeding program.

example, maize requires more location-specific research than crops such as sugarcane, rice and wheat, which are adaptable over a wide range of the globe (Evenson, 1984; Maredia, 1993).[33]

The second point to emphasize is the time frame required to develop new technology for a Green Revolution. As a rule of thumb, breeders estimate that it takes an average of 10 years to develop and farmer-test new crop varieties, and 15 to 20 years to develop and diffuse new livestock technology. The history of research on hybrid corn in the United States is instructive on this point. A theory of hybridization dates back to 1905, public research expenditures on hybrid corn began in 1910 and the first returns from hybrid corn production became evident in the United States after 1933 (Schultz, 1990).

3. Institutional Innovation. The third precondition for a Green Revolution involves the art of assembling an efficient system of farmer support institutions (public and/or private) to diffuse improved technology (seeds, fertilizer, credit) to farmers and to market the increased agricultural output (Bonnen, 1990). However, instead of helping African nations develop an efficient system of public and private farmer support organizations, donors have littered Africa's rural landscape with thousands of often rival and uncoordinated development projects. Research on institutions should examine both technological and institutional innovation as an interactive process.[34] The research agenda for social scientists on technological and institutional innovations for smallholder agriculture in Africa is wide open (Eicher/Baker, 1992).

4. Favorable Economic Policy Environment. The economic preconditions for a Green Revolution include the creation of a set of expectations among farmers that it will be profitable for them to invest their family labor in accretionary capital formation: clearing land, levelling fields, removing stones, and draining fields. These land improvements are of critical importance as farmers move from area expansion to increasing yields on land already under cultivation. The crucial economic incentive question for African governments is to create an incentive structure to ensure that yield-increasing technology will be profitable for the long pull. Unless

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[33]Rice and wheat are the two dominant food staples in Asia. India and many other Asian countries imported Green Revolution wheat varieties from Mexico and rice varieties from the Philippines in the 1960s. However, Africa has six food staples: rice and wheat (the two urban "fast foods"), cassava, sorghum, millet and maize. Because maize has less global adaptability than wheat and rice, African countries, especially those in Eastern and Southern Africa where maize is a food staple, will have to develop national and/or regional (public and/or private) maize breeding and testing capability.

[34]See the important study by Hayami and Yamada (1991).

smallholder agriculture can be shown to be profitable on a recurring basis, farmers will not mobilize private savings and invest them in farming or agree to pay head and land taxes for local clinics, schools, feeder roads and extension agents.

SUMMARY

Since independence in 1960, most Africa nations have imposed heavy taxes on farmers and treated agriculture as a national parking lot for the poor. Each African nation needs to develop the capacity to deal simultaneously with short term food emergencies and long term agricultural growth. Because of increasing population pressure and the closing of the frontier, future food production in Africa will have to come increasingly from raising crop yields rather than through area expansion - i.e., bringing idle land under cultivation. Although it is currently fashionable to draw lessons from Asia's Green Revolution experience for Africa, there is much that can be gleaned from Africa's experience in generating its own Green Revolutions.

Zimbabwe's first maize-based Green Revolution from 1960-80 was spearheaded by several thousand white commercial farmers who developed a powerful farm organization that made the case in the political arena for a strong national public research system, efficient public and private farmer support institutions, a favorable economic environment for farmers, and an export-oriented farm policy. But Zimbabwe's first Green Revolution starting in the early sixties failed to capture world attention because it was neither replicated by Zimbabwe's smallholders, nor by smallholders in other African nations.

At independence in 1980, Zimbabwe's new government helped level the playing field for smallholders by removing the racial barriers to access to credit and marketing, integrating the two racially divided extension services, and directing the national public research system to reorder priorities in favor of smallholders. Zimbabwe's second maize-based Green Revolution was led by smallholders who doubled maize production from 1980/86. The rapid expansion of smallholder maize production in the 1980s provides solid evidence that smallholders will respond to new production opportunities if four interrelated preconditions are met: political leadership for a smallholder road to development, available technology, efficient public and private farmer support institutions and a favorable macroeconomic environment for agriculture.

However, Zimbabwe's mixed record in reforming its farmer support institutions since independence should be carefully studied by other nations seeking to replicate Zimbabwe's smallholder-led Green Revolution. Zimbabwe's experience has shown how difficult it is to

restructure farmer support organizations to serve hundreds of thousands of dispersed smallholders. Before South Africa dismantles its commercial farms, it should study Zimbabwe's mixed record with land settlement and restructuring farmer support institutions to support smallholders.

The economic history of Zimbabwe reinforces the basic point that each nation must address a number of specific problems arising from its past history as well as some generic problems such as developing the prime movers of agricultural development and a capacity to manage a national food economy in times of abundance and scarcity. These country specific problems illustrate why donors should stop flooding Africa with generalized policy prescriptions (e.g., structural adjustment programs) and standard institutional models such as the Training & Visit (T&V) extension model. Case studies of agricultural intensification under rapid rates of population growth in Africa are needed to help deepen our understanding of how to develop technological and institutional innovations as an ongoing process. The findings from these on-going studies can feed into the preparation of long term agricultural growth strategies for each country.

Africa's emerging maize-based Green Revolution suggests that it is going to be longer, more costly and scientifically more difficult to bring about Green Revolutions in Africa than in Asia. There is a need for social scientists to carry out additional country studies of Africa's emerging maize-based Green Revolution. Because of the institutional vacuum throughout rural Africa, there is a need for a large increase in social science research on such institutional issues as: How to develop politically powerful farm organizations? How to develop cost effective and sustainable credit institutions to serve the majority of farmers? What are the optimal public-private arrangements in agricultural research, fertilizer, credit and seed delivery systems? What are the technical and economic merits of alternative extension models? What are the most effective ways for non-governmental organizations (NGOs) to assist in agricultural, rural development and environmental programs?

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