Agricultural Economics, 4 (1990) 117–143
Elsevier Science Publishers B.V., Amsterdam – Printed in The Netherlands

Building African Scientific Capacity for Agricultural Development

Carl K. Eicher
Department of Agricultural Economics, Michigan State University, East Lansing, MI 48824-1039 (U.S.A.)

(Accepted 16 May 1989)

Abstract

Eicher, C.K., 1990. Building African scientific capacity for agricultural development. *Agric. Econ.*, 4: 117–143.

During Africa's first two decades of independence from 1960 to 1980, priority was given to increasing the size of national extension services because it was assumed that technology could be imported from industrial countries and the International Agricultural Research Centers. Over the past decade, donors have turned their attention to assisting national agricultural research systems (NARS). But many NARS are performing poorly and are faced with a high turnover of scientific staff and inadequate operating budgets. Moreover, the present donor-financed project by project and country by country approach to building African scientific capacity is seriously flawed. This paper examines Africa's agricultural research history over the past six decades and draws lessons for strengthening national and regional agricultural research systems over the coming 30 years.

> "The true measure of the success of a program of international and technical collaboration is not in its accomplishments during the period it is in force but rather in what happens after foreign aid has been withdrawn."
>
> –George HARRAR, 1967, p. 20.

Introduction

The biggest challenge facing the international agricultural research community in the 1990s is sub-Saharan Africa, a continent of 45 diverse economies and 500 million people. The development of improved technology through agricultural research is central in addressing Africa's dual problems of lagging food production and rural poverty. From independence in 1960–1980, donors assisted in expanding national extension services in Africa because it was assumed that improved technology could be borrowed from industrial countries and international agricultural research centers. Starting around

0169-5150/90/$03.50

1980, donors offered short-term project support to strengthen national agricultural research systems (NARS) in Africa. But Africa has one-fifth the number of R&D scientists and engineers per million people as Asia. Moreover, about one-fourth of the total number of agricultural researchers in NARS and academic staff in Faculties of Agriculture in Africa are expatriate. In short, after three decades of independence, Africa has a low level of scientific capacity.

This paper presents some thoughts on building African scientific capacity and strengthening national and regional agricultural research systems (NARS) in sub-Saharan Africa (Africa) over the next 30 years. The thesis of this paper is that since many African countries are generations behind Asian and Latin American countries in terms of their stage of scientific capability and institutional maturity, the short-term project approach currently used by donors to build African scientific capacity should be replaced by long-term institution-building approaches that were effective in Asia in the 1960s and 1970s. But because of Africa's cultural and institutional diversity, no single model of institution-building should be imposed on Africa. Moreover, because of the differential stage of development among African countries, institution-building approaches that are effective in middle-income countries such as Zimbabwe and the Cameroon, will have to be modified for countries at an earlier stage of development, such as Guinea, Chad, Burundi, Somalia and Uganda.

The performance and sustainability of NARS will be examined over two 30-year periods: the colonial period from 1930 to 1959 and post-independence from 1960 to 1989. This historical assessment raises some longer-term issues to ponder in strengthening NARS over the coming 30 years, 1990–2020. Finally, some of the implications are explored for African states, and donors.

African development context

In 1957, Ghana, formerly the Gold Coast, attained its independence amid an outpouring of joy and high expectations. Three years later, 17 additional countries won their independence, thus explaining why 1960 is often referred to as the date of Africa's independence. Today, 45 countries totaling around 500 million people make up sub-Saharan Africa. But despite the euphoria accompanying independence in the late 1950s and early 1960s, there has been a fundamental mismatch between the enormous physical production potential of Africa and the capacity of African governments to achieve their economic aspirations. Africa's poverty is captured in a single statistic: the total GNP of the 45 countries in sub-Saharan Africa in 1985 was slightly less than the total GNP of Spain, a nation of 40 million (World Bank, 1987a).

African states are generally small in terms of population. Half of the 45 countries have fewer than 5 million people, pointing up the need to examine

how NARS in these countries can pursue what Emil JAVIER calls "intelligent borrowing" as the primary strategy for acquiring new technology. Intelligent and systematic borrowing of technology is the hallmark of the dynamic economic growth of Japan, Singapore, South Korea and other countries, including The Netherlands, where currently about half of the technology used by farmers is imported. Nevertheless, there is a view in some scientific circles in Africa that borrowing is an inferior technological path.

The stage of institutional development of African states relative to Asia and Latin America is a sensitive topic that was shunned in the early years of Africa's independence in the 1960s and 1970s and is slowly starting to be discussed openly. For example, the respected Africanist, Colin Legum, recently observed that as colonial powers withdrew from the continent in 1960, they "left behind them a series of national states, but very few nation-states. The level of development of the continent's nation-state was still roughly equivalent to that of Europe or China in the fourteenth and fifteenth centuries – and certainly no later than the seventeenth century" (Legum, 1985, p. 24).

The early stage of Africa's development is limiting the amount of foreign aid that can be currently absorbed with integrity. Most donors are ignoring the differing stage of institutional maturity of individual African states as they prepare standard 5–7-year projects to strengthen NARS and national extension services. Moreover, these short-term projects are invariably 'front-loaded' with quick-disbursing activities such as buildings, vehicles, and equipment.

A few studies are starting to document the scientific and institutional gap between Africa, and Latin America and Asia (Lele and Goldsmith, 1989). For example, Shapiro (1985) has shown that Africa has about one-fourth the number of scientists, engineers and managers per million people as Asia. Two-thirds of the villages in India were electrified in 1987 as compared with a small fraction in most African countries. Sri Lanka and Sierra Leone both had per-capita incomes of $330 in 1983, but the life expectancy was 69 years in Sri Lanka as compared with 38 years in Sierra Leone (Behrman et al., 1988). There are written records of farmer irrigation associations in Thailand dating back 600 years (Surareks, 1986). By contrast, farmer irrigation associations are in their infancy in Africa because only 3–5% of the cropped land is under cultivation as compared with 30–50% in Asia. A recent study of 25 World Bank-financed agricultural development projects in East Asia, Latin America and Africa points to substantial differences in the sustainability of agricultural projects by continent. The study reveals that all of the ten projects in Latin America and Asia were considered economically sustainable, compared with only two of the 15 projects in Africa (Cernea, 1987, p. 4). These findings suggest that donor-financed agricultural projects, including support to NARS in Africa, should be designed differently than those in Asia and Latin America. But, Africa's scientific and institutional gap should be expected

because it is partially the inexorable outcome of a century of colonial underinvestment in developing Africa's scientific and managerial capacity. Also, it should be kept in mind that most African countries have been independent for barely 30 years relative to 150 years in Latin America.

Institutions, sustainability and African development

In this paper, I have used a broad definition of institutions to include institutions and organizations and the rules and conventions that govern them. Over the past two decades, there has been a lack of hard analytical and empirical research on the economics, financing and sustainability of strategic national agricultural institutions, such as NARS and extension services. For example, to date there is not a single published study of the economics of investment in agricultural research for any NARS in sub-Saharan Africa. As a result, feasibility teams are forced to use rate of return estimates from studies in Asia and Latin America to justify donor investments in commodity research, FSR projects and NARS in Africa. But this should not come as a surprise. The late Gunnar Myrdal reports that when he was carrying out research for *Asian Drama* in the 1960s, the most difficult issue was learning how "to deal with the political issues of changing institutions, which were then, as now, avoided by most ordinary economists in their writings on development" (Myrdal, 1984, p. 154).

Nevertheless, the study of institutions is growing in popularity among economists. In a 20-year investigation of the economic development process in 23 countries over the 1850–1914 period, two scholars recently concluded that "institutions mattered most in distinguishing between country groups experiencing more successful and less successful economic development" (Morris and Adelman, 1988, p. 209). The authors concluded that "diversity in growth, diversity in institutions and diversity in applicable theories were the hallmarks of the process of nineteenth century development." Glenn L. Johnson contends that "institutional limitations are presently the most serious constraining factor" on agriculture in the developed, newly industrialized and developing countries (Johnson, 1989, p. 177).

Sustainability came of age with the publication of *Our Common Future*, commonly known as the Brundtland report (World Commission on Environment and Development, 1987). But to date, there has been little debate on the determinants of sustainable agricultural institutions in Africa. A sustainable NARS must meet three basic requirements. First, a sustainable NARS must be able to meet a performance test: the ability to plan and implement national research programs and develop improved technology in an efficient manner. Second, a sustainable NARS must have the capacity to change and adapt in order to meet the evolving research needs of its clients and stakeholders over

time. Third, a sustainable NARS must institutionalize the capacity to generate domestic financial support and develop a stable cadre of national scientists to carry out its research mission in line with evolving priorities.

The hard core knowledge base on how to strengthen institutions such as NARS, extension services and faculties of agriculture in Africa is woefully inadequate. Research is urgently needed on the causes of the widespread failure of parastatals and the poor performance of national research and extension services (Eicher, 1982; Lipton, 1988). But research should also examine why some agricultural institutions are strikingly effective such as the Kenya Tea Development Authority that serves 150 000 smallholders, the Zimbabwe Smallholder Cotton Marketing Board, the Botswana Meat Commission, West Cameroon Coffee Cooperative Union, and the Mali Sud Cotton Project that serves 70 000 smallholders. These success stories should be carefully studied to draw lessons for institution building in the 1990s.

Three decades of independence have produced a large knowledge base on why many foreign aid-financed agricultural and rural development projects are not performing well at this early stage of Africa's economic history and institutional fragility (Cernea, 1987; World Bank, 1987b, 1988d; Eicher, 1989). There is consistent evidence that human capability and institutional barriers to development have been skirted in the drive to increase foreign aid flows to African agriculture – especially during the rapid build-up of aid for direct action projects over the 1973–83 period. Starting around 1983, the foreign aid pendulum swung from project to policy-based lending. But regardless of whether the focus was on project or policies, the end result has been the same: the long-run human capability, scientific and institutional and social organizational issues – the prime movers of agricultural development – are being seriously neglected by both African policy makers and donors. There is a need for a fundamental reexamination of the assumptions about Africa's stage of economic history, the differential levels of development of various African states, absorptive capacity, recurrent costs and strategies for building African capacity in research, extension, and training.

The longer one works in Africa, the more one is forced to conclude that a human capability/institution building model of development should replace the long term technical assistance and overseas training model. The shortcomings of the technical assistance model are painfully apparent in Somalia. A recent joint UNDP/IBRD technical mission dug deeply into the mode of delivering foreign aid to Somalia, a country riven with clan wars and a century or two behind most Asian countries in terms of its level of scientific, institutional, and administrative maturity. The mission reported that donors were collectively pumping US$100 million into Somalia each year to support 1200 expatriates on technical assistance contracts to various government agencies

and overseas training for Somali nationals (UNDP and IBRD, 1985).[1] Nevertheless, this revolving door model of foreign advisors and overseas training is not achieving the ultimate objective, "the development of national capacity through the permanent transfer of skills and know-how to Somali nationals and national institutions" (UNDP and IBRD, 1985, p. 2). Without question, the model is not addressing the long-term problem of developing sustainable Somali institutions.

We shall now examine Africa's colonial agricultural research history from 1930 to the eve of independence in 1959.

Agricultural research during the colonial period: 1930 – 1959

National agricultural research services

A skeletal agricultural research infrastructure was established in most countries in Africa during the first two to three decades of this century.[2] A few countries such as the Sudan launched research programs immediately following World War I (Idris, 1969). By 1930, small groups of researchers were at work on export commodities, but food crop research included sorghum in Uganda, maize in Zimbabwe and Kenya, rice and cassava in Zaire, and rice in anglophone and francophone West Africa. In most countries, a few scientists worked on specific crops in a loose organization which was more modest than present-day national agricultural research systems. The exception was the massive Belgian research operation in Zaire (formerly the Belgian Congo).

The creativity and productivity of NARS during the colonial period can be illustrated through historical sketches of research in Zaire, Zimbabwe and Kenya over the 1930–59 period. In Zaire, about two-thirds of the budget of the Belgian-financed national agricultural research service (INEAC) was focused on export crops and one-third on food crops.[3] Research on oil palm was launched in 1933 with the goal of developing a high-yielding palm to replace the tall, low-yielding wild palm that grew in the bush in West and Central Africa. In 1939, after only 6 years of research at the INEAC station at Yangambi in northern Zaire, a team of five colonial researchers unlocked the genetics of the oil palm that led to the development of hybrid varieties that out-yielded wild

---

[1] About US$90 million was spent on the 1200 long-term advisors and about $10 million on overseas training in 1985.

[2] Colonial research in anglophone countries is chronicled by Jeffries (1964), McKelvey (1965) and Masefield (1972).

[3] Professor Eric Tollens, Catholic University of Leuven in Belgium is carrying out a study of the return to Belgian investment in research on eight commodities in Zaire from 1933 to 1959.

palms by several hundred percent under farm conditions (Beirnaert, 1940; Tollens, personal communication, 23 July 1988). The oil palm research at INEAC had large regional and international spillover effects which laid the foundation for the modern oil palm industry in Cote d'Ivoire (formerly the Ivory Coast),[4] Nigeria (Eicher, 1967), Malaysia (Hartley, 1970), and Indonesia. Research "spillovers" refer to the benefits from research which accrue to farmers and consumers in countries that import technology without paying for the cost of its development.

INEAC's rice research also demonstrates the regional spillover effects of a technology-producing national agricultural research system (TP/NARS). In 1958, INEAC released an upland rice variety, O.S.6, after 6 years of breeding. Although O.S.6 is not grown in Zaire, it remains one of the dominant upland rice varieties in West Africa 30 years after its release. O.S.6. is grown under different local names in West Africa and it accounts for about 90% of the upland rice currently grown in Nigeria. In summary, the INEAC research program in Zaire illustrates the vast potential of national research services in Africa to produce new food and export crop technology for local needs as well as the needs of surrounding technology borrowing (TB) NARS.

The NARS of Zimbabwe is the second example of the creativity of a national research system in Africa. Hybrid maize development in Zimbabwe from 1932 to 1960 represents a textbook example of a NARS in Africa producing new technology without relying on imported germplasm. In 1932, H.C. Arnold launched a maize improvement program in Zimbabwe (then Southern Rhodesia) followed by A.G.R. Rattray in 1938. In 1949, 17 years after research was initiated, the first hybrid, SR-1, was developed by crossing two locally bred open-pollinated varieties, Southern Cross and Salisbury White. But SR-1 was not released to farmers because yields were low and research continued from 1949 to 1960 in a search for higher-yielding hybrids. In 1960, SR-52 (Southern Rhodesia-52), a single-cross hybrid, was released to commercial farmers after 28 years of research on hybrids (1932–1960). Looking back over the past six decades of research on food crops in Africa, the SR-52 white maize hybrid is undoubtedly the Green Revolution food crop success story in Africa (Eicher, 1984). Although the size of the maize research program in Zimbabwe has been small (two to four researchers), the program is known for its continuity, its scientific and administrative leadership and its productivity.[5] Zimbabwe's ex-

[4] In 1947, the French established the Institut de recherche pour les huiles et oleangineaux (IRHO) to carry out research on oil palm. Cooperation between INEAC and IRHO scientists played a critical role in developing the modern oil palm industry in Cote d'Ivoire (Drachoussoff, 1965).

[5] A.G. Rattray served as director of maize research from 1938 to 1968. Zimbabwe's maize research program has been directed by four scientists over the past six decades (1932–1989).

perience also illustrates the extensive spillover effects of a technology producing NARS (TP/NARS). SR-52 maize seed has been sold as far north as Ethiopia, as far west as the Cameroon, and as far south as the Republic of South Africa.

In Kenya's national agricultural research system, it took Michael Harrison and his maize team only 9 years (1955–1964) to develop a high-yielding hybrid maize variety by crossing a local variety with a variety imported from Ecuador. Kenya's experience illustrates the potential of importing germplasm and underscores the need for NARS in Africa to develop the high level of technical capacity required to pursue a strategy of "intelligent borrowing" of technology from neighboring countries and the global system.

Regional research institutes

Regional research institutions were introduced during the colonial period to deal with the small country problem and stimulate the production of export commodities for European markets (Kyomo, 1988). In 1930, Ghana was the world's largest cocoa producer, but the industry was plagued by insect and disease problems. To deal with these problems, in 1938 the British colonial service established a Cocoa Research Institute at Tafo to serve Ghana. The Institute carried out highly successful studies of controlling several cocoa diseases, including swollen shoot virus, capsid and black pod. Spraying programs based on these research findings were instrumental in boosting Ghana's cocoa production to a peak output of 520 000 metric tonnes in 1965 (Martinson et al., 1987).

In 1944, the Cocoa Research Institute of Ghana was renamed the West African Cocoa Research Institute (WACRI) and given a mandate to serve the British colonies of Ghana and Nigeria. The WACRI staff in 1944 was composed of 15 British scientists. WACRI had a productive life span of 18 years but in 1962, 5 years after independence, the government of Ghana dissolved WACRI and set up the Cocoa Research Institute of Ghana (CRIG). In the shift from a regional to a national mandate, twelve expatriate staff resigned, leaving seven local professional staff and 25 vacancies at (CRIG). The number of Ghanaian scientific staff increased slowly to eleven (of 17 total) in 1970 and to 25 by 1985. The mandate of CRIG was expanded in 1975 to include coffee, kola, and shea nuts.

But the Cocoa Research Institute of Chana (CRIG) has been buffeted by changing government decisions on its administrative home. For example, CRIG has been administered by the following six organizations from 1962 to 1989:

- National Research Council
- Ghana Academy of Sciences,
- Council for Scientific and Industrial Research (CSIR)

- Ministry of Cocoa Affairs
- Ghana Cocoa Marketing Board, and
- Ghana Cocoa Board.

CGIG has been reshuffled on the average of once every 4.5 years. No scientific organization can flourish in an environment of such organizational turmoil.

We now turn to oil palm research in West Africa. Nigeria was the world's leading producer of oil palm during the colonial period and in 1939, the British colonial government established the Nigerian Oil Palm Research Station in Benin in order to meet the growing challenge of oil palm production on plantations in the Far East. In 1951, the British converted Nigeria's oil palm station into the West African Institute for Oil Palm Research (WAIFOR), with a mandate to serve the British West African territories of Nigeria, Ghana, Sierra Leone and the Cameroon. In the 1950s, WAIFOR was a highly productive regional research organization with a scientific staff of 16 senior officers (WAIFOR, 1955–56).

Soon after Nigeria became independent in 1960, the new government decided to nationalize WAIFOR and rename it the Nigerian Institute for Oil Palm Research (NIFOR). During the 1962–64 transition period, ten of the 15 research officers left the Institute. When NIFOR was formally established in 1964, it had a staff of ten senior officers and the number increased slowly to 15 in 1970. Nigeria's oil boom of the 1970s provided funding for a quantum jump in NIFOR's staff from 15 senior officers in 1970–71 to 283 in 1985 (NIFOR, 1965–66, 1970–71, 1985).

But today, NIFOR is not performing well. Most of NIFOR's budget is used to pay the salaries of its vast administrative, scientific and support staff. Only about 1/3 of its 283 senior staff are directly engaged in research while the other 2/3 are in administration, support services, social services and revenue generating activities. NIFOR's research mandate has been broadened beyond oil palm to include date palm, raphia, coconut and other palms. But in 1985, only 48 scientists were working on the key crop – oil palm – while 64 out of the 283 senior officers were administering the Institute. NIFOR is also starved for foreign exchange to purchase equipment and supplies. In summary, NIFOR is top heavy with administrative staff and it has a mandate resembling a government development corporation. Many specialists believe that oil palm research in Nigeria is less productive today with 283 senior officers than when it had 15 from 1955 to 1970.

The stagnation of cocoa and oil palm research in Ghana and Nigeria stands in sharp contrast to the experience of Malaysia and Indonesia. In 1925, Malaysia established the Rubber Research Institute of Malaysia (RRIM) and concentrated its national research effort on rubber for four decades. Malaysia became independent in 1957, the same year as Ghana, but Malaysia chose the agricultural road to development while, under Nkrumah, Ghana opted for the

industrial path. In the late 1960s, Malaysia embarked on a massive agricultural diversification program away from rubber by establishing the Malaysian Agricultural Research and Development Institute (MARDI) in 1971. Malaysia drew on Zaire's pioneering research on hybrid palms (Beirnaert, 1940) and over time developed hybrids suitable for Malaysian conditions. In 1978, oil palm research was spun off from MARDI into a new institute, the Palm Oil Research Institute of Malaysia (PORIM, 1985). Malaysia is also planning to spin off cocoa research from MARDI and set up a separate cocoa research institute with the goal of around 100 scientists and technicians. Malaysia increased its agricultural research staff from 100 officers at independence in 1957 to 1000 today. Malaysia's highly productive research system has helped diversify its export base, and Malaysia is now routinely selling palm oil to Nigeria. Ghana's per-capita GDP of $390 in 1986 stands in sharp contrast to $1830 in Malaysia.

Nigeria and Ghana have dissipated their research base for oil palm and cocoa and lost world market shares to Malaysia and Indonesia. Restoring the competitive position of oil palm and cocoa research will require more than increased financial assistance from donors. Many basic political, managerial and scientific problems are plaguing export crop research in West Africa. These problems must be addressed by Africans at both the political and scientific levels.

But in francophone Africa several regional research programs are still performing well. One of the most successful is the CFDT/IRCT network that supports cotton production and marketing in ten countries in francophone Africa.[6] Cotton research is carried out by a cadre of about 100 IRCT researchers in France and in francophone Africa.[7] In nine of the ten francophone countries where data are available, average cotton yields increased four-fold over the 20-year period, 1963–1982 (Dequecker, 1983). The CFDT is a private cotton management and extension organization with four decades of experience in Africa. The World Bank recently evaluated the CFDT/IRCT model in Burkina Faso, Cote d'Ivoire, and Togo – and concluded that it is a "striking success" when compared with other agricultural development projects in Africa (World Bank, 1988b, p. 29). Lele et al. (1989) reports that phasing out regional cotton research and extension programs in anglophone Africa in the 1970s is partially responsible for the slow growth in cotton production in anglophone relative to francophone Africa over the past 15 years.

---

[6] Institut de Recherches de Coton et des Textiles Exotiques (IRCT). Compagnie Francaise pour le developpement de fibres textiles (CFDT).

[7] In 1986, the IRCT network of 105 scientists was composed of the following: 26 researchers in France, and 40 expatriates and 39 national cotton researchers in the ten main Francophone cotton growing countries in Africa.

Five lessons from the colonial research experience

Colonial research included many failures such as the inability to achieve breakthroughs in sorghum and millet after six decades of research, underinvestment in training African scientists and the pursuit of inappropriate research strategies in many land abundant countries (Carr, 1982; Binswanger, 1986). But despite these shortcomings, there were some stunning successes in organizing, financing and executing colonial research that have relevance for contemporary agricultural research policy in Africa:

1. Small commodity research teams. In most cases, three to four scientists, and in a few cases, no more than half a dozen scientists, formed the commodity teams of TP/NARS that produced hybrid maize in Zimbabwe and Kenya, rust-resistant wheat in Kenya, improved tea clones in East Africa, cotton in Uganda, and improved soybean and cotton varieties in Zimbabwe.

2. Creativity of technology producing NARS (TP/NARS). During the colonial period, numerous countries demonstrated the creativity of national agricultural research systems in producing new technology.[8]

3. Borrowing technology. Borrowing technology is a proven colonial research strategy. The tea industry in Eastern Africa drew heavily on imported clones from Sri Lanka and India. Zimbabwe's SR52 maize seed was borrowed by a dozen African countries.

4. Research spillovers: Regional, Pan African, and international. Research spillovers from TP/NARS and regional institutes are illustrated by hybrid oil palm, hybrid maize, cotton and other commodities. For example, Cote d'Ivoire, Nigeria, Malaysia, and Indonesia borrowed the basic breeding strategy for hybrid oil palm from Zaire and used it to develop hybrids for local conditions. The spillover issue should be explicitly incorporated in feasibility studies to strengthen NARS in the 1990s.[9]

5. Regional research: Efficient but dependent upon external financing. Regional research was pursued to serve the large number of small colonies. It was highly efficient because of its concentration on a few commodities, assured overseas funding, and its continuity of administrative and scientific leadership. Examples of successful regional research include the East African

---

[8] For a summary of 48 years of cocoa research in Ghana, see (Martinson et al., 1987).
[9] Most feasibility studies of NARS devote little attention to research spillovers and the interaction of NARS in a subregion. For example, see Mali (1988) and Niger (1988).

Agricultural and Forestry Research Organization (EAAFRO), the Federation of Northern Rhodesia (now Zambia), Southern Rhodesia (now Zimbabwe) and Nyasaland (now Malawi), and the West African commodity research institutes (cocoa, oil palm, rubber, rice).

Agricultural research since independence: 1960 – 1989

The collective experience of NARS in the first three decades of independence can be analyzed under five topics:

Political turmoil, destruction of institutions, and the brain drain. At independence, the institutional base of African agriculture was geared to supporting large farms, plantations, ranches and export agriculture. The 1960s and 1970s were marked by the destruction of many of the inherited regional and national research institutions. Soon after independence, for example, Guinea and Madagascar terminated the services of French research assistance. In 1962, Nkrumah abolished Ghana's national extension service. Tanzania abolished local government and farm cooperatives in the mid-1970s. Numerous training institutions, such as Makerere University in Uganda, were devastated during internal political upheavals.

The localization and basic restructuring of agrarian institutions to serve the majority of rural people is now underway throughout Africa. Anglophone countries such as Nigeria, Kenya, Ghana, and Tanzania have achieved substantially greater progress in the nationalization of their NARS and Faculties of Agriculture than francophone countries. For example, after 29 years of independence, Cote d'Ivoire has 73% of its agricultural research and teaching posts filled by expatriates as compared with 6% in Ghana and none in Nigeria (Pardey and Roseboom, 1989). This is a puzzle that warrants further analysis and debate at the political and technical levels.

Without question, one of the underreported events limiting African agriculture today is the agricultural brain drain that has been fueled by coups, civil wars and political unrest. For example, Ghana, Ethiopia, Uganda, Somalia, Tanzania, and Zambia have been stripped of agricultural scientists and teachers through the brain drain.

Unbridled growth of the state bureaucracy. Thirty years of independence have been marked by an increase in the state machinery serving agriculture:

- Sub-Saharan Africa started independence in 1960 with a profound extension bias of 21 200 extension agents and 1329 researchers. This bias was intensified as African states hired an additional 36 000 extension agents over the next 20 years (Judd et al., 1987, pp. 11–13).

- The Congo increased the size of its extension staff ten-fold from 1960 to 1972 (Young, 1988, p. 26).
- In Ghana, the Cocoa Marketing Board employed 105 000 in the early 1980s to handle a crop half as large as that which 50 000 employees had managed in 1965 (Young, 1988).
- In Nigeria, the national agricultural research service expanded from 100 researchers in 1960 to around 1000 today (Pardey and Roseboom, 1989).

In many cases, the expansion of the state institutions has been accompanied by an erosion in the performance of the institutions, with the bulk of the budget used to pay salaries (Abernethy, 1987).

The Green Revolution footprint. The Green Revolution has achieved the impact of a small footprint on Africa's rural landscape. Dalrymple (1986a, b) reports that the total area of modern wheat and rice varieties under cultivation in sub-Saharan Africa in 1983 was about 800 000 ha (wheat 556 000 and rice 242 000 ha) which is roughly equivalent to one-quarter of the annual cropped area in Zimbabwe, one of the 45 countries in Africa. Since the Green Revolution has barely touched Africa, African leaders and the donor community must face up to the reality that the CGIAR and French research networks have not delivered the volume of new food crop technology that many experts had implicitly promised when the first CGIAR center IITA, was established in Ibadan some 20 years ago. Three lessons flow from the limited impact of Green Revolution in Africa to date. The first is the need to strengthen the capacity of NARS to develop new technology and supplement the efforts of the CGIAR, CIRAD and the global research system. The second is to strengthen the capacity of NARS to become more efficient borrowers of technology from neighboring countries and the global research system. The third is the need for the CGIAR to reexamine its strategy of strengthening the capacity of the NARS of Africa.

Foreign aid buildup for NARS. In the 1960s and 1970s, donors invested heavily in developing the CGIAR global system, including four IARCs with their headquarters based in Africa. In 1980, the CG system launched a new institute, ISNAR, to help strengthen national agricultural research systems. During the 1980s, donors channeled investments to the NARS of Africa. The World Bank took the lead in co-financing a large loan for the NARS of Sudan in 1979 followed by loans to Senegal, Rwanda, Malawi and other countries in the early 1980s. The loans by the Bank and other donors to African NARS in the 1980s are noted for their conservative time frame (typically 5–7 years), support for a large number of commodities (e.g. 17 in the World Bank Project for Rwanda), quick disbursing activities such as buildings, equipment and vehicles, farming systems research (e.g. Senegal, Rwanda and Sudanese proj-

ects) and insufficient attention to the crucial issues of human and financial sustainability (Eicher, 1982b; 1989).

What flows from the record of donor-financed projects for African NARS during the 1980s is the inescapable conclusion that the interrelated issues of the size, performance and sustainability of NARS are not being addressed by African policy makers, NARS and donors. Today, most NARS do not have the institutional, managerial and financial capacity to absorb current levels of project aid "with integrity" and to sustain the project activities after foreign aid is phased out. But this problem is not restricted to NARS. In some subregions such as the Sahel, foreign aid officials are reluctant to discuss the financing of recurrent (operating) costs of institutions because it is assumed that donors will be paying some of these costs for the indefinite future – perhaps for another generation or longer.[10]

Sustainability: the Achilles heel of NARS and regional institutes. Soon after independence in the late 1950s and early 1960s, virtually all regional research institutes in anglophone Africa were phased out with the exception of the Tea Research Foundation of Central Africa, a private research institute based in Malawi that was originally set up to serve tea estates in the region. But the Foundation has received some donor support for several decades (R.T. Ellis, personal communication, 8 August 1988). In francophone Africa, several impressive regional research networks are still in operation such as the ten country CFDT/IRCT cotton research, extension and international marketing network.

Today, after three decades of independence, many NARS and regional research systems are performing poorly, and are heavily dependent upon foreign aid. In fact, Zimbabwe has one of the few NARS in Africa that is basically financed from national sources and staffed by local scientists. The issues surrounding the human and financial sustainability of national and regional research systems call for in depth research and critical debate in the 1990s.

---

[10] The recurrent cost problem is basically the inability of an African government to pay for the operating costs of an institution or service such as a NARS (Howell, 1986). Most feasibility studies of NARS ignore the recurrent cost problem or assume it away by unrealistic assumptions about the ability of an institution to gain special budget support from the Ministry of Finance. For example, a recent feasibility study of the NARS in Niger, assumed that the Ministry of Finance would increase the real budget for INRAN, the NARS of Niger, by an average of 7% per annum in the 1990s (Niger, 1988).

Scientific capacity building: 1990 – 2020

Drawing on Africa's research experience over the past 60 years, the following issues emerge for debate on strengthening national and regional agricultural research systems over the next 30 years:

Geopolitics of science and technology for agricultural development. The central question to be addressed by African states, scientists and the international community in the 1990s is the following: How can African nations of varying sizes organize themselves to become more technologically proficient? The present donor-financed project by project and country by country approach to building African scientific capacity is seriously flawed. The road ahead requires a vision of the evolving role of science and technology in Africa's rural transformation over the next 25–50 years. There is an urgent need for the NARS, the Special Program for African Agricultural Research (SPAAR) and the major donors to develop a long term geopolitical and coordinated approach to scientific capacity-building in Africa. But the foundation for this new vision of the role of science and technology in Africa development must be rooted in Africa and must flow from Africa's historical, cultural, technical, and political experience. For example, Professor Thomas Odhiambo of Kenya contends that African "agricultural research leadership, in concert with the geopolitical leadership, must create and nurture an environment that encourages research entrepreneurship and invigorates technological innovation" (Odhiambo, 1988, p. 48). African scientific capacity-building should also include long-term international financial support for regional research and MSc training institutions (because of the small country problem) for at least the next 20–30 years.

Payoff to coordinated investments in research, extension and training. Most studies reporting high rates of returns to investment in agricultural research in Asia and Latin America and industrial countries are, in fact, joint returns to investments in research, extension and training. The payoff to a coordinated set of investments to strengthen the institutional base (research, extension, and training) for agriculture is captured in a pioneering study of U.S. agricultural research by Evenson, Waggoner and Ruttan (1979). The authors found that the highest payoffs to research came from a coordinated set of interactive investments to further the decentralization of research and the promotion of research-extension linkages. The conclusion that flows from this study is the need to shift the debate from strengthening research to the coordination of investments in research, extension and training (Bonnen, 1987). The issue for donors to ponder in the 1990s is the following: what national and regional mechanisms need to be developed to strengthen the coordination of research, extension and training institutions in support of African agriculture?

Strength in diversity of institutional approaches. Africa's experience since 1960 has illustrated the diversity of institutions, the strength in this diversity and the need to foster diversity in the future. For example, despite the failure of regional research systems in anglophone Africa since 1960, the French directed CFDT/IRCT multi-country cotton model is performing well in francophone Africa. On the other hand, Zimbabwe's vertically integrated cotton research, production and extension model is thriving without scientific assistance from an industrial country such as France. The spectre on the horizon that should be confronted is the World Bank's drive to promote one extension model – T&V – throughout Africa, a model promoted by the World Bank in 32 of Africa's 45 countries.

Agricultural research investment norms and priorities. How much should African states spend on agricultural research? Presently, most donors follow the guideline that a desirable agricultural research investment target would be in the range of 0.5–2.0% of the total national value of agricultural GDP. The World Bank has argued that a desirable investment target for research for many countries would be an annual expenditure (recurrent, plus capital) "equivalent to about 2 percent of agricultural gross domestic product" (World Bank, 1981, p. 8). But this norm is derived from industrial countries with a century or more of experience in mobilizing political and financial support from farm organizations, commodity groups, private firms and state and federal organizations. There is little empirical information from Africa on the pay off to investing 0.5–2.0% of agricultural GDP in research. There is, however, enough historical and anecdotal evidence to conclude that some of the recent pronouncements on the level of investment in NARS should be taken with a grain of salt. For example, Dayanatha Jha recently concluded that there is "substantial underinvestment" in agricultural research in Africa because 14 countries were spending less than 0.5% of their agricultural GDP on research (Jha, 1987, p. 267). But the ready availability of foreign aid in the 1980s has led to an overinvestment in some NARS relative to their current stage of institutional maturity, absorptive capacity, scientific leadership, projected government revenues, and political support to maintain the NARS after foreign aid is phased out. For example, it is usually easier for the administrator of a NARS to mobilize an additional million dollars of research support from donors than from domestic sources. Although Vernon Ruttan (1987) has repeatedly stressed the need to tie incremental donor funding for NARS to matching funds from the recipient government, in practice, donors are reluctant to enforce this common sense approach.

The agricultural research investment norms derived from the experience of advanced countries, either capitalist or socialist, can be used as rough guides but not as decision rules for donors and African states. If foreign aid is

allocated to NARS in Africa according to the 1–2% investment norm, it may inflate the size of the NARS (staff, buildings, and equipment) beyond the capacity to mobilize domestic political and economic support to sustain it over time. The question of how much to spend on agricultural research in Africa in the 1990s should be pursued through empirical research on African NARS.

Size, priorities and performance of NARS. The size of many NARS has increased dramatically since independence in 1960. Four factors help explain the growth of NARS and why this growth has often been at the expense of the quality of the research program. First, since independence, as part of the normal expansion of the state bureaucracy, many NARS have increased the number of scientists, technicians, buildings, equipment, research stations, research projects, and operating budgets beyond the ability to sustain these activities from national budgets. In many cases, this expansion has outstripped the capacity of local research administrators to restrict the number of research problems addressed, manage the national research enterprise, pay staff on time, plant experiments on schedule, and mobilize political and bureaucratic support from the Ministry of Finance to finance and sustain the system after foreign aid is phased out. For example, Nigeria's petroleum boom has fueled the expansion of its NARS from around 100 scientists at independence in 1960 to 1000 in 1989, but the research system is starved for operating funds. Professor Francis Idachaba, Vice Chancellor of the University of Agriculture, Makurdi recently reported that "Research management probably constitutes the most important constraint on Nigeria's National Agricultural Research System" (Idachaba, 1987, p. 351).

Second, many NARS have been under intense political pressure to absorb new university graduates. In Kenya, for example the NARs has been under pressure to go beyond the normal practice of hiring agricultural graduates to accepting some of the burgeoning number of science graduates from the university system, a system that has grown from one university in 1970 to five in 1989.

Third, donors have directly and indirectly contributed to the increase in the size of NARS. For example, donors are currently paying a substantial share of the recurrent budget of the national agricultural research systems in Mali, Ghana, Senegal, Niger, Zambia, Rwanda, and many other countries. It is almost impossible to cite a donor feasibility study that recommends reducing the size of a NARS and concentrating on upgrading the quality of the present research staff and the relevancy of its research program. The fourth factor contributing to the growth of NARS is the lack of institutional mechanisms to finance regional research institutes.[11] As a result, there is duplication of research programs in neighboring NARS.

---

[11] For a discussion of federal/state financing of research in the U.S. federal system of government, see Schweikhardt (1989).

These examples illustrate how national scientific, political and bureaucratic interests have interacted to inflate the size of many NARS and enabled the directors of NARS to postpone some of the tough decisions on priorities in terms of the number of scientists, number of research stations and number of research projects. The ready availability of foreign aid has served an "escape valve" for local administrators who are often inexperienced and unwilling to take the hard scientific and financial decisions on size and priorities. In summary, many African countries are making some of the same mistakes that Asian and Latin American countries made in the 1960s and 1970s when the emphasis was placed on expanding the size of NARS to the point where there were many research facilities and researchers "without programs" (Ruttan, 1987, p. 78).

Strategies for scientific capacity building. The preparation of an Africa-wide strategy to strengthen African scientific capacity would be a paper exercise because the continent is too big, complex and hobbled with colonial legacies to be captured in a single strategy. For example, the political forces and colonial legacies at play in a subregion such as southern Africa are much different from those in the Sahel. For these reasons, there is an urgent need for African scientists to take the initiative in preparing a subregional strategy to strengthen the core national agricultural services – research, training, and extension – in each of the five major agroecologies: the Sahel, Coastal West Africa, Central Africa, Northeast Africa and Southern Africa. Each subregional strategy should incorporate technology producing (TP) NARS, technology borrowing (TB) NARS, projected research spillovers, research networks and post graduate training. The pioneering work of SACCAR in Southern Africa serves as a model for developing an African scientific perspective on subregional research and post graduate training priorities in agriculture. The need to foster research in African faculties of agriculture is necessary because local post graduate training must be research-based. If the cycle of overseas training is to be broken, there is a need for coordinated investments in developing both national and regional capacity in research and post graduate training.

Restoring the primacy of commodity-based research. During the colonial period, long-term, highly focused research on a single crop such as cotton, groundnuts, cocoa, oil palm, or maize, was successful in producing new technology that was relevant to African conditions. But many NARS and donors have ignored this experience and have spread their support for research over a large number of commodities and promoted a diffuse research effort. For example, until 1985, USAID was supporting research on 28 commodities in Africa but it subsequently reduced the number to eight (USAID, 1985). A

World Bank-financed project in Rwanda endorsed research on 17 commodities. In Malawi donors supported the national research system in the 1980s but instead of concentrating on maize, the staple food, "donors were mainly concerned with institution building, training and methodology (increased on farm trials, farming systems research etc.) . . . this dominant "process orientation" allowed, by default, the continuation of a diffuse research effort" (Kydd, 1989, p. 140). Over the past decade, research networks have been aggressively promoted by donors and farming systems research (FSR) was often given priority over commodity research. Africa is now saturated with research networks and FSR is now in decline. African research administrators are seeking to find a better balance between commodity and farming systems research. The key issues in the FSR debate are striking the proper balance between the number of commodity and FSR scientists, budget allocation to commodity research, FSR and research networks and strengthening the linkages between these activities. A strategic priority in the 1990s is strengthening national commodity research teams of four to twelve scientists per team to carry out research on a few priority commodities. In some countries, one commodity team should be strengthened while in others three to four commodity teams will be required. Both on-station and on-farm research should be carried out by the commodity teams. Both are hallmarks of a modern national research system.

Strengthening technology generating NARS. Each subregional strategy to strengthen agricultural research in the 1990s should start with the premise that the 45 NARS of Africa should be divided into technology producing (TP) and technology borrowing (TB)NARS.[12] Eight to ten of the larger TP/NARS in Africa (one to two per subregion) should receive long term (20 years) coordinated donor assistance to enhance their capacity to produce new technology to meet national needs and the needs of the surrounding (TB)NARS. In practice, however, most technology producing countries will also borrow technology. For example, Zimbabwe is a TP/NARS but it carries out no tea research because it is cheaper to help finance the Tea Research Foundation in neighboring Malawi and import tea clones from the Foundation.

Improving the capacity to borrow technology. Borrowing technology is a way of life in Asia but it is viewed as an inferior technological option by some

---

[12] USAID's strategy to strengthen Africa's NARS is based on the implicit assumption that countries are at different stages of institutional maturity and that foreign assistance must be tailored to the stage of development, the size of a country and to a nation's absorptive capacity (USAID, 1985). USAID's strategy breaks new ground by dividing the 45 NARS in Africa into eight to ten technology producing (TP/NARS) and the balance into technology borrowing NARS (TB/NARS).

African scientists and politicians. For example, General Obasanjo recently reported,

> "The transfer of technology is an illusion, a catchy phrase conjuring up images of high-level scientific and technical expertise willingly and altruistically handed over in gift-wrapping from the owner in the developed world to us in Africa and the rest of the Third World" (Obasanjo, 1987, p. 31).

But for most countries in Africa, especially the 22 countries with less than 5 million people, the most efficient strategy for acquiring new agricultural technology will be intelligent borrowing from neighboring countries, regional institutes and the global research system. Borrowing technology requires a high level of technical competence to borrow, screen, test and adapt technology to micro environments. A strong case can be made for donors to offer modest support ($300 000 to $500 000 per year) to a large number of TB/NARS for the next 15–20 years to help them enhance their capacity to borrow and adapt technology.

Human resource sustainability of NARS. Many African states, donors and members of the university community maintain that more training is needed to replace expatriates and expand the size of NARS. But this standard prescription was overtaken by events in many countries in the 1980s as agricultural graduates at the certificate, diploma and higher levels found it increasingly difficult to find jobs. In addition, many NARS and universities in Africa are hemorrhaging and losing scientists and teachers as fast as they are trained. For example, the average loss of NARS research officers with a university degree is estimated to be about 7% per year (World Bank, 1988c, p. 18), a rate that would require a NARS to replace its entire cadre of researchers roughly every 14 years. But in some NARS the turnover of scientists is substantially higher than 7%. In a recent study of the NARS of Senegal, ISRA, a total of 18.1% of Senegalese scientists left ISRA in 1987 (Wessen, 1989). Another serious problem is the loss of productive scientists and teachers over 40 years of age. There is an urgent need for a reexamination of the human resource sustainability of NARS. On the one hand, more training is needed to replace the expatriates. But on the other hand, unless the incentive structure is dramatically improved for national scientists and teachers, the agricultural brain drain will continue. And unless selected universities develop strong subregional MSc programs, overseas training at the MSc level will continue indefinitely. Overseas PhD training in most fields of agriculture will be required for another 25–40 years.

Financial sustainability of NARS and regional research systems. The financial sustainability of NARS is a serious problem that is not being addressed by the administrators of NARS, donors or social science researchers. Research

by social scientists is urgently needed on what drives African NARS to stake out a national research program (in terms of the number of scientists, research stations, commodities, problems and geographical coverage) that far exceeds the national financial capacity to support it. Research is also needed on alternative strategies to finance national and regional research systems. Although many regional organizations in Africa have failed, regional research institutions are needed to assist the small countries in Africa improve their capacity to borrow technology from TP/NARS and the global system. SPAAR should carry out a special study of the establishment of an international foundation for strengthening African scientific capacity, including the financing of regional research and MSc training institutions for the coming 20–30 years. The dual objectives of the regional research organizations would be to generate new technology and assist the NARS in small countries increase their scientific capacity.

Guidelines for SPAAR and donors: 1990 to 2020

The agricultural research history of Africa over the past 60 years has shown that building research capacity is an incremental process that extends over a period of decades. This analysis has documented the creativity of numerous national research services and suggests that African governments and donors should progressively strengthen the capacity of NARS to enable them to play the lead role in generating technology in Africa in the future. The CGIAR, CIRAD and other international research organizations should continue to reinforce NARS while, at the same time, moving further upstream to link up with biotechnology centers throughout the world.

The challenge for donors in the 1990s is to move beyond the resource transfer model of financing the construction of buildings and purchasing equipment and vehicles for NARS, and pursue a human capability-institutional building model that is geared to the specific needs of African nations at this early stage of their development. The three hallmarks of the human capability model are:

- the slow, step by step process of improving the scientific and financial management of a NARS;
- upgrading the quality and relevancy of research programs to improve the performance of the institution; and
- developing support from clientele groups to finance, staff and sustain the research system from domestic sources.

Many donors assume that African countries are at a fairly similar stage of political and institutional maturity and that NARS require financial assistance for buildings, equipment, vehicles, and operating costs. But Africa's diversity requires institution-building strategies to be tailored to the specific

stage of a nation's institutional, scientific, and political maturity. The World Bank's proposed Africa-wide strategy for strengthening NARS does not highlight the wide variability in the stage of development among African countries (World Bank, 1988c). But this should come at no surprise because "The World Bank is providing financial but not intellectual leadership in strengthening the institutional base of African agriculture" (Eicher, 1989, p. 26).[13]

The mission of the CGIAR system and the approach that it uses in dealing with NARS in Africa should also be reexamined. When George Harrar, F.F. Hill, and others were laying out the CGIAR system in the early 1960s, they had a limited time horizon of 15 to 20 years in mind for the system. Hill was of the opinion that these new (International Agricultural Research Centers (IARCs) should have continuity of funding from public and private sources for a "sufficiently long period of time to enable them to carry out their assigned missions . . . usually fifteen to twenty years, sometimes longer" (Hill, 1964, p. 152). In the early 1960s, there was a general perception that the early IARCs could be turned over to the host countries in several decades (Ruttan, 1987). But one CGIAR center has celebrated its 25th anniversary, one its 20th, and both are planning programs for the year 2000. In short, the CGIAR system is firmly entrenched and a few scholars such as Vernon Ruttan have argued that the CGIAR system should be given permanent status in the global research system.

But after 20 years of CGIAR activities in Africa, the CGIAR system does not have a feasible plan of action to strengthen Africa's NARS. This is especially troubling because the CG system is spending about 45% of its budget on Africa, a region of 500 million people compared with 800 million in India and a billion in China. Four hard questions about the CGIAR's role in Africa in the 1990s should be addressed:

(1) What constitutes a successful international effort in agricultural research in a subregion of Africa such as the Sahel? Should donor assistance to the CGIAR system be evaluated on the basis of the volume of new technology produced, or on the dual objectives of producing technology and strengthening NARS?
(2) Is the CGIAR prepared to modify its technology generating focus in Africa and develop a dual strategy of generating new technology and strengthening NARS?
(3) Is the CGIAR prepared to rebudget human and financial resources to help improve the capacity and increase the sustainability of NARS?

---

[13] For a critique of the World Bank strategy, see Eicher (1989).

(4) What is the mechanism for bringing France and the CGIAR together to develop a joint action plan to strengthen the NARS in francophone West Africa? (Eicher, 1989).

The Special Program for African Agricultural Research (SPAAR) that was established by donors in 1985 is charged with improving donor cooperation and coordination to strengthen NARS and regional research systems in Africa. Four guidelines for SPAAR and the international donor community flow from this analysis:

(1) The minimum time frame to include in a strategy to strengthen African scientific capacity is one generation, about 25–30 years.
(2) Five subregional plans should be developed to strengthen NARS in Africa.
(3) Feasibility teams preparing donor projects to assist NARS should discontinue using the guideline of investing 1–2% of agriculture GDP in NARS because it is not based on African experience and conditions. The uncritical use of this guideline allows donors to sidestep thorny issues such as recurrent costs, and human and financial sustainability.
(4) Foreign aid should be rationed to TB/NARS in small amounts over the next two to three decades. Donors should agree on making long term coordinated investments in eight to ten TP/NARS over the next 30 years.

The following research topics should be pursued by agricultural economists:

(1) Expost and exante rate of return studies on investment in agricultural research in Africa, including the institutional determinants of these returns (Bonnen, 1987).
(2) Methodologies for setting agricultural research priorities under African conditions.
(3) Financial sustainability of NARS and regional and multi-country research systems such as the CFDT/IRCT cotton research network.
(4) Economics of training and human capital formation.
(5) Institutional performance. There is need to develop new measures of the performance of research institutions over time (Horton, 1986).

Acknowledgements

An earlier version of this paper was prepared while I was on sabbatical leave at ISNAR and released as a Working Paper by ISNAR (Eicher, 1989). I would like to thank The Twentieth Century Fund, the Rockefeller Foundation, and the International Service for National Agricultural Research (ISNAR) for their generous support during my 1987–88 sabbatical leave from Michigan State University. The preparation of this manuscript was supported by the Food Security in Africa Cooperative Agreement DAN-1190-A-00-4092-00 be-

tween the U.S. Agency for International Development (USAID) and Michigan State University's Department of Agricultural Economics.

References

Abernethy, D., 1988. Bureaucratic growth and economic stagnation in Sub-Saharan Africa. In: S.K. Commins (Editor), Africa's Development Challenges and The World Bank. Lynne Rienner, Boulder CO, pp. 179–214.

Behrman, J., Deolalikar, A.B. and Wolfe, B.L., 1988. Nutrients: impacts and determinants. World Bank Econ. Rev., 2: 299–320.

Beirnaert, A., 1940. La problème de la sterilité chez le palmier a huile. Bull. Agric. Congo Belge Leopoldville, 21: 95.

Binswanger, H., 1986. Evaluating research system performance and targetting research in land-abundant areas of Sub-Saharan Africa. World Dev., 14: 469–475.

Bonnen, J.T. 1987. Agricultural development: transforming human capital, technology and institutions. In: B.F. Johnston, C. Luiselli, C. Contreras and R. Norton (Editors), U.S. – Mexico Relations: Agriculture and Rural Development. Stanford University Press, Stanford, CA, pp. 267–300.

Carr, S., 1982. The impact of government intervention on smallholder development in North East Uganda. Wye College, University of London, 88 pp.

Cernea, M., 1987. Farmer organizations and institution building for sustainable development. Reg. Dev. Dialogue, 8(2): 1–19.

Dalrymple, D., 1986a. Development and spread of high yielding wheat varieties in developing countries. U.S. Agency for International Development, Washington, DC, 99 pp.

Dalrymple, D., 1986b. Development and spread of high yielding rice varieties in developing countries. U.S. Agency for International Development, Washington, DC, 117 pp.

Dequecker, J., 1983. Cotton: the organization of research in West Africa. Courrier, 82 (Nov/Dec.): 76–79.

Drachoussoff, V., 1965. Agricultural change in the Belgian Congo: 1945–1960. Food Res. Inst. Stud., 5: 137–201.

Eicher, C.K. 1976. The dynamics of long-term agricultural development in Nigeria. J. Farm Econ., 49: 1158–1170.

Eicher, C.K., 1982. Reflections on the design and implementation of the Senegal agricultural research project. Department of Agricultural Economics, Michigan State University, East Lansing, MI, 17 pp.

Eicher, C.K., 1984. International technology transfer and the African farmer: theory and practice. Work. Pap. 3/84, Department of Land Management, University of Zimbabwe, Harare, 34 pp.

Eicher, C.K., 1989. Sustainable institutions for African agricultural development Work. Pap. 19, International Service for National Agricultural Research, The Hague, The Netherlands, 38 pp.

Evenson, R.E., Waggoner, P. and Ruttan, V.W., 1979. Economic benefits from research: an example from agriculture. Science, 205: 1101–1107.

Harrar, J.G., 1967. A pattern for international collaboration in agriculture. In: Strategy Toward the Conquest of Hunger. Rockefeller Foundation, New York, pp. 16–39.

Hartley, C.W.S., 1970. Oil palm research and development in Africa and Malaysia. In: H. Bunting (Editor), Change in Agriculture. Praeger, New York, pp. 97–104.
Hill, F.F., 1964. Developing agricultural institutions in underdeveloped countries. In: A.H. Moseman (Editor), Agricultural Sciences for the Developing Nations. American Association for the Advancement of Science, Washington, DC, pp. 141–153.
Horton, D., 1986. Assessing the impact of international agricultural research and development programs World Dev., 14: 453–468.
Howell, J. (Editor), 1986. Recurrent costs and agricultural development. Overseas Development Institute, London, 223 pp.
Idachaba, F., 1987. Agricultural research in Nigeria: organization and policy. In: V. Ruttan and C. Pray (Editors), Policy for Agricultural Research. Westview, Boulder, CO, pp. 333–362.
Idris, H., 1969. The evolution of government agricultural research in the Sudan: the golden jubilee of Gezira Research Station, Wad Medani, 1918–1968. Sudan Agric. J., 4: 1–12.
Jeffries, Sir Charles (Editor), 1964. A review of colonial research, 1940–1960. HMSO, London, 238 pp.
Jha, D., 1987. Strengthening agricultural research in Africa: some neglected issues. Q. J. Int. Agric., 26: 265–275.
Johnson, G.L., 1989. The urgency of institutional changes for agriculture in less-developed countries, newly industrialized, and developed countries. In: D. Clubb and P. Ligon (Editors), Food, Hunger and Agricultural Issues. Winrock International Institute for Agricultural Development, Morrilton, AR, pp. 177–196.
Judd, M.A., Boyce, J.K. and Evenson, R.E., 1987. Investment in agricultural research and extension. In: V. Ruttan and C. Pray (Editors), Policy for Agricultural Research. Westview, Boulder, CO, pp. 7–38.
Kydd, J., 1989. Maize research in Malawi, Lessons from failure. J. Int. Dev., 1: 112–144.
Kyomo, M.L., 1988. Some issues in regional cooperation in agricultural research: lessons from the southern Africa region. In: D. Pickering (Editor), African Agricultural Research and Technological Development. World Bank, Washington, DC, pp. 116–121.
Legum, C., 1985. Africa's search for nationhood and stability. J. Contemp. Afr. Stud., October: 21–45.
Lele, U. and Goldsmith, A., 1989. The development of national agricultural research capacity: India's experience with the Rockefeller Foundation and its significance for Africa. Econ. Dev. Cult. Change, 37: 305–343.
Lele, U., Von de Walle, N. and Gbetibouo, M., 1989. Cotton in Africa: an analysis of differences in performance. MADIA Project, World Bank, Washington, DC, 36 pp.
Lipton, M., 1988. The place of agricultural research in the development of Sub-Saharan Africa. World Dev., 16: 1231–1257.
Mali Repub./ISNAR, 1988. Programme de developpement de la recherche agronomique au Mali: analyse du systeme national de recherche agronomique. Bamako/International Service for National Agricultural Research, The Hague, The Netherlands.
Martinson, V., Adomako, D. and Manu, M., 1987. Forty eight years of cocoa research at the Cocoa Research Institute of Ghana. Cocoa Grow. Bull., 38: 39–55.
Masefield, G.B., 1972. A history of the colonial agricultural service. Clarendon, Oxford, 184 pp.
McKelvey, J.J., Jr., 1965. Agricultural research. In: R.A. Lystad (Editor), The African World. Praeger, New York, pp. 317–351.

Morris, C.T. and Adelman, I., 1988. Comparative patterns of economic development, 1850–1914. Johns Hopkins University Press, Baltimore, MD, 575 pp.
Myrdal, G., 1984. International inequality and foreign aid in retrospect. In: G. Meier and D. Seers (Editors), Pioneers in Development. Johns Hopkins University Press, Baltimore, MD, pp. 149–172.
NIFOR (Nigerian Institute for Oil Palm Research) Annual Report, 1965–66, 1970–71, 1985. Benin City, Nigeria.
Niger Repub./ISNAR, 1988. Programme de developpement de la recherche agronomique au Niger. Tome 1, Analyse du systeme national de recherche agronomique. Tome 2, Proposition d'un plan national a long terme. Niamey/International Service for National Agricultural Research, The Hague, 48 pp.
Obasanjo, O., 1987. Africa in perspective: myths and realities. Council on Foreign Relations, New York, 51 pp.
Odhiambo, T.R., 1988. The innovative environment for increased food production in Africa. In: B.W.J. LeMay (Editor), Science, Ethics and Food. Pap. Proc. Colloq. organized by the Smithsonian Institution. Smithsonian Institution Press, Washington, DC, pp. 38–51.
Pardey, P. and Roseboom, J., 1989. Agricultural Research Indicator Series: A Global Database of National Agricultural Research Systems. University of Cambridge Press, Cambridge, 547 pp.
PORIM (Palm Oil Research Institute of Malaysia), 1985. Annual Resport 1985. Selangor, Malaysia.
Ruttan, V.W., 1987. Toward a Global Agricultural Research System. In: V. Ruttan and C. Pray (Editors), Policy for Agricultural Research. Westview, Boulder, CO, pp. 65–97.
Schweikhard, D., 1989. Financing agricultural research in a federal system of government: Optimal cost-sharing for state and national investments. Department of Agricultural Economics, Michigan State University, East Lansing, MI, 341 pp.
Shapiro, K., 1985. Strengthening agricultural research and educational institutions in Africa. Hearings, the Subcommittee on Foreign Operations, the Senate Committee on Appropriations, U.S. Senate, Washington, DC.
Surareks, V., 1986. Historical development and management of irrigation systems in northern Thailand. Chaing Mai Univ., Thailand, 285 pp.
UNDP and IBRD, 1985. Somalia: report of a joint technical cooperation assessment mission. Rep. P588-SO, New York and Washington.
USAID, 1985. Plan for supporting agricultural research and faculties of agriculture in Africa. Bureau for Africa, U.S. Agency for International Development, Washington, DC, 30 pp.
WAIFOR (West African Institute for Oil Palm Research), 1955–56. Fourth Annual Report. Benin City, Nigeria.
Wessen, P., 1989. Causes and impacts of turnover of research scientists within the Senegalese agricultural research institute: 1981–1987. Department of Agricultural Economics, Michigan State University, East Lansing, MI, 158 pp.
World Bank, 1981. Agricultural research: Sector policy paper. Washington, DC, 110 pp.
World Bank, 1987a. The World Bank Atlas. Washington, DC.
World Bank, 1987b. The twelfth annual review of project performance results. Washington, DC, 178 pp.
World Bank, 1988a. World development report, 1988. Washington, DC, 307 pp.
World Bank, 1988b. Cotton development programs in Burkina Faso, Cote d'Ivoire and Togo. Washington, DC, 147 pp.

World Bank. 1988c. Strengthening agricultural research in Sub-Saharan Africa: a proposed strategy. Washington, DC, 28 pp.
World Bank. 1988d. Rural development: World Bank experience, 1965–86. Washington, DC, 132 pp.
World Bank. 1988e. The challenge of hunger in Africa: a call to action. Washington, DC, 18 pp.
World Commission on Environment and Development, 1987. Our Common Future. Oxford University Press, Oxford/New York, 383 pp.
Young, C., 1988. The African colonial state and its political legacy. In: D. Rothchild and N. Chazan (Editors), The Precarious Balance: State and Society in Africa. Westview, Boulder, CO, pp. 25–66.