

Staff Paper

The Evolution of Agricultural Education and Training: Global Insights of Relevance for Africa

Carl K. Eicher

Staff Paper 2006-26

August 2006



Department of Agricultural Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48824

MSU is an Affirmative Action/Equal Opportunity Institution

**The Evolution of Agricultural Education and Training: Global Insights of
Relevance for Africa**

Carl K. Eicher
ceicher@msu.edu

Abstract

68 pages

**THE EVOLUTION OF AGRICULTURAL EDUCATION AND TRAINING:
GLOBAL INSIGHTS OF RELEVANCE FOR AFRICA**

Carl K. Eicher¹

Michigan State University

ceicher@msu.edu

August 1, 2006

¹ This research was commissioned by the World Bank (AFTHD). The findings, interpretations and conclusions expressed here are those of the author alone, and do not necessarily reflect the views of the Board of Executive Directors of the World Bank or of the governments they represent. The author thanks William Saint for general guidance and specific comments.

Contents

Abstract	<i>i</i>
1. Introduction.....	1
2. Strategic Context and Rationale for Investment in Agricultural Education and Training (AET) in Africa.....	3
3. Assessment of the Global AET Experience.....	7
United States	7
Japan	10
Philippines.....	12
Malaysia.....	15
India	17
Brazil.....	22
Denmark.....	25
Netherlands	26
4. Lessons from the Global AET Experience	29
5. Hard Choices and Good Practices.....	33
6. Operational Recommendations for World Bank AET Investments.	38
References.....	55

Abstract: *Today, it is conventional wisdom to speak of knowledge resources as being central to a nation's competitiveness and its economic destiny. Such wisdom gains urgency when one is discussing biotechnology and the African farmer. Two statistics highlight the dilemma of the African farmer. First, the average yield of food staples has been flat since independence in 1960. Second, there are 48 countries in Africa and only one (South Africa) of these is producing genetically modified (GM) crops commercially. Why? The answer is that most government and university research systems in Africa are producing only a trickle of new technology and improved farm practices. Consequently, African nations are severely challenged to invest in generating new knowledge for increasing agricultural productivity.*

This paper is part of a larger World Bank study of agricultural education and training (AET) in Sub-Saharan Africa. It focuses on the institution-building experience of countries outside Africa. Eight countries were selected for an analysis of the evolution of financially sustainable faculties of agriculture and national agricultural research systems. Four are industrial countries and four are classified as lower/ middle income countries. One of the major conclusions is that the political systems in many African countries have neglected agriculture. Africans have committed only about one-third to one-half of the public investment in agriculture as did their Asian counterparts during Asia's Green Revolution during the sixties and seventies. .

Another major finding is that building an interactive system of three core institutions—research, education and extension—has been, and will remain, a multi-generational challenge. In the case studies of the United States, Japan and Brazil, the average duration for developing a financially sustainable system of these three core institutions ranged from 40 to 60 years. Many African governments and donors are currently myopic about investing in higher agricultural education. But with dwindling opportunities for overseas study, African universities will ultimately be responsible for training and replenishing the stock of human capital in their respective nations' research and extension services. Many recent studies of human capital, including training, education and health, have shown that human capital can contribute to worker productivity and agricultural growth. Yet in spite of the donor cutback of support for human capital improvement programs in Africa, the linkages between overseas and African universities have continued to evolve. Expanding information technology capacities are opening the electronic door for novel institutional partnerships to improve AET in Africa.

Based on a global literature review and the experience of a number of donors and African countries, it is proposed that the World Bank prepare an Africa AET Plan with a 30-year time frame for strengthening AET in Africa. Phase I covering the first 15 years of the Plan can be prepared by drawing on the global and African experience, a few additional studies commissioned by the Bank, and discussions with stakeholders in Africa and with other donors. Nevertheless, it should be pointed out that building a science-based AET system to manage the transition from overseas training to M.Sc. and Ph.D. training within Africa is a time consuming, complex and costly process. The tentative budget for Phase I of the Plan is USD 1 billion to train 1,000 African PhDs in all fields of agriculture while strengthening the teaching and research capacity of African universities and faculties of agriculture. In the process, some difficult choices will have to be made regarding the most cost-effective strategies to boost the capacity of African universities and national research systems to increase agricultural productivity.

1. INTRODUCTION

“Since most Africans are farmers, raising the productivity of farmers is a *sine qua non* of raising the African standard of living.”

- W. Arthur Lewis, 1955

“Everything else must wait but not agriculture.”

- Prime Minister Pandit Nehru, 1947

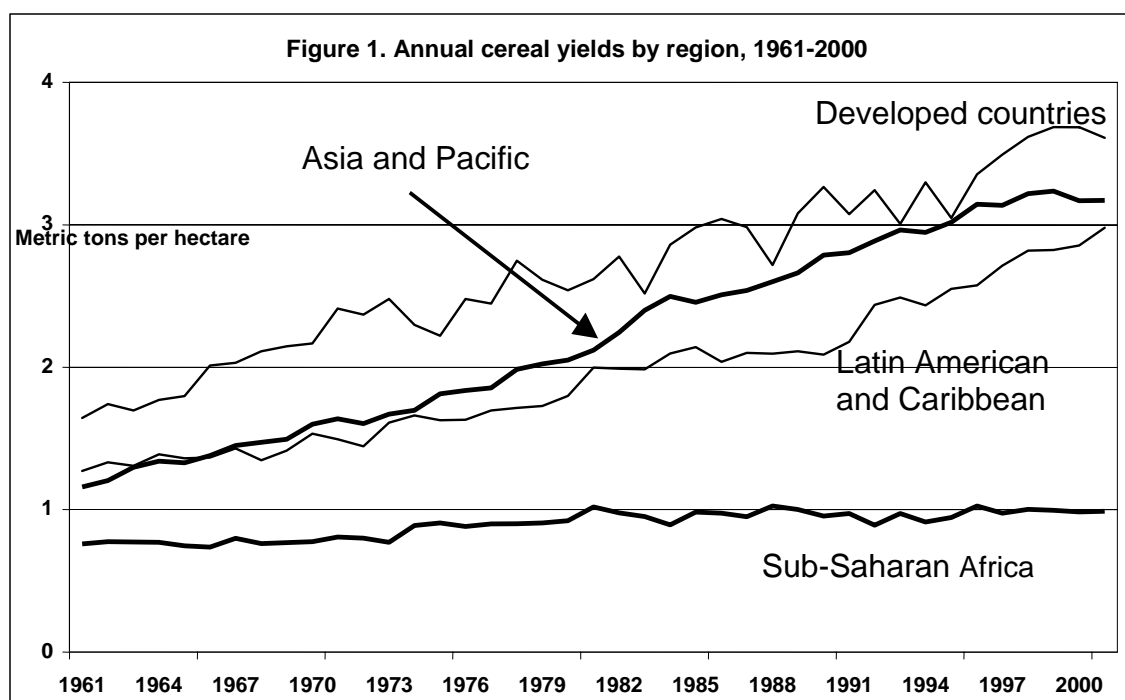
On the eve of Africa’s independence in 1959, Africa was a modest food exporter and India was facing a food crisis. The government of India requested the Ford Foundation to finance an international team of experts to study their looming catastrophe. The team became known as the “agricultural production team” and it was charged with drawing on the common experience of world agricultural development and preparing an emergency report to address India’s stark threat of a 28 million ton shortfall in food grain supplies by 1966. The production team’s report, *India’s Food Crisis and Steps to Meet It* (Ford Foundation 1959), turned out to be one of the most influential reports in Asian development circles in the 1960s because it challenged the government’s assumption that food crop technology was on the shelf, and that village-level community development and extension agents were capable of motivating farmers to increase food production.

The production team found that the technology shelf for food grain crops was empty and it called for an increase in the number of trained scientists, stepped-up research on increasing food crop yields, and importing new technology as the driver of development. India imported high yielding wheat and rice varieties and allocated them to farmers to adopt in high potential areas. With strong political leadership, continuity of government funding and donor guarantees of food aid to feed the cities for a decade, India began a sixteen year march of pushing up wheat/rice yields until it became self sufficient in food in 1981. India invested heavily in human capital by sending approximately 1,000 students to the United States in the 1970s to pursue a Ph.D. degree in various fields of in agriculture. India also developed a new model of higher agricultural education, the State Agricultural University (SAU), that drew on the decentralized American model by building at least one SAU in each state. T.W. Schultz has called the SAUs a “brilliant institutional innovation” (Schultz 1964).

The early promise of the “Green Revolution” mobilized government and donor support for agriculture throughout Asia from the mid-1960s to the mid-1980s. In fact, India and many other Asian countries invested two to three times as much in public spending on agriculture during this period as African countries are spending today. The Green Revolution also spurred donors to create a “Green Revolution Lobby” that included members of foundations, donors, universities and the private sector. Members of the lobby helped make the case for increasing foreign aid for agriculture, investing in the CGIAR system, and expanding the coverage of the Green Revolution to lower rainfall areas (Byerlee 1993). But the upbeat message of the Green Revolution lobby slowly lost its momentum in the mid-1980s because “Asia was awash with

grain.” Subsequently donors and foundations cut the number of agricultural specialists on their staffs.²

After the Green Revolution’s success in Asia, the table was turned and Africa became the home of the world’s food crises. Like India of the 1960s, the average food grain yield in Africa has been flat since independence in 1960 (Figure 1).³ Although the USDA and the FAO warned Africa in the early 1980s that it was facing a long term food production problem comparable to India’s of the 1960s, it was not until one million people died in Ethiopia during the famine of 1985 that the world became aware that Africa was facing a long term food crisis. Ironically, donor funding to African agriculture declined in 1986 after the famine and continued on a downward trajectory until 2002 (Kane and Eicher 2004). The reasons for the donors’ pullback are complex. Basically, they concluded that after 25 years of support to African agriculture, the track record was poor, few successes were on the horizon and when success did occur, it was often undermined by civil strife.



Source: World Bank 2006

Many international NGOs in Africa have mobilized donor support to enable them to make the transition from providers of emergency aid into grassroots development institutions. Although these NGOs have invested in health, education, and community development programs, most of the successful projects have not been scaled up to make an aggregate impact at the national level. Today, the NGO Lobby has considerable influence in most industrial countries,⁴ and may often

² USAID has marginalized agriculture over the past 15 years and reduced its core technical staff in agriculture from 250 in 1985 to 45 in 2003. Ten of the 45 were in Africa where USAID had 23 missions and three regional offices (Eicher 2004).

³ Maredia and Raitzer (2006) studied the contribution of the CGIAR and NARS research on food security in Africa and found that 20 percent of the total benefits from research resulted from crop genetic improvement and 80 percent from biological control of the cassava mealybug.

⁴ For example, InterAction is a U.S. umbrella group representing more than 160 development NGOs.

be present at the donor bargaining table in many African countries. Simple statistics drive home this point. Aid to agriculture in Africa declined from 29 percent of the total in 1981 to 10 percent in 2001, while the aid to rural poverty alleviation (health and education) increased from 22 percent in 1981 to 56 percent in 2001. The decline in donor support for agriculture in Africa has been matched by a lock step increase in donor support for health and education (Table 1). Although investments in health, primary education, and agriculture are complementary investments, Kane and Eicher (2004) argue that a development strategy based on rural social services (education and health) and food aid represents a narrow and inefficient approach to poverty reduction in Africa. The bottom line is that agricultural growth and rural income generation are essential to sustain rural social services and roads after donor assistance is terminated or redirected.

Table 1. Percentage Allocation of Sector Aid to Africa: 1981-2001

	1981	1986	1991	1996	2001
Social Infrastructure & Services	22	23	32	45	56
Economic Infrastructure	31	31	28	25	19
Agriculture - Forestry - Fishing, Total	29	27	19	14	10
Other Production Sectors	8	9	7	3	3
Multisector	<u>9</u>	<u>11</u>	<u>14</u>	<u>12</u>	<u>12</u>
Total Sector Allocable	100	100	100	100	100
<i>Total Sector Allocable (USD million 2001)</i>	<i>6,517</i>	<i>7,808</i>	<i>8,747</i>	<i>6,741</i>	<i>9,957</i>

*Source: OECD CRS Database
Kane and Eicher 2004*

The three aims of this paper are: first, to draw insights from global experience on the role of agricultural education and training (AET) in increasing agricultural productivity; second, to identify some key choices and good practices for strengthening AET institutions in Africa; and third, to generate operational recommendations appropriate for the World Bank and other donors in Africa.

2. STRATEGIC CONTEXT AND RATIONALE FOR INVESTMENT IN AGRICULTURAL EDUCATION AND TRAINING (AET) IN AFRICA

The funding situation for African agricultural development has now begun to brighten. The decline in donor aid to Africa started in 1986, a year after Ethiopia's famine, and continued until it began to reverse itself until 2002 (Cleaver 2003). Subsequently, G8 countries agreed at the Gleneagles Summit in July 2005 to provide an extra US \$50 billion in aid by 2010 and to double

aid to Africa.⁵ In 2003, NEPAD launched its Comprehensive African Agricultural Development Program (CAADP) and secured agreement from African governments that they would increase their expenditures on agriculture from the current average of 2.4 percent to 10 percent by 2010.

Higher agricultural education is of strategic importance to the World Bank. Some 1,600 universities with agricultural education capacities can be found in World Bank client countries, including both independent agricultural universities and agriculture-related faculties (such as veterinary medicine and forestry within general universities (Alex and Byerlee 1999). These agricultural training institutions are important for development programs in Africa for four reasons:

- Universities often have the potential to support agricultural research and extension programs by using existing staff and faculties (e.g. libraries, laboratories, demonstration farms) at little extra cost.⁶
- Universities are able to access to global research findings and share this information with academic staff and students, as well as researchers in NARs and instructors in extension training programs.
- Universities are the principal means for replenishing the stock of human capital in research, extension and agribusiness organizations in Africa⁷.
- Agriculture is highly location specific. Appropriate training in agriculture requires a detailed and intimate knowledge of local farming systems.⁸

Despite these positive contributions of universities to African development, there are two major reasons why donors have reduced their support for overseas training over the past decade. In many countries, the reliance on overseas post graduate training to develop qualified staff for agricultural research and extension is no longer feasible because of the rising costs of graduate education (Table 2). Second, African political leaders, universities, donors and foundations are concerned about the high percentage of students who do not return home after degree completion.⁹

⁵ Prime Minister Junichiro Koizumi of Japan reported that Japan would double its Official Development Assistance (ODA) to Africa (Koizumi 2006). DVID's (2006) White Paper on poverty promises to increase aid to Africa.

⁶ Many universities in Africa have a large stock of agricultural scientists with M.Sc. and Ph.D. degrees. For example, in 1995, there were 547 African scientists with a Ph.D. in agriculture employed by universities and 357 in the NARS (National Agricultural Research Systems) in Eastern and Southern Africa (Mrema, 1997).

⁷ In industrial countries, the attrition rate of scientists is 3 to 4 percent per year. In the mid eighties, ISNAR reported that attrition rates in excess of 7 percent among research staff were the norm in Africa. These rates imply that the entire research staff of NARS would have to be replaced every 14 to 16 years.

⁸ The shift from a concern over farm production to the environment in Europe has been described as shifting from agricultural education to "green education". As a result, many universities in Europe and the United States have dropped agriculture from the name of a department or university in order to maintain enrollments. For example, Wageningen University of Agriculture in the Netherlands suffered a decline in enrollment and changed its name to Wageningen University and Research (WUR). Likewise, the Catholic University of Leuven in Belgium recently changed the name of its Faculty of Agriculture to the Faculty of Applied Biological Sciences. The issue at hand is not name change per se but whether the curriculum is shifting away the skill mix needed in Africa. For a discussion of how plant breeding is losing students to biotechnology see (Guner and Wehiner (2003).

⁹ World Bank support for such training declined by 34 percent from 1990 to 1997, and USAID agricultural training in the United States fell by 66 percent from 1987-89 to 1995-97 (World Bank 1999a, p.5).

Table 2. Estimated Total Cost of M.Sc. and Ph.D. Degrees in Agricultural Economics in Various Countries in 2006.

<u>Degree</u>	<u>Years</u>	<u>University/Country</u>	<u>Estimated Total</u> <u>US\$ Cost</u>	<u>Year</u>
M.Sc.	2	U.S. Sandwich*	30,000	2006
M.Sc.	2	U.S. Universities with USAID Fellowships	60,000	2006 (incl. Out-of-state tuition)
M.Sc (Econ)	2	Africa/AERC/Economics**	30,000	2006
M.Sc.	2	CMAAE (Collaborative Masters Program in Agricultural Economics in Eastern, Central and Southern Africa)	20,000	2006
M.Sc.	2	Imperial College Distance Learning Program, London	15,200	2006
M.Sc.	2	Kwa Zulu Natal, South Africa	32,700	2006
M.Sc.	2	Norwegian University of Life Science (UMB)	45,000	2006
Ph.D.	3	U.S. Universities with USAID Fellowships	90,000	2006 (incl. out-of-state tuition)
Ph.D.	3	India Agriculture Research Institution	22,500	2006
Ph.D.	3	University of Agriculture Bangalore (India)	25,000	2006
Ph.D.	4	Belgium *** (Sandwich degree)	42,500	2006

Source: Eicher 2004 and updated in 2006

*One year in U.S. and research at home in year two. Home University awards degree.

**African Economic Research Consortium (AERC) was established in 1988. Currently 21 universities in 17 African countries collaborate and eight of the 21 award M.Sc. and Ph.D. degrees in Economics

***Tollens (2006). At the Catholic University, Leuven, Belgium, the sandwich/fellowship program is based on four years of study of which 16 months are spent in Belgium (a few months per year) without family. The student is not paid by Belgium while he/she is at home during the four years. The fellowship includes four international air tickets and funds for the student's academic supervisor to visit the student once or twice in the field.

Historically, the World Bank and USAID have invested heavily in global AET projects. From 1964 to 1990, the World Bank provided USD 712 million for 41 projects supporting 60 institutions in 25 countries (half of all projects and 80 percent of the funding went to Asia). From

1952 to 1996, USAID provided USD 456 million to help develop 63 agricultural universities in 40 countries (World Bank 1999). Despite notable success stories in developing AET institutions in Brazil, India, Morocco, China, Chile, and Malaysia, the overall track record of donor investments in AET within Africa is riddled with “false starts.”

Since donor-financed AET projects have been underway for 40 to 50 years in developing countries, it is instructive to analyze the problems encountered in these projects. To this end, eight country case studies were undertaken to flag critical issues for discussion. The World Bank (1992) reviewed its global portfolio of projects in support of agricultural higher education during 1964 to 1990 and noted the success of many of their training components. But the associated institution-building objectives were hampered by weak incentives, overstaffing and the high transaction costs of reporting to the Ministry of Education rather than the Ministry of Agriculture. In 1997, the World Bank assessed its global agricultural extension and research projects, reporting that the Bank’s agricultural research policy (World Bank 1981a) devoted little attention to the potential role of universities in research (Purcell and Anderson 1997).

Willet (1998) reviewed World Bank global expenditures on research, extension and agricultural higher education and found that agricultural higher education received about 2 percent while agricultural research and extension garnered 98 percent of the World Bank’s \$4.8 billion of global investments in research, education and extension between 1987 and 1997. The Bank extended agricultural education loans to just three African countries between 1987 and 1997.

A recent update of this review showed that World Bank lending for agricultural education components of 28 projects in Sub-Saharan Africa totalled USD 5 million between 1998 and 2004. Although Bank lending to agricultural training institutions was USD 71 million, the combined lending for education and training only constituted 7 percent of total IBRD/IDA lending in the 28 reviewed projects (Rygnestad, Rajalahti and Pehu 2005).

Support for agricultural university development has been a major feature of USAID’s agricultural assistance program from 1952 to 1989. USAID launched its first university development program in Ethiopia by helping build a Faculty of Agriculture at Alemaya between 1952 and 1968. In the late 1980s, USAID sponsored a series of impact studies of agricultural university development projects in ten countries (Hansen 1989, 1990). But today in the Land Grant Universities of the United States, one finds growing frustration over USAID’s reduced support for long-term agricultural training and capacity-building, especially in Africa.

To address these concerns, the Presidentially appointed Board for International Food and Agricultural Development commissioned a study that found that USAID funded 9,128 students from developing countries to study in the United States in all disciplines during 1990. But by the year 2000, this number had dropped to 1,212. In agriculture disciplines, the global number fell from 310 students in 1990 to 82 in 2000 (BIFAD 2003). On this basis, BIFAD recommended that USAID renew its global investment in long-term training and capacity-building for agriculture and rural development. But USAID responded by allocating only USD 2.7 million over three years to support pilot training and capacity-building projects in Mozambique, Mali, Ghana, Zambia, and three countries in Eastern Africa (Springet 2005). USAID’s allocation of this modest amount for pilot projects reveals that USAID has put long term training and

strengthening of agricultural universities “on hold.” And with this decision, USAID abrogated its historical leadership position in long-term training and capacity-building for agriculture.

This overview of AET experience over the past fifty years has flagged a number of issues that need to be addressed in future AET projects in Africa (Jones and Blackie 1991). The Bank’s good practice paper (1999) argues that reliance on overseas post-graduate training to develop qualified staff for agricultural research and extension “is no longer feasible” and that “agricultural universities in developing countries must increasingly assume responsibility for higher degree training.” But the World Bank and USAID pullback from both overseas training and capacity-building in Africa represent a disturbing retreat from this recommendation. These inconsistent actions raise an important question: Why have the donors and foundations that helped to build agricultural universities in Asia and Latin America failed to help African universities develop their own graduate training and research programs? The following is a ranking of the principle reasons for this pullback based on my experience in Africa:

- During the 1980s and 1990s, there was a widespread belief that investment in primary and secondary education would generate higher rates of returns than investments in tertiary education. The World Bank and many donors accepted this claim and actually reduced their investments in tertiary education during this period. But Schultz (1975), Bloom, Canning and Chan (2005), and others have shown that higher education can produce public as well as private benefits. Many donors now accept this updated view of the payoffs to investment in tertiary education.
- The magnitude of the collective institution-building task is much larger in the 48 countries of Africa relative to the small number of Asian countries (India, Thailand, Philippines and Indonesia) that participated in donor-financed agricultural institution-building in the 1960s and 1970s.
- The declining rate of students returning home after degree completion overseas.
- The Cold War, civil wars and drought have disrupted graduate training and capacity-building programs in many African countries that have large agricultural potential.¹⁰
- The rising cost of graduate education in the U.S. and Europe relative to programs in Asia.
- The large number of university-trained professionals who returned home after overseas training and worked for 10 to 15 years, but then migrated to live in the African Diaspora (Tettey and Puplampu 2006).

These insights leads one to conclude that the capacity-building challenge in food and agriculture for the 48 countries of Africa is today much larger and more difficult to solve than the challenge facing Asia during the 1960s. In Zambia, for example, 180 agricultural projects were supervised by the Ministry of Agriculture in the late 1980s. In Malawi, one international expert reported that “donor congestion” was a major factor limiting his capacity-building work. By contrast in the

¹⁰ These countries include the Angola, Congo, Ethiopia, Ivory Coast, Mozambique, Nigeria, Sudan, and Zimbabwe. Consider the experience of the Ivory Coast and Zimbabwe. In the 1970s, the Ivorian agricultural model was considered the poster story of Africa (Devarajan et al 2001). Likewise, Zimbabwe’s smallholder-led hybrid maize revolution of the early 1980s was known as the agricultural success story of eastern and southern Africa because it was based on 28 years of government-financed maize research that produced a maize hybrid which increased yields of small scale farms by 40 percent (Eicher, 1985). Today, both countries have been brought to their knees by political unrest.

early 1960s, only three major donors helped India to develop capacity in research (Rockefeller Foundation), extension (Ford Foundation), and universities (USAID). These and other organizations set up an informal “Green Revolution Lobby” that turned out to be effective in mobilizing donor support for AET in Asia and Latin America. Today, a dozen or more donors and a multitude of NGOs operate in virtually every country in Africa. But unlike Asia where imported high yielding wheat and rice varieties enticed donors to invest in agriculture throughout the sub-continent, the agricultural performance in Africa has been limited to “islands of success” (Haggblade 2005).

To summarize, building AET capacity in Africa has been filled with disappointments and subsequently placed on hold by many donor agencies. They might do well to heed the sage advice that Vernon Ruttan offered fifteen years ago about the urgency of agricultural institution-building in Africa:

“The thing that bothers me is that the donors have consistently tried to avoid the issue of institution-building in Africa. In South and Southeast Asia in the 1950s, the donors were building the institutional capacity it took to create the growth that began in the 1960s. In the 1970s, we didn’t do it in Africa because we were on the basic needs and rural development kick. An agronomist was viewed as doing elite stuff. A plant breeder was even more elite. I think it’s time that the donors begin to take the issue of institution-building seriously or in 2010 we are going to be having this same conversation” (Ruttan, 1991 p. 195).

Even though the institution-building challenge has been postponed in Africa, African educators and participants in BASIC, RUFORUM, FARA and the SROs are asking for an answer to this critical question: *How, where and when will the next generation of African agricultural teachers, researchers and extension workers be trained?* Educators in Mali are asking this question because 60 percent of the academic staff at the Faculty of Agriculture at Katibougou will retire in ten years. How will the next generation of Malian teachers be trained? Rector Kropff of Wageningen University recently reported that although his university will continue to train M.Sc. and Ph.D. students from developing countries and support capacity-building programmes, “the main bottleneck is a lack of funding.”

3. ASSESSMENT OF THE GLOBAL AET EXPERIENCE

As Vernon Ruttan and others have urged, it is time to examine how to mobilize African and donor support to build an agricultural science base and complementary core institutions capable of increasing agricultural productivity. The first logical step is to study the experience of industrial and developing countries in building productive and financially sustainable AET systems. The following eight countries have been selected for analysis and insights: four industrial countries (U.S., Japan, Denmark and the Netherlands) and four developing countries (India, Philippines, Malaysia and Brazil). The insights derived from the AET and capacity-building experience of these countries will deepen our understanding of how African nations and donors might work together to develop globally competitive and financially sustainable teaching, research and extension institutions. The first of the eight countries in this global summary is the United States. We shall concentrate on the Land Grant education model as it was developed there and in Nigeria.

United States: The Land Grant University Experience

When U.S. agricultural higher education is discussed in development circles, it often starts with 1862 when the U.S. Congress passed legislation that established Land Grant colleges, the United States Department of Agriculture (USDA), and the Homestead Act.¹¹ But long before 1862, a global search had already begun to build an agricultural science base for an ecologically diverse agriculture. In 1819, the Secretary of the Treasury instructed U.S. naval officers and consuls to collect new plants and germplasm from around the world. On the surface, this seems to be an unusual role for a young government, but it was based on the fact that the United States was not well endowed with a wide range of crops.¹² These germplasm expeditions represented the first institutional step in a large and enduring government commitment to agricultural research and to American farmers. The second step was a government decision to link germplasm excursions with the free distribution of seed to farmers, encouraging them to become farmer-breeders in different ecological areas. Members of the U.S. Congress were allowed the free use of the U.S. postal system to distribute new seed varieties to farmers.¹³ By 1860, American farmers were able to feed a population of 31 million and export 20 million bushels of wheat – mainly to Europe – in competition with Denmark’s grain exports to the United Kingdom.

The early U.S. experience demonstrated that farmers, with rare exceptions, were ineffective as plant breeders and in developing high-yielding grain varieties. The U.S. experience with corn research reveals why U.S. universities shifted from the farmer-researcher and free seed model to research on genetics and plant breeding in the 1890s. The first major payoff to this research came

¹¹ Provided free land to settlers if they lived on their land for five years.

¹² Kloppenberg (1988) reports that the crops of economic importance that originated in North America were sunflowers, blueberry, cranberry and artichoke. Native Americans added maize, beans and squash, but these crops did not provide the foundation for rapid agricultural growth and international trade.

¹³ In 1849, 60,000 packages of free seed were distributed to farmers without cost by the Postal Service (Kloppenber 1988).

with the discovery of hybrid corn in the 1920s, followed by its rapid adoption in the 1930s.¹⁴ The lesson that flows from this example is not to expect farmers, NGOs and extension agents to develop new high yielding crop varieties. Nevertheless, participant research involving farmers and farm organizations has an important role to play in channeling problems to researchers, speeding up diffusion of new technology, and making the case for agriculture in the political process.

Long before the Land Grant Act of 1862, farmer associations were established by farmers, merchants, politicians and urban leaders who believed that improving agriculture would increase welfare of all members of society, rural and urban.¹⁵ For example, the Philadelphia Society for Promoting Agriculture was established in 1785.¹⁶ In 1862, the Land Grant Act provided federal funds to help each state set up a Land Grant College for the teaching of scientific agriculture. The Land Grant Colleges subsequently helped persuade the US Congress to enact federal legislation in 1887 to provide permanent federal funding to Land Grant Colleges in order to build a decentralized, applied research capacity – state by state.¹⁷ In 1914, Congress passed the Smith-Lever Act which established a national extension system by helping finance extension services in Land Grant Colleges and linking them with the USDA in a loose coordination structure (Bonnen 1998). Land Grant Colleges were subsequently expanded to include law, medicine, social science, and renamed Land Grant Universities.¹⁸ Today, there are 50 states in the U.S. and 60 Land Grant Colleges/Universities. The Land Grant model is an agricultural knowledge system that embraces human capital, technology and institutions. The components of the model were assembled and interlinked through a piecemeal, pragmatic and political process over a sixty year period (1860-1920) (Bonnen 1962).

But the issue before us is the performance of Land Grant Universities in developing countries. Unfortunately, the answer to this question is often cast in terms of success or failure. The following discussion of the transfer and performance of the Land Grant University model in Nigeria points to a more nuanced answer.

The Variable Performance of the Land Grant Model in Nigeria

At Nigeria's independence in 1960, Nigeria only had one faculty of agriculture (at Ibadan) and it was basically a teaching institution. In the early 1960s, USAID awarded contracts to four US

¹⁴ Corn provides a good example. The early corn yield tests in Iowa were based on searching for superior seed corn on Iowa farms for 12 years from 1904 to 1915. The chosen "superior" seeds were planted on 75,000 field plots and the average corn yield in Iowa was 32.4 bushels an acre from 1896 to 1905 compared with 33 bushels during 1913, 1914 and 1915 (Schultz 1964).

¹⁵ Bonnen (1998) has produced the definitive account of the evolution of the Land Grant system of higher education as an institution for development. The literature on the Land Grant model is voluminous. See Johnson and Okigbo 1989; Kloppenburg 1988; Sanders et al 1989; Marcus 1985; Price et al 1989; Eicher 1984; Buttell 1985; Swanson 1986; Wilcock and McDowell 1986.

¹⁶ Benjamin Franklin was a founding member of the Philadelphia Society which celebrated its bi-centennial anniversary in 1985 and it was only recently dissolved.

¹⁷ Farmers did not press Congress for funds for research until the land frontier was closed in the 1880s. The Hatch Act was passed by Congress in 1887 to provide federal funding for research at state agricultural experiment stations (Ferleger 1990). Likewise, Brazil did not invest heavily in research until its land frontier was closed in the 1970s.

¹⁸ By contrast, most colonial administrations in Africa first developed research capacity for export crops followed by a build-up of extension, and only much later, by the development of universities and faculties of agriculture. This explains why the power base in agriculture in most African countries lies in government research and extension services.

Universities – Michigan State, Colorado State, the University of Wisconsin and Kansas State University – to assist Nigeria in building new Land Grant Universities in four different regions and help them to expand undergraduate enrollments and strengthen the agriculture extension and research services. The University of Nigeria was opened at independence in 1960 with the support of a Michigan State University (MSU) team sponsored by USAID. The MSU team was charged with helping to develop an American Land Grant type of university in the eastern region of Nigeria (Johnson and Okigbo 1989). The MSU faculty at the University of Nigeria had a paucity of knowledge about colonial institutions – especially agricultural research, extension and the commodity boards that financed research on export crops. Although the American team was naïve, they were enthusiastic about developing University of Nigeria linkages with the government research and extension services.

But the operational challenge of crafting a national system of interactive agricultural support institutions turned into a nightmare because three of the U.S. universities reported to Vice Chancellors who in turn reported to the Ministry of Education. The fourth U.S. University reported to the Director of Extension in the Eastern Region. In the Eastern Region where the University of Nigeria was located, the transaction costs were high in trying to establish communication and partnerships between the University of Nigeria and the Ministry of Agriculture's regional research station some 100 miles away (Johnson and Okigbo 1989). Although the MSU team failed to help the University of Nigeria develop its research and extension programs, it did assist in teaching and building academic staff capacity through overseas training programs. Today, the University of Nigeria has an enrollment of 30,000 students and the University has made important contributions to Nigerian development over the past four decades. The balance sheet shows that the Land Grant model was successful in building teaching capacity, but unsuccessful in establishing research and extension at the University of Nigeria.

But much can be learned from an important Land Grant success story in the Northern region of Nigeria in the 1960s and 1970s (Olson 1965; Goldsmith 1990). In 1962, the Legislature of Northern Nigeria created Ahmadu Bello University (ABU) at Zaria. In 1963, USAID awarded a contract to Kansas State University to help develop the new university and teach undergraduates while newly-recruited Nigerian staff were sent for graduate training overseas. The faculty of agriculture began in 1962-63 with six students and a teaching staff of two. Visionary Nigerian political leaders transferred the entire staff of the Research Institute of the Northern Ministry of Agriculture to Ahmadu Bello University.¹⁹ The Ministry of Agriculture also transferred five senior researchers to the newly-established Research-Liaison Section of Ahmadu Bello University in order to promote a two-way flow of information from farmers to researchers and a flow of technology from researchers to extension agents and farmers. The Institute of Public Administration was transferred to ABU and the Institute of Islamic studies at Kano was affiliated with ABU. These politically astute transfers pieced together a Nigerian adaptation of the Land Grant University model that was crafted by edict and concession to serve the 25 million people (mostly farmers) in Northern Nigeria.

¹⁹ The Institute for Agricultural Research was established in 1925 by the British Colonial Service and it had a reputation as being the finest agricultural research institute in Anglophone West Africa. In 1962, it had an establishment of 65 senior staff and three research substations (Olson 1965).

The ABU experience reveals how African political leaders and Nigerian and American scientists pragmatically created a functioning agricultural knowledge triangle that contributed to this important Land Grant success story (Kansas State University 1974). But the success of the Land Grant model at ABU was crucially dependent upon the Nigerian political decision to unify research and education in the same institution – ABU – and to transfer its entire agricultural research staff to Ahmadu Bello University. The administrative separation of research and higher education in many countries in Africa has had a crippling effect on the development of national agricultural innovation systems (Rukuni 1996).

Japan’s Agricultural Transformation: 1868 To 1912

Japan’s transformation from a feudal culture to an industrial society in just one generation is a textbook success story. Soon after Emperor Meiji assumed the reigns of power in 1868, he established a new government called the Meiji Restoration. He committed Japan to rapid modernization based on compulsory universal primary education (1872) and imported agricultural and industrial technology from the United States and Western Europe. The overarching goal of the Meiji government was “to build a wealthy nation and a strong army” through industrialization so that colonization by the western powers might be prevented (Hayami 1988). The goal of agricultural development was to increase domestic food supplies in order to prevent a rise in the cost of living of urban workers. Agricultural policy focused on rice, the main “wage good” for industrial workers, and later on silk production for export markets.

To achieve rapid modernization through technology-borrowing, Emperor Meiji dispatched a high level mission headed by Vice President Tomomi Iwakura to tour the United States and Europe for 22 months between 1871 to 1873. Members of the mission filled hundreds of notebooks with information on every facet of industry and farming in the United States, including a meticulous analysis of large-scale mechanized farms, equipped with horses and reapers. President Grant gave a glittering reception for the visitors through a special \$50,000 fund appropriated by the United States Congress. The mission then visited eight European nations, including Germany where they were fascinated by the embryonic research on chemical fertilizer and science-based agriculture. Bismarck encouraged the Japanese to generate their own investment capital for development purposes and to avoid foreign indebtedness.

When the Iwakura mission returned to Japan, it lauded “the technical superiority of western agriculture and the use of fertilizer and machines” and recommended that Japan borrow western technology, lock, stock and barrel. To implement the Iwakura recommendations, the Japanese set up an agricultural research station to test the foreign farm equipment and new products such as grapes from the United States and sheep from England. Students were sent overseas to the so-called “advanced countries” for training and instructors were hired from the United States and England to teach in the newly-opened Komoba agricultural school, later redesignated in 1892 as the University of Tokyo, College of Agriculture. But teaching by the British instructors proved ineffective.

In 1893, the national agricultural experiment station was formed with six branch agricultural colleges (Ogura 1970). The curriculum was based on science and technology that had been

developed for American farming conditions where the average size of a family farm was many times larger than the average Japanese farm.²⁰ But after less than a decade of experimenting with imported technology in industry and agriculture, the Meiji government came to the conclusion in the early 1880s that foreign technology was a stunning success in industry, but a failure in agriculture – except in northern Japan where large blocks of land on the island of Hokkaido were suitable for large farms and American horse-drawn farm equipment. The Japanese discovered that the grapes, sheep and large-scale machinery, which were both technically sound and profitable on large farms in land-abundant America, turned out to be “poisoned gifts” to Japanese farmers where the overarching concern was increasing rice yields on small plots of land and soaking up surplus farm labor in farming and related activities.

The economic failure of the American model of large-scale farming prompted the Meiji government to set up a Ministry of Agriculture in 1881 and charge it with developing a new agricultural strategy consistent with Japan’s climate and agrarian structure of tiny family farms. The new strategy concentrated on increasing yields on small farms through the application of chemical fertilizer and improved seeds. To develop yield-increasing crop technology, the Japanese government hired German scientists, on long-term contracts, to pursue research on soil science, agricultural chemistry, and chemical fertilizer along the lines pioneered by the famous German scientist, Von Liebig.

The government hired successful Japanese farmers as extension agents, paying them to travel throughout the country to diffuse seed varieties and agricultural practices used by the better farmers. In 1881, the veteran farmers met in Tokyo and established a new organization, the Agricultural Society of Japan, modeled after the Royal Agricultural Society of England, and charged it with extending technical information to farmers. Three years later, the National Agricultural Association was established to exercise political influence on behalf of farmers. All farmers in Japan were required by law to join the Association and pay membership fees. Thus, the seeds of agrarian power in Japan were grounded in compulsory farm association membership and group action to acquire political influence for farm people. Africa has much to learn from this experience.

Japan’s economic transformation from a feudal to an industrial power in one generation (1868 – 1912) was based on a development strategy that fostered the concurrent growth of agriculture and industry. Japan’s yield-increasing agricultural strategy was highly successful in boosting rice production on small-scale farms and generating a surplus to feed the cities. A land tax was introduced in the 1870s to extract revenue from farmers to finance the central government and promote industrialization.

What is most significant for Africa about the Japanese case is Japan’s ability to learn from its own experience. After only eight years of experimentation, 1873 – 81, the government concluded that the American model of large-scale farming with horses was inappropriate for Japan’s land-short economy and tiny farms. Japan shifted course and invested heavily in developing its indigenous research capacity in order to increase rice yields on small-scale farms and to promote the growth of rural small-scale industries. The results were impressive. Japan’s smallholder

²⁰ Small scale family farms averaged about one hectare (2.2 acres) per household.

agricultural strategy generated the same annual compound rate of agricultural growth (1.6%)²¹ as the U.S. farmers using horses and tractors over the 100 year period between 1880 and 1980 (Hayami and Ruttan 1985 p. 166).

Japan's smallholder development strategy has contemporary relevance for land-short countries in Africa (e.g., Malawi and Rwanda) because it was a pioneer in demonstrating that tiny farms of one to two hectares could serve as a motor of development provided they had access to new technology that was profitable on a recurring basis, an acceptable level of risk, and access to markets. Finally, Japan's experience demonstrates that an agrarian society could be transformed by the concurrent development of agriculture and industry into an industrial power within a single generation.

Rural education contributed importantly to Japan's agricultural transformation:

- In 1872, compulsory universal primary education was introduced.
- A Technical Education Bureau was established in the Ministry of Education and the first agricultural technical college was established in Hokkaido in 1872.
- The better performing students were sent abroad for further training with an obligation to serve in positions designated by the Ministry of Education for twice the number of years spent abroad studying (Ogura 1970).

The U.S. and Japan pursued an identical strategy of sequencing public investments in the agricultural knowledge triangle (research, extension and AET). Both gave priority to education followed by research and then waited for a period of time before setting up a national extension system.²² Japan and the United States both established decentralized research systems and each set up roughly the same number – about 350 – of branch research stations to address the problems of micro-ecologies. In essence, public sector research and extension systems were demand-driven in both countries because the states (prefectures in Japan) were the funders of research, whereas the counties²³ were the funders of extension. This system has been an important factor in creating performance incentives. The decentralization, in effect, simulated market-like forces (Ruttan 2001).

The Philippines: Evolution of a Regional Knowledge Hub

The evolution of agricultural higher education in the Philippines is primarily the story of the development of the University of the Philippines at Los Banos (UPLB). The College of Agriculture was started almost 100 years ago in 1910. But after the first decade, the college went through a crisis because of a lack of faculty members. The Department of Agricultural Education was established in the 1920s. Then the College was destroyed during World War II. After the

²¹ Although 1.6 percent rate of growth of agricultural output is low by today's standards, Japan's annual population growth rate was only 1.0 percent during the period 1868 - 1914.

²² The U.S. national extension system was set up in the U.S. in 1914 and 1948 in Japan.

²³ Counties are comparable to districts in many countries.

war, the College was rebuilt and it started to train students from Southeast Asia in tropical agriculture. The first Southeast Asia training course in agricultural extension was held on campus in 1958.

In 1952, Cornell University was selected by the U.S. Government (under the Point IV Program) to help upgrade and expand the undergraduate program while institutionalizing the Land Grant philosophy of problem-solving research, instruction and applied training among the younger members of the faculty and UPLB staff. The Cornell team developed a solid reputation for its assistance in strengthening the graduate program and training faculty members both in the Philippines and at Cornell (Oyer and Javier 1974). Cornell's faculty members also served as a bridge between UPLB and the International Rice Research Institute (IRRI), which was established on the UPLB campus in 1960 with Rockefeller Foundation support and it became operational in 1962. Many IRRI researchers supervised Los Banos graduate student research, taught an occasional class, and served on PhD guidance committees. Cornell staff also helped expand the number of students from Southeast Asia enrolled for graduate study at Los Banos.

During the first phase of the Cornell/Los Banos cooperation (1952-60), a total of 51 American professors, including 35 from the Cornell campus, participated in the project and served one to three years at Los Banos (Turk 1974). Concurrent with the USAID contract in agriculture, Cornell accepted another USAID contract to assist in upgrading the College of Forestry at Los Banos from 1957-1960. In 1960, the undergraduate phase of Cornell's work was completed (1952-1960).

In 1963, Dean Umali of UPLB secured Ford and Rockefeller support to finance a second phase of the Cornell/UPLB partnership. The objective was to strengthen graduate programs at UPLB in order to train more staff and more graduate students from Southeast Asia. The graduate phase lasted from 1963 to 1972. Cornell University rendered yeoman service in helping improve the quality of UPLB over two decades (1952-1972). The 20 year history of this partnership is reported in the classic by Kenneth Turk, *The Cornell-Los Banos Story* (1974).

The emergence of UPLB as a regional knowledge hub should be studied by CGIAR managers and scientists working in Africa. Clearly, physical proximity is an important starting point in the development of a regional knowledge hub. Since IRRI and Cornell staff were based on the UPLB campus, new human capital chains were developed that benefited the training and research programs in both institutions.

This success leads to the question: *Why have CGIAR linkages with African universities been so tenuous over the past forty years?* Gelia Castillo (1997), UPLB rural sociologist, describes the difficulty in developing and maintaining research partnerships over time.²⁴ Now that the CGIAR has just completed a massive training assessment (CGIAR 2006), the issue of expanded training and developing regional knowledge hubs can be debated by the Science Council of the CGIAR. Special attention should be given to drawing lessons for Africa from the following experiences: the IRRI/UPLB training and research partnerships, the evolution of the UPLB knowledge hub, CIAT's linkages with universities in Colombia, and the large number of basic crop production courses offered by IRRI, ICRISAT and CIMMYT (Walker 2006).

²⁴ Also see Hall et al 2001.

Just as the Cornell team completed the graduate program phase of work in 1972, the President of the Philippines declared martial law throughout the country. During the 1970s and 1980s, UPLB's graduate program was under stress and in competition with the improved graduate programs of other universities in the region.

At that time, Roger Montgomery, Agricultural Development Council (ADC) Representative, visited universities in five countries of southeast Asia and reported that the colleges of agriculture in the region faced a common set of problems (Montgomery 1978). He concluded:

“The problem areas boil down to three: the retention of trained staff, the development of the master's program, and a lack of study of the supply and demand for the output of a master's program in economics or agricultural economics.”

Despite these common problems facing universities in Southeast Asia, universities in Thailand and Malaysia have grown in stature and recognition. This has been partially due to their higher rates of economic growth²⁵ and a long term build-up in the quality of their human capital base. Two examples illustrate this point. An estimated 15,000 Thais pursued short- and long-term technical training and education in the United States from 1950-1986 (USIS 1986). Thailand's leading public university in agriculture, Kasetsart, started to offer graduate degrees 50 years ago, receiving substantial help from the Rockefeller Foundation.

The UPLB has experienced a loss of academic staff because of more favorable financial incentives in the private sector, NGOs and overseas.²⁶ Women staff played an important role in this international migration and they have worked hard to climb the ladder in overseas agricultural research agencies. In their report on women scientists and managers in agricultural research in the Philippines, Brush, et al. 1995 pointed to a possible motivation for emigration:

“Women occupy lower positions than men, more women occupy junior-level positions than men, and men are twice as likely as women to hold senior-level positions. While more than three-quarters of the women with B.Sc. degrees are in junior positions, fewer than 60% of the men with B.Sc. degrees are in junior positions.”

After nearly a century of operation, UPLB has served the nation and the region through its graduate program and the development of a regional knowledge hub.²⁷ Looking to the future, UPLB recently signed a cooperative agreement with Cornell University to carry out research in plant-breeding and bio-technology. The Cornell/UPLB partnership from 1952 to 2006 is an example of an emerging trend for developing country universities to maintain academic partnerships with universities in industrial countries for 50 years or more. UPLB currently has an enrollment of 8,000 undergraduates and it offers 44 M.Sc. and 19 Ph.D. programs.

²⁵ In 2004, the per capita gross national income was \$1,170 in the Philippine, \$2,540 in Thailand and \$4,650 in Malaysia (World Bank 2006).

²⁶ A recent book on the international brain drain contends that the Philippines—more than any other country-- has made the export of human capital a fundamental part of its development strategy: (Kapur and McHale 2005).

²⁷ The regional organization is called SEARCA (Southeast Asia Regional Center for Research and Agriculture).

Malaysia's Drive to Reach Developed Country Status by 2020

Malaysia and Ghana both won their independence in 1957. But Malaysia is now a prosperous, middle-income country while Ghana has roughly the same per capita income as it did some 50 years ago. Malaysia's population of 25 million is almost equally divided between the ethnic Malay and the ethnic Chinese who control large segments of the economy, including banking, manufacturing and plantations. Malaysia is a textbook case of a country that has invested heavily in agricultural research so as to generate rapid growth of exports, and also in education to achieve the important social goal of helping the poor Malay farmers while building an industrial labor force. The government of Malaysia recently released its new Five Year Plan and announced the goal of achieving "developed country status" by 2020. The biggest share of government investment – one fifth – is earmarked for education and training in order to maintain Malaysia's competitiveness with China and India in electronic exports.

Following independence in 1957, Malaysia's political leadership committed itself to an agriculture-led development strategy and created a haven for foreign private investment with guaranteed repatriation of profits. While Ghana's Nkrumah was criticizing multi-national firms in the late 1950s and '60s, Malaysia encouraged foreign private investments, even though foreigners possessed three-quarters of the large rubber estates, owned all of the tin dredges, and controlled much of Malaysian foreign trade. A year after independence, Malaysia signed bilateral investment pacts with West Germany, Japan and the United States. In 1966, Deputy Prime Minister Tun Abdul Razak toured the U.S. and wooed American capital, but he did not beg for foreign aid. Instead, Razak took the long view when he met with potential American investors:

"We are not looking for direct handouts. If you want to expand and invest and you look around the world for a suitable place to do this, then I suggest you look to Malaysia where you will find the basic requirements you seek – political stability within a democratic framework and potential progress to mutual advantage of both our countries." (Razak cited in Saravanamittu 1983, p.30)

Malaysia's open door for foreign private investment is based on a strategy of financing development via foreign investment rather than foreign aid. This strategy has paid off handsomely. For example, it is reported that Taiwan's direct investment in Malaysia in 1991 was larger than the total USAID budget of one billion dollars for all of Sub-Saharan Africa.

During the past 50 years, the Malaysian government has been deeply committed to agricultural development. From 1960 to 1983, it invested an average 20 percent of the government budget in agriculture (Jenkins and Lai 1992). In contrast, African nations invested an average of 4.1 percent in 2001 (Fan and Rao 2003). Malaysia has also pursued its comparative advantage in natural resource-based export growth (rubber, oil palm and cocoa) long after many development experts had advised African nations to shift from export crops to industrialization. Malaysia's reliance on export crops in the 1960-85 period was crucial for its development. Many development experts have praised Malaysia's success in replacing Nigeria as the leading oil palm exporter in the world (Hashim 1992). The World Bank's then Vice President for Africa,

Edward K. Jaycox, had this to say at a meeting of African Ambassadors to the United States at a 1992 conference in Washington, D.C.:

“When is the last time anybody invested in research in cocoa or oil palm in Africa? Well, the Malaysians have been investing in research. They are going to take you guys to the cleaners if you do not wake up and listen to the music” (Jaycox 1992).

For the first decade after independence, Malaysia continued to give priority to natural rubber. But with declining world rubber prices in the 1960s and increasing competition from synthetic rubber, Malaysia shifted its priorities to oil palm production. The rapid growth of the oil palm industry was fueled by massive public investments in clearing new land, building houses for new settlers, investing in R&D, and private investment in plantations (estates) and processing plants. In 1979, the government set up the Palm Oil Research Institute of Malaysia (PORIM) to increase oil palm yields and find new uses for oil palm in international markets. Starting with only four scientists in 1979, PORIM currently has a scientific staff of 188 (full-time equivalent) scientists working on an array of research projects, including oil palm, plant breeding, biotechnology and new industrial products (Stads, Tawang and Beintema 2005).

Malaysia has pursued a number of different educational strategies over the past sixty years. In the 1960s and 1970s, Malaysia invested heavily in primary and secondary schooling in rural areas in order to achieve the political goal of appeasing its political base—the impoverished rural Malay. In the 1970s, it developed a massive program to send Malays overseas for higher education.²⁸ The goal was to create a Malay middle class within half a generation. Today, education and training represent the most important government investment in Malaysia’s new Five Year Plan.

In addition to investing heavily in education at all levels, Malaysia’s human capital improvement strategy is known for its attention to incentives. It is refreshing to note that the government is focused on designing an incentive structure to mentor and retain scientists rather than trying to attract members of the diaspora to return home.²⁹ Today, new research officers in MARDI are eligible for postgraduate training after one to three years of service. Notably, university enrollment in agriculture has shifted significantly toward women students, and 34 percent of the agricultural researchers in the country are now female (Stads, et al 2005).

Malaysia’s drive to achieve “developed country status” by year 2020 has intensified the government’s support for biotechnology research on oil palm because it is now the second most important vegetable oil in the world behind soybeans. Malaysia’s USD 6.4 billion of oil palm exports in 2004 was second only to its export of electronic goods (Abdulla 2005). From a global perspective, agricultural scientists in Malaysia are using biotechnology to increase oil palm yields so that Malaysia can compete with the three leading global soybean producers—Argentina, Brazil and the United States. Looking ahead, the Director of the Oil Palm

²⁸ In the 1980s, Malaysia had the second largest foreign student group in the United States behind Iran.

²⁹ In 1989, I visited MARDI and learned that it was paying its research officers US\$2000 per month which was then “halfway between UN and IBM Singapore rates” and attractive enough to keep a large share of its scientists at home. In addition, research officers in 1989 were given a round trip air ticket to Mecca and a generous housing, automobile and retirement package. In contrast, the salary for an assistant professor at the University of Ghana, Legon was US\$2,400 per year in 2002.

Biotechnology Group, University of Kebangsaan, Malaysia reports that crops such as oil palm will not be looked upon as a commodity crop in the future. Instead, the role of the oil palm will change to that of a “biofactory,” engineered to produce an array of specialty products such as bio-diesel, bio-plastics and pharmacology products.

Malaysia has developed a number of national, regional and global partnerships to maintain its competitive advantage, mainly in bio-fuel, especially since the rising price of energy. On the national level, Malaysia’s large government R&D activities are closely linked with universities and private companies.³⁰ MARDI maintains collaborative links with 40 national and international research agencies. Currently, ten different agencies are conducting agricultural research in Malaysia. Malaysia currently has 1,200 (FTE) scientists engaged in agricultural research. This is about double the number of scientists in Kenya, a nation slightly larger than Malaysia (Stads, Tawang and Beintema 2003).

To summarize, although Malaysia has actively promoted private sector development, the government is still financing 95 percent and the private sector is financing 5 percent of the total agricultural research budget (Stads, Twang and Beitema (2005). By contrast, many African countries are relying on foreign aid to finance 30 to 40 percent of their agricultural research budgets. One of the most important lessons of the Malaysian success story is that the government can play a critical role in investing public funds to support research, higher education and the promotion of export crops, and can creatively use trade to build up the economy. Evenson sums up the case for public investments by noting that every country has to use public funds “to buy its way into the growth process” and after that has been accomplished, private investment will follow (Evenson 2005).

India: The 16 Year March

India’s economy is growing at a phenomenal rate of 9 percent, and it has 60 million tons of grain in storage. However, these impressive achievements can best be appreciated in historical perspective. In 1968, Nobel Laureate Gunnar Myrdal concluded that India and other Asian nations were “soft states”, incapable of rapid growth because of cultural and religious beliefs. How do we reconcile Myrdal’s pessimistic views with India’s current 9 percent annual economic growth rate? What can Africa learn from India’s development experience? And what has been the role of AET in this success story that has improved food security, reduced poverty and contributed to environmental sustainability?

Soon after India won its independence in 1947, it gave priority to the Soviet heavy industry model of development, setting up a Ministry of Planning and preparing its first Five Year Plan (Mellor 1976). India’s agricultural strategy was based on Gandhi’s Community Development model wherein a multi-purpose, village-level worker encouraged farmers to build schools, roads

³⁰ A group of Malaysian scientists is working with scientists from the Massachusetts Institute of Technology to insert bacterial genes into oil palm to produce plastic from the fronds of oil palm trees. The driving force behind research on bio-plastics is the fact that oil palm is the most efficient oil yield crop and the assumption that the world’s supply of petroleum will run out in less than fifty years. The research on bio-plastics is pursued by inserting bacterial genes into the oil palm. The researchers from Malaysia and MIT hope that the palm fronds will someday include a plastic which can be used to make consumer and industrial products.

and plant subsistence crops (Holdcroft 1984). In the early 1950s, the Government requested the Ford Foundation to assist in upgrading these community development (extension) programs (Moseman 1970). Also, the Rockefeller Foundation was invited to help strengthen agricultural research capacities, and USAID was asked to help introduce and institutionalize a new type of university called the State Agricultural University (SAU) based on the U.S. Land Grant University model. The goal was to set up at least one SAU in each state. India gave priority to a bottom-up extension approach because of Ghandi's self-help movement and the influence of the extension bias in U.S. foreign aid programs in India during the 1950s (Goldsmith 1988).³¹

Extension in India is now managed by the State Ministries of Agriculture, although the Federal government has a small department for overall policy, coordination etc. The SAUs have extension subject matter specialists who are professors but they are not supposed to do front line extension work. Their role is to support the state extension services through training, etc. However, for some more specialized commodities such as horticulture, they actually do some of the face to face extension. The bigger farmers have learned to go straight to the universities for advice rather than to the state extension workers.

It is commonly believed that India's food crisis was solved in 1966 with the importation of 18,000 tons of high yielding wheat seed from Mexico that Norman Borlaug and Mexican scientists had developed over two decades of research. But the reality is that Borlaug carried some of the new high-yielding wheat seed to India in 1962. Indian scientists then tested the seed in five years of local trials, training local farmers and participating in debates among Indian scientists and members of the Parliament over the danger of importing foreign wheat and rice – the two main food staples of India. The cabinet approved the importation of wheat seed in 1966 and it contributed to the bumper harvests of 1966-68 which became known as the Green Revolution. With the personal attention of Prime Minister Nehru and outstanding political leadership, India slowly increased food output and achieved food self-sufficiency in 1981, after a 16 year march.

Our analysis of an important institutional innovation in India, the State Agricultural University (SAU), begins in 1876 when the first agricultural college was set up at the Saidapet Experimental Farm in Madras (Goldsmith 1990). In 1889, the Home Department of the British Colonial Service charged both the Agriculture and Education Departments of the government of India to accept an "obligation to take positive measures for the education of the rural classes in the direction of agriculture" (Waida 1997). During the 1890s, agricultural colleges were established in three locations and the University of Bombay offered a diploma course in agricultural science. Since agriculture and education were state responsibilities, all agricultural colleges as well as research and extension fell under the supervision of the States (Randhawa 1986). India's head start in agricultural training relative to Africa is illustrated by the fact that virtually all of India's agricultural research staff possessed a B.Sc. degree or higher at independence in 1947. In contrast, 90 percent of the researchers in the African NARS were expatriates and just 10 percent were African at independence in 1960 (Beitema, Pardey and Roseboom 1998).

Turning to the critical question whether postgraduate students should be educated in India or overseas, the Indian government examined this issue in the 1920s. It then authorized the Indian

³¹ See Rice (1974) for a discussion of US funded extension in Latin America in the 1940s.

Agricultural Research Institute (IARI) to offer postgraduate courses in agriculture (Goldsmith 1990). In 1958, the Institute was granted university status and it became the National Postgraduate School of Agriculture, thus allowing it to offer both M.Sc. and Ph.D. degrees in virtually all fields of agriculture. IARI provided structured courses to graduate students in contrast to the traditional Indian system in which Ph.Ds were awarded on the basis of only a dissertation and an oral exam. The most important contribution of the IARI was the training of a large number of Ph.D.'s to staff the SAUs that were being set up in the late 1950s and 1960s, and doing so on the basis of graduate degrees that required both course work and field research (Pal 1974).

In 1949, the University Grants Commission recommended that a system of rural universities be created. An Indo-American team was formed and later an Indian delegation visited the U.S. It was impressed with the contribution of the Land Grant Universities to the U.S. development experience. Upon its return to India, the team recommended the establishment of at least one State Agricultural University (SAU) per state. A second Indo-American team was established in 1959 and it urged the government to develop a few pilot SAU models that could be studied and replicated. In 1960 India took the bold decision to create a new rural institution – the SAU – that was directly responsible to the states and beyond the control of the Federal Ministry of Education. Later, USAID provided funding for five American universities to enter into partnerships with nine of the newly established SAUs. The five American universities supplied 300 professors on assignments of two or more years to these nine Indian universities. An Agricultural Universities Commission was established in 1960, and the government invited the Rockefeller Foundation to help to craft a system of core institutions to support the development and spread of the Green Revolution (Lele and Goldsmith 1989).³² The Ford Foundation also helped the Indian Council of Agricultural Research to build centers of excellence to serve all of India at some of the state universities during the 1960s.³³

The Governor of each state is the nominal head of the university and he/she appoints a Vice Chancellor for the University. Each SAU has a research and teaching mandate. Funds for research come from state governments, the Federal government through the Indian Council for Agricultural Research (ICAR), and other sources such as foundations and the private sector. Today, 42 state agricultural universities (some states have more than one) are interlinked to form a national system. Most of the SAUs have respectable M.Sc. programs and an increasing number have solid Ph.D. programs. Tanzanian and Nigerian missions have visited India to study the SAU system.

The introduction of the SAUs and the directive that the States transfer their extension and research programs to the control of the SAUs was initially met with resistance. In fact, some of the States dragged their feet up to a decade before they executed these transfers. But even more

³² This is a classic article on the role of the Rockefeller Foundation in helping build India's national research and higher education institutions. The Foundation supplied long term advisors (11 years in the case of Cummings and five for Moseman) and urged the government to focus and concentrate crop trials on wheat, rice and maize. The Foundation offered sustained support for the crop improvement program for almost two decades. In addition to helping generate and transfer new technology, the Foundation helped develop human capital through a large fellowship program. But India has enjoyed political stability since independence in 1947, a central ingredient that has been missing from Africa.

³³ For example the Foundation extended a \$642,000 grant to Punjab University to develop a national program in water conservation in association with the Department of Agricultural Engineering.

critical was State financial support for the SAUs. When the SAU's were first established in the 1960s, the States paid 30 to 35 percent of the entire SAU budget. Today, the States pay 80 to 85 percent of the SAU budgets, with balance coming from the Indian Council of Agricultural Research and the private sector. A number of authors have commented that the quality of the individual SAU today is mainly a function of the degree of financial support received from their respective state and the local accountability that goes with it. (Easter et.al. 1989). M.S. Swaminathan contends that the SAUs have been an important success story and a contributor to India's national food security objectives.

A massive build up of human capital was a central feature of India's drive to cobble together a productive agricultural research, extension and education system. Because of the lack of knowledge about US institutions, the Rockefeller Foundation awarded 90 short term travel grants to Indian scientists and teachers to visit agricultural colleges and experiment stations in the United States between 1959 and the early 1970's (Lele and Goldsmith 1989).³⁴

As background to sending Indian scientists to overseas universities, it should be kept in mind that India had a head start on Africa in terms of the availability of training institutions in India at independence. For example, the agricultural college at Lyallpur was started in 1901 and it became the Punjab Agricultural College in 1906 and affiliated with Punjab University in 1917. In the 1920's, graduate education was introduced at the master's level followed by doctorate programs in the 1940s. By contrast, the first university in Nigeria was established at Ibadan in 1948 and two years later it opened a Faculty of Agriculture. However, it proved difficult to attract first-rate students to study agriculture. For example, in 1950 only one student stepped forward to enroll in agriculture as compared with 50 students in medicine, 113 in the arts and 58 in the sciences. India sent over 1000 Indians for advanced training in agriculture and natural resources to the United States during the 1960s and 1970s (Lele and Goldsmith 1989).

Larry Busch (1988) studied the evolution of the SAUs from 1960 to 1988 and prepared a provocative report on the future of the SAUs. He asserted that the problems that the SAUs were then facing were issues of a more global nature than simply increasing production. He argued that the global issues included improving and diversification of diets, food processing technologies, building an increasingly diverse agriculture, including milk, poultry, fruits and vegetables, as well as horticultural and high value crops for exports. This global theme was repeated at the celebration of India's 50th anniversary in 1997 when R.S. Paroda argued that "There should be a shift from an information-based curriculum to a skill-based, problem-solving curriculum in the newer sciences, such as biotechnology, information technology and geographic information systems" (Mehta and Mathur 1999). A committee chaired by M.S. Swaminathan was empowered to examine the linkages between the SAUs and the research institutes in the Indian Council of Research. The Swaminathan Report made 20 recommendations, including the need to prepare for global competition, harnessing frontier science and technology, strengthening partnerships, teacher training and retraining, computer-aided extension and instruction, and others. Two of the twenty recommendations deserve special mention in this global survey of eight countries. The first is women's technological empowerment and the second is the financing of agricultural education.

³⁴ The Rockefeller Foundation resisted the pressure to invest in university buildings and equipment.

The Swaminathan Report argued that women’s technological empowerment holds the key to rural prosperity and household nutritional security, and recommended that home science education needed to be totally reorganized. The Report suggested that the first three years of training should deal with general topics such as nutrition and science, but that the final year should provide options such as biotechnology, biodiversity, seed technology and food technology. An alternative term to “home science” was suggested: College of Agricultural Technology and Nutrition for Women.

The Swaminathan Committee Report also made the case for multiple sources of financial support for agricultural education and research. First, since agricultural education is a state subject, it is the responsibility of State Governments to provide a major share (about 80 to 85 percent) of financial support for agricultural education. Through this State financing, pressure can be exerted on the SAU’s to conduct research and extension on state problems. The second source of financial support for the SAUs is the Indian Council of Agricultural Research. The Council acts like the University Grants Commission and it has responsibility for providing supplementary grants to improve the educational standards in SAUs. The Swaminathan Committee recommended that one percent of GDP at the Central and State levels should be earmarked for agricultural research and education, of which at least 20 percent, both at the central and state levels, should go for agricultural education. The third source of financial support for the SAUs is the private sector.

India has built diverse and complex agricultural research and agricultural education systems. The research institutions come under the national apex body, the Indian Council of Agricultural Research (ICAR) and the State Agricultural Universities (SAU) report to the states. At independence, agricultural education at the university level was offered by only 17 Agricultural colleges. When India celebrated its 50th anniversary in 1997, it had 34 SAUs³⁵ and many other State Colleges and State Agricultural Universities. In 1997, the annual student intake in the SAUs was 13,500 at the undergraduate level, 6,000 at the Master’s level and 1,550 at the Ph.D. level. This is an impressive achievement.

To summarize, India’s development of its agricultural research and universities system since independence was accelerated by the threat of famine, dedicated and open Indian leadership, the serendipitous availability of high-yielding wheat and rice varieties in the mid-1960s, and long-term donor assistance to build an agricultural knowledge system. India is a textbook example of how a poor country can build an interactive and productive agricultural knowledge system over a period of 40 to 50 years. During the 1960s and 1970s, the Ford Foundation financed a large-scale extension build-up, the Rockefeller Foundation helped strengthen agricultural research, and USAID helped conceptualize and finance a new institutional innovation – State Agricultural Universities.

India has achieved a successful institution-building program, but the current 42 State Agricultural Universities have had a variable track record in terms of quality and the ability to mobilize financial support. Many of the SAUs are in need of reform and the ICAR is pressing the SAUs to develop partnerships with regional and global universities and the private sector in order to facilitate this process. Without question, much of India’s success in the past 50 years has

³⁵ The number of SAU’s has been increased to 42 today.

been credited to political stability, its openness to institutional innovation, and a sense of urgency to innovate and contribute to increasing household food security and to reducing poverty.

Brazil's Agricultural Success Story: Insights for Africa

Africa, the donor community, and agricultural educators have much to learn from Latin America's development experience over the past forty years (Levy 2005; World Bank 2005; Schuh 1970). There are several ways to tap this experience. The first is to select an issue/problem and examine it within a regional framework. Fienup's (1976) analysis of introducing M.Sc. programs in agricultural economics in eight countries in Latin America in the 1960s and 1970s is overflowing with insights that are relevant to Africa today. Another approach is to take a development institution such as extension and examine the reform of extension systems in Latin America and draw lessons for Africa.³⁶ A third avenue is to focus on a country that is considered an agricultural success story. Brazil has been selected for a case history because of its agricultural success.

The focus of this case study of Brazil is on the evolution of research and education linkages over the past 50 years.³⁷ Brazilian policy makers have developed macro-economic policies and a system of agricultural research and education that have turned it into a global agricultural powerhouse that is feeding 175 million people at home and is the world's largest producer of coffee, oranges and sugarcane. Moreover, it is the global leader in bio-fuel research.³⁸ Brazil is also a major exporter of soybeans, coffee and orange juice (Roseboom 2004). However, most of the growth in production has come from medium- and large-scale farms while bypassing the Brazilian smallholders.³⁹

Brazil's human capital strategy was launched in 1953 when USAID provided some support for institution-building and extension programs at the Federal University at Viçosa. A decade later, USAID provided support to four American and four Brazilian agricultural universities, one for each region of the country. Over the life of this ten- year USAID-funded project (1963-73), the emphasis was on improving the quality of undergraduate teaching and helping hundreds of Brazilians pursue graduate training in Brazilian and U.S. universities. The size of the human capital improvement program is illustrated by the fact that 914 Brazilian graduate students in the agricultural sciences were in residence in U.S. universities in 1970/71 (Swanson 1986).

The results of Brazil's human capital improvement plan are impressive. In the Federal University of Ceará in the Northeastern State, only two percent of the faculty had advanced degrees in 1963 and most worked part-time. A decade later, 86 percent of the faculty worked full-time and by 1986, 82 percent of the faculty held advanced degrees (Sanders et al 1989 and

³⁶ Uganda has borrowed ideas from Chile on the privatization of extension.

³⁷ But Africa does not have much to learn about agricultural extension from Brazil because it is in disarray on how to organize and assist small, medium and large scale farms. In the early 1990s, the Government of Brazil closed its extension program and transferred it to the state governments. But when the new Government took over in January 2003, it transferred the responsibility from the Ministry of Agriculture, Livestock and Food to the Ministry of Agrarian Development with a goal to assist family farms (smallholders) (Roseboom 2004). Today extension is primarily a state and federal function.

³⁸ Brazil's research on converting sugarcane into bio-fuel started some 25 years ago.

³⁹ The present government is addressing this social imbalance.

Schuh 2006). The introduction and expansion of graduate (M.Sc.) programs was a key factor in expanding the research output of Brazilian agricultural universities. For example, from 1973 to 1989, the Federal University of Ceará produced 335 M.S. theses in all fields of agriculture (Fox 2006).

Without question, the Brazilian human capital programs in agriculture were successful. Much of the credit for this goes to the Federal Government and the initiatives of the Ministry of Education. The University Reform Act of 1968 tied promotions to higher graduate degrees and other academic performance criteria on agricultural higher education. The reform eliminated the European system of having one professor per department and replaced it with a departmental structure and U.S. academic ranks. The reform also required academic staff members to work full-time (Fox 2006).⁴⁰

The highlights of Brazil's human capital improvement program are the following:

- expanded the number of graduate programs,
- increased the percent of faculty members with advanced degrees,
- purchased books and journals for the libraries and equipment for the labs,
- created long-term human capital chains among U.S. and Brazilian scientists, and
- generated a demand for university graduates, research and faculty consultancies in response to the growth of private input and marketing firms in the 1970s and 1980s.

The USAID contracts with four American Land Grant Universities and four Brazilian Universities were effective in teaching, mentoring and expanding the research output of universities. But they did not succeed in recreating the Land Grant University model because Brazil was already implementing its own national research and extension programs (Sanders 2006). The two main activities for visiting American professors were to improve the quality of teaching and to help extract more research output from the universities. The introduction of graduate degree programs addressed the research goal because the professors and M.Sc. students represented a cost-effective way to carry out research. For a summary of a success story of the Ford Foundation's support in building macro-economic capacity in departments of economics throughout Latin America, see Harberger's (1998) "Letter to a Younger Generation."⁴¹

Today, Brazil has more than 5,000 full-time equivalent researchers and its total research expenditure accounts for about half of the total agricultural research spending in Latin America. However, Brazil took some hard decisions on reforms that are relevant to African NARS today. The Brazilian Agricultural Research Corporation (EMBRAPA) was established in 1972 as a private-law, public institution with administrative and financial autonomy linked to the Ministry of Agriculture and charged with using science and technology to increase agricultural productivity. EMBRAPA's charter included a provision that it did not have to follow Civil Service hiring practices and it was free to hire whoever was considered most qualified at national and international wage rates (Pastores and Alves 1977). When EMBRAPA became operational

⁴⁰ Although Fox (2006) reports that this did not eliminate moonlighting, it curtailed it.

⁴¹ Harberger devoted much of his University of Chicago career working with Latin American students and teachers on macro economic issues, especially in Chile.

in 1973, it took the difficult decision to upgrade the quality of its scientific staff by retaining only half of the 6,705 employees of its old system (Pastores and Alves 1977). It then launched a massive human capital program and spent 20 percent of its total budget from 1974 to 1982 on training programs in Brazil and abroad. In fact, in the late 1970s and 1980s, EMBRAPA had an average of more than 300 researchers enrolled each year in postgraduate training programs. Today, one half of EMBRAPA scientists possess a Ph.D. degree.

But 40 years ago no one would have predicted that Brazil would have one of the strongest NARS in the world today. In 1965, T.W. Schultz surveyed U.S. assistance programs in Latin America over the 1945-65 period and concluded that “the sad truth is that not a single first class agricultural research center has been developed (in Latin America) as a consequence of these (U.S.) activities” (Schultz 1965, p.63). But EMBRAPA’s success story reminds African scientists that the future of agricultural research in Africa is not foreordained. Much will depend on political leadership, vision, policies, strategies, incentives, innovations and hard work over a period of 30 to 40 years (Macedo et al 2003).

Brazil, Malaysia and China have honed their skills in developing incentives for building and retaining a scientific labor force. The incentive structure for Brazilian scientists is designed to keep the best scientists at home and thwart the brain drain. For example, in 2001 the average salary for a senior scientist at EMBRAPA’s Tropical Cassava and Fruit Research Station was between US\$14,500 and US\$35,000 per year (Matos 2001). In Ghana, by contrast, the Director of the Government’s Cassava Research Program reported that the salaries for his researchers were “too low to quote” (Otto 2000).

Almost 20 years ago, Brazil launched its research on GM crops and today it, along with Argentina and Chile, are among the major producers of GM crops in the world. Brazil is now looking to the future and figuring out how to close the social imbalance between the large farms and the smallholders while intensifying research on new products such as bio-fuel for home and international markets. One of the puzzles is how to reward researchers who develop new products and crop varieties. For example, a group of researchers spent 20 years in developing the process to convert sugarcane to produce bio-fuel that now satisfies Brazil’s entire domestic oil and gasoline market.⁴²

Without question, public sector investments have been of strategic importance in both research and human capital improvement in Brazil. The Brazilian Agricultural Research Organization (EMBRAPA) generates 97 percent of its budget from public and only 3 percent from foreign sources (Roseboom 2004). The opportunity for Brazil to offer technical assistance to Lusophone Africa is an obvious option that requires study and debate. For example, Mozambique is decentralizing its national research system and it needs a vigorous staff development program. This offers an opportunity to establish human capital chains among Mozambicans and Brazilian scientists. The nature of agricultural production and the underlying biological sciences dictate the need to develop a strong agricultural science base within Mozambique. Brazil is now in a position to become an important contributor of technical assistance to Mozambique, Angola and other countries in Africa.

⁴² The University of Campinas-Sao Paulo is carrying out research to develop GM sugarcane to enhance its value as a bio-fuel.

Denmark: The Growth of an Agribusiness Nation

During the 1870s, Denmark was a nation of large-scale farms producing butter and grain, primarily for the British market. But this model came under assault when the United States opened the transcontinental railway and began exporting wheat to Great Britain and Europe.⁴³ As a result, the economic base of Danish agriculture was undercut, prompting wheat prices to fall by 40 percent and butter prices by 15 percent (Friedman 1974). However, after a few years of turmoil, a number of technological advances spurred the transformation of Danish agriculture. In 1878, a Danish inventor developed a cream separator and a few years later small-scale farmers organized two new institutions – the cooperative creamery and marketing cooperatives. Four factors – investment in education, the cream separator, cooperatives, and a shift from producing grain to dairy, bacon and pork exports – transformed Danish agriculture. Ruttan (1982) and others contend that the introduction of compulsory education over 150 years ago (1814) and significant public investment in higher agricultural education played important roles in Denmark’s transformation from a grain-dependent to a diversified agribusiness exporter.

In 1783, the Royal Agricultural and Veterinary College was established in Copenhagen and in 1858, the Veterinary College was reorganized to include agriculture and chemistry. Although Denmark was a small nation of 2.5 million, the Agriculture and Veterinary College was well known in Europe. The Danish College and the German graduate educational model were both forerunners of regional models of education. In 1917, the Royal College had 400 male and female students enrolled from Denmark and several foreign countries, including Bulgaria, Romania and Finland (Haggard 1917).

In 1814, when compulsory education was introduced, schools were developed and literacy became common even among the peasantry (Ness 1961). In 1850, the Folk High Schools were introduced as free adult boarding schools. Today, there are around 90 Folk High Schools in Denmark with courses lasting from one week to ten months.

The cow was the centerpiece of Denmark’s agricultural transformation. Cows on small-scale farms produced milk and the cooperative creamery picked up the milk by horse-drawn wagons every day and took it to cooperative creameries. The cream separator divided the milk into cream for making butter and skim milk was fed to pigs and converted into bacon. Prior to the invention of the cream separator, the production of butter was dominated by large-scale farms (manors) which could afford to build a “skimming hall”, a ventilated room where milk was kept fresh for a day or longer to allow the cream to rise and be skimmed off to make butter. The invention of the cream separator removed the need and the capital constraint of building a skimming hall and reduced the volume of milk that had to be produced daily in order for butter production to be economically viable.

With the advent of the cooperative creamery, a sufficient quantity of milk could be picked up daily from small-scale farms that were cooperative members so that the creamery could make butter every day (Ruttan 1982, p.431). The inflow of cheap grain from the United States and Russia in the 1870s and 1880s, together with growing markets for livestock products in Europe,

⁴³ See Haggard 1917; Jensen 1937; Ness 1961; Ruttan 1982; and, Chipeta 2004

spurred Danish farmers to shift from making butter on large-scale farms to small-scale farms producing bacon and dairy products (e.g. cheese, butter, etc.) for European markets. In 1917, Haggard studied this transformation and reported, “Whatever else may be doubtful or open to argument in connection with Danish agriculture, one thing remains clear, namely, that it owes the greater part of such prosperity to the co-operative movement” (Haggard 1917, p. 188).

From 1870 to 2000, small- and medium-sized farms were dedicated to mixed farming and all were owner-operated. During this period, the government supported public investment in research and education, helped pay the salaries of livestock advisors (a forerunner to the extension service) employed by farm organizations, awarded prizes at livestock shows, supported animal breeding centers, and published herd books. But the most important innovation between 1870 and 1890 was the spontaneous development of producer and marketing cooperatives. Many have argued that the foundation of mass literacy helped farmers come together and develop cooperatives and business enterprises. The first cooperative creamery was founded in 1882; eight years later there were 679 of them. In 1930, agricultural exports accounted for 80 percent of all Danish exports, thus making Denmark the agribusiness nation of the world. Looking back, two of the most crucial decisions taken by the government were to introduce mass education and to reject a proposal by the Parliament to impose tariffs on grain imports. The rejection has forced Danish farmers to innovate and remain competitive in global markets.

Today, the Royal Veterinary and Agricultural University (KVL) in Copenhagen is the only Danish University specializing in agriculture and veterinary science. It is responsible to the Danish Ministry of Food, Agriculture and Fisheries. There are currently 3,500 students attending KVL, including 400 PhD students.

The Danish Agricultural Advisory Center is currently the national center of advisory (extension) service for Danish farmers. The Center is owned and run jointly by the two main farm organizations: The Danish Farmers’ Union and the Family Farmers’ Association. Local and direct advice is given to farmers by 85 local advisory centers which are owned and run by local farmers and the family farmers’ organization.

Netherlands: The Continuous Need for New Knowledge

The composition of a nation’s agricultural exports is a remarkably good indicator of the structure of the industry and of the types of knowledge resources that have to be generated or imported to maintain a competitive position in national, regional and global economies over time. Mulder and Kuper (2006) report that only 8 percent of the value of Dutch agricultural production is composed of crop production because Dutch agriculture is aimed at importing bulk products such as cereals and soybeans, and at exporting high value and processed products such as flowers, vegetables and products from the livestock industry. The generation of new knowledge is therefore extremely important for the Netherlands to compete in the global market, including newly opened links with China. China wants to learn from the horticultural development in the Netherlands in order to expand its flourishing greenhouse horticulture production in the Yangtze

Delta. In exchange, the Dutch industry is anxious to develop a promising new market for the sale of its greenhouse technology.

But the capacity of the Netherlands to go head-to-head with China did not materialize over the past fifty years (Korstanje 2006). In fact, the historical records show that 110 years ago, C.H. Claessen was the docent for the “winter school in horticulture” in the Westland area of the country. The winter schools taught growers about “unknown crops” in evening classes two or three times per week over a period of two winters. Because of the success of these schools, the town leaders and growers decided to establish a Horticultural Research station of 2.5 hectares in Naaldwijk in the Westland. This is the same area that is currently the center of the Netherlands’s leading greenhouse complex with over 2,500 hectares of horticultural crops. In 1910, research was launched on melon trials and the construction of various types of tomato greenhouses for evaluation by growers.

But the Dutch did not invent greenhouse technology. Around 1900, Dutch glasshouse horticulture lagged behind that of neighboring countries and the concept of the greenhouse was imported from Belgium, the cucumber house from England, and the Dutch light structure from the Channel Islands (Buurma 2001). The refinement of the greenhouses in the Netherlands was spearheaded by growers with the assistance of researchers in the small research station. The Dutch experimented with different types of glass and the Venlo glass was the first glasshouse where a number of different crops could be grown.

Over the past fifty years, the Netherlands has frequently reorganized its extension service to solve new problems with new knowledge from its schools, universities and the private sector. And since the Netherlands is among the most advanced countries in privatizing extension, it merits a review of the evolution of thinking among growers and extension authorities at Wageningen University (Roling 1988; 1998 and Van den Ban 1987; 1996). After the severe famine during the Second World War, food security assumed central importance and the number of extension workers was increased from 518 to 1,219 between 1946-1951 (Wielinga 2000). With the help of the Marshall Plan, Dutch agriculture introduced new machinery, adopted agricultural technologies, and increased food production. After World War II, Wageningen College was upgraded to Wageningen University and a number of branch research stations were set up and attached to the University. The founder of the Department of Extension at Wageningen University, Professor van den Ban, called this the period “the coming of age of extension.” Extension became known as a profession of workers who offered “assistance to decision-making processes” (1974). During the 1970s, extension evolved from the transfer of technology to the discovery and application of new knowledge. During the 1970s and 1980s, extension in the Netherlands was seen as a facilitator for empowerment, and participation became a major tool to enhance local organizations (Wielinga 2000).

During the 1980s, overproduction and pollution emerged as major national problems. The Dutch Ministry of Agriculture, Nature Management and Fisheries issued a report concluding that the Government had a key role to play in stimulating vitality in rural space which meant that it should encourage people to take responsibility for creating multifunctional rural space attractive to farming, recreation, living and making money. This decision meant that new knowledge had to be generated and extension workers had to be retrained to address rural space. But the

Government cut the extension budget in the 1980s and, following the example of privatizing extension in New Zealand and England, the Netherlands followed suit in 1989 and privatized extension (Wielinga 2006). The privatization was not pure in the sense of “private funding and private delivery” (Rivera and Zijp 2002) because in reality, it turned out that “the main change was the shift from a government service to a company with commercial goals and employees losing their status as government officers” (Wielinga 2006). Today, the jury is still out on the performance of this latest extension model.

The main lesson from the Dutch extension experience is that new knowledge is continuously needed to solve new problems over time. This also means that the educational system (schools, colleges, universities, farmers and the private sector) must be closely connected with extension managers so that farmers and farm organizations can ensure that the need for new knowledge is anticipated and generated. For example, now that Dutch scientists and managers are developing business and professional linkages with Chinese organizations, what skills should be developed in local schools to facilitate this new venture?

The Dutch educational system differs considerably from other countries. At the level of secondary education in the United States and elsewhere, agriculture is an optional subject. But in the Netherlands, the structure of agricultural education consists of four levels: (1) junior secondary level; (2) senior secondary; (3) agricultural schools for students from 15 to 18; and (4) practical training centers. Moreover, there are three recent trends in schooling. First, the percentage of students enrolled in production courses declined from 75% in 1975 to 25% today (with emphasis on marketing, gardening & water management). Second, student enrollment is increasing in the “green sector”. Third, enrollment at Wageningen University has declined and the total enrollment was 4,800, of which 1,200 were Ph.D. students in 2005 (Mulder & Kupper 2006).

Turning to the global flower industry, there is no question that access to public and private knowledge resources has enabled the Netherlands to go head to head with its major rival – Spain. The Netherlands is the main destination for Kenyan flowers (Wijnands 2005).⁴⁴ The major lesson that emerges from the Dutch experience is that access to knowledge resources is an on-going activity in the transition from one set of problems to another. The Dutch maintain their competitive advantage in the flower and horticultural markets through public and private partnerships and by maintaining one world class university, four levels of agricultural education, and managers and scientists who are known for their entrepreneurial skills. But the ultimate lesson is that development is basically a process of learning from experience and it all started 110 years ago during the winter courses for growers at Naaldwijk. Although public/private research partnerships are increasing in the Netherlands, van der Meer (2002) reports that securing private contributions are far from easy. Much time is required from public sector managers to negotiate and monitor private sector contributions. Nienke reports that private investment in agriculture and agribusiness was 58 percent in the Netherlands in year 2000 (Pardey and Beintema 2006). The KLM airline is part of the public/private partnership that promotes Dutch flower trade. KLM is a major shareholder in Kenya Airways and this helps air-

⁴⁴ On the organization of research, see Van der Meer (2002); Roseboom and Rutten (1998). For insights on marketing in an era of global supermarkets see, Labaste (2005) and Reardon et al (2003).

freighting the cut flowers from Kenya to the flower auctions at Aalsmeer near Schiphol airport in the vicinity of Amsterdam.

4. LESSONS FROM THE GLOBAL AET EXPERIENCE

The industrialized country studies reveal that building a system of core AET institutions requires a multi-generational time frame, a period of time that extends far beyond typical donor-financed projects. The historical AET experience shows that because of the accretionary nature of human capital improvement over a period of decades, the priorities for agricultural research, training and extension must flow from the vision of the political leadership of each country about the role of science and technology in the nation's development. The scientific leadership of a country then has the responsibility to start with the overall vision and develop a science and technology policy statement and strategies to interlink universities, public research institutes, extension and the private sector (Idachaba 1995).

The *first* lesson from the global AET experience is that mobilizing and sustaining political support for AET investments is the most important and most difficult issue to address in designing and financing a system of agricultural development institutions. The experience of the Philippines illustrates how political factors can condition AET development. From 1952 to 1972, the University of the Philippines expanded rapidly and admitted an increasing number of graduate students from other countries. But then, martial law was imposed in 1972 and since that time its economic growth rate has been substantially lower than that of Malaysia, Thailand and more recently, India.

Kenya provides another example. At independence in 1963, Kenya had one public university with a Faculty of Agriculture. Due to a number of overnight political decisions, Kenya has now added four more public universities. Today, Kenya maintains five different Faculties of Agriculture or Natural Resources. If Kenya is interested in gaining donor support to strengthen its M.Sc. programs, the first step would be for a group of Kenyan academics to complete a self assessment followed by the preparation of a Business Plan and a list of the needed reforms, including the possible mergers of some of its faculties. After the reforms are agreed upon, the next step would be for Kenyans to prepare proposals for help in financing and implementing the reforms. Unless the reforms originate in Kenya and are driven by Kenyan leadership and financial commitment, the long term financial sustainability of donor assisted projects will be questionable (Oniangó and Eicher 2004).

The country studies have revealed that many different ways can be used to mobilize political support for AET, and different ideologies and development pathways can be followed. For example, in 1884 the National Agricultural Association of Japan was established to exercise political influence on behalf of farmers. In the United States, the decentralization of agricultural research and extension to 50 states and 350 branch research stations established local and state links to the political system because most of the funding for research and extension comes from

state and local sources – not the federal government.⁴⁵ But in Africa, most of the funding for research and extension comes from national budgets and donor aid with little input from farmers and farmer associations in setting research priorities or assessing performance.

The eight country studies point out the critical role of public investment in helping a poor country “buy into the growth process.” Evenson (2003) uses this term to emphasize the up front public investments needed in research, rural roads, schools, irrigation systems before private investors will enter the input distribution and marketing sectors. Africa’s commitment of an average 2.4 percent of its government’s budget to agriculture is distressing in a continent where more than 60 percent of the people depend on the rural sector for their jobs, food and income (Fan and RAO 2003). Africa’s current expenditure on agriculture is dismal when compared with Asia’s public expenditure in the 1970s and 1980s. India spent 10 to 20 percent of its government budget on agriculture in the 1970s, while Malaysia spent an average of 20 percent of government investment on agriculture from 1960 to 1983 (Jenkins and Lai 1992).

The generally low level of African government funding for agriculture raises some tough political questions about priorities and the likely financial sustainability of future AET investments in Africa. To address these questions, a recent OED evaluation of a World Bank study of capacity-building in Africa reports that a paradigm shift is necessary to embrace a broader perspective that includes not only institutional rules of the game, but also “political dynamics that drive institutional change” (World Bank 2005a, p.49). These findings and the author’s experience reinforce the point that the political and institution-building issues should be explicitly addressed in depth instead of assuming that the promised level of future African financial support will be forthcoming for AET projects. Currently, 97 percent of the Malaysian agricultural research budget is from public resources and three percent from private. Likewise in Brazil, 95 percent is from public and a 5 percent from private sources. The global AET experience plays up the need for a sustained public sector commitment to investment in agriculture research over a period of decades.

The *second* lesson of the past century underscores the critical role of time and learning from experience about how to nurture the co-evolution of technology and institutions for a particular country. The eight country studies revealed that building a *system* of agricultural institutions is a multi-generational process. The average time required for the U.S., Japan, Brazil, and India to develop a productive and financially sustainable *system* was 40 to 60 years. To be sure, it is easy to develop one or two components of the agricultural knowledge triangle in a time frame of 10 to 20 years. For example, when donors were financing human capital development through fellowships for long-term overseas training, it was possible to focus on strengthening the research and extension arms of the knowledge triangle. But since overseas training programs have been slashed, the research–extension model of agricultural development represents an incomplete and unsustainable model of technology-generation when no consideration is given to human capital replenishment from local and regional universities.

The *third* lesson from the country studies is the futility of promoting one model of agricultural higher education such as the Land Grant model or one model of extension such as the Farmer

⁴⁵ For insights on mobilizing political support for agriculture in the United States see Hardin (1952); Hadwiger (1982); Marcus (1985); Sauer and Pray (1987); Ferleger (1990).

Field School model (Gallagher 2006). The Land Grant model of higher education was discussed in four (U.S., Brazil, India and Philippine) of the eight country studies as well as Nigeria. The following insights emerge from the experience of the Land Grant model at home and overseas: the Land Grant University is a unique American institution where the College of Agriculture internally manages the three arms of the agricultural knowledge triangle – research, education and extension. At Michigan State University, for example, the Dean of the College of Agriculture and Natural Resources meets with his three Associate Deans (extension, research and teaching) once a week to prod, cajole and force them to work together and contribute to the achievement of the multiple goals of the college. The weekly and monthly meetings help reduce “transaction costs” – i.e., the time and effort that it takes to collect information, negotiate and reach decisions. To be sure, in many countries it has been impossible to replicate the three components of the Land Grant model because of path dependence and entrenched research and extension departments. Nevertheless, the model has been successful in India, Ahmadu Bello University in Nigeria, Hassan II University in Morocco, and at UPLB in the Philippines.

The *fourth* lesson from the global AET experience addresses the matter of incentives. This relates to brain drain, the Diaspora, and the low returnee rate of students on long-term training overseas. To date, many commentators have criticized students who do not return home while failing to mention that many countries treat their scientists like “high class clerks in the bureaucracy of their government” (Schultz 1984). Today, a large number of commentators are promoting the idea that many African scientists in the Diaspora should return home to pursue their professional careers. But M.S. Swaminathan, former Director of the NARS of India and Director General of IRRI, argues that “not much time should be wasted on questions like the brain drain. What is important is to nurture and care for the brains remaining in the country” (2004).

Two examples illustrate ways of mitigating the brain drain. In Malaysia, overseas training is considered as an investment into the national research system. Malaysia has used a set of monetary (subsidized automobile and housing loans) and non-monetary incentives (free trip to Mecca) to reward and retain scientists. Today, new research officers in MARDI in Malaysia have an opportunity for overseas study after one to three years on the job. In Chile, world class Ph.D. programs have been developed and its universities are extremely important components of the National Agricultural Research system. The number of researchers (50) in four universities in 1960 has grown to seven universities by 1995. Competitive research grant programs in which universities compete represent a large share of research funds for universities (Roseboom 2004). Today, Chile has 16 universities with agricultural research capacities. In short, Chile has developed a system of institutions and incentives to reward and retain scientists.

An American soil scientist with vast experience in helping get his postgraduate students to return to Africa reports that “The critical issue is having a professionally rewarding environment as a means of attracting postgraduates to return to Africa and stay. There also need to be assurances that the home country will indeed hire them. In many countries, the work environment has improved incentives. This is crucial because imposing bonding requirements and limiting students from going overseas to certain destination countries deals with the symptoms rather than the cause of the brain drain.”

The *fifth* lesson is that the increasing cost of M.Sc. and Ph.D. training has attracted the attention of many donors who are urging universities in Sub-Saharan Africa to cut the cost of training by adopting the sandwich model (Table 2) or by creating regional centers of excellence in graduate training. The eight country studies and follow-up communication with many academics around the world confirm that many high quality M.Sc. programs are currently available in countries such as India, Thailand, Chile and Brazil. In fact, one can go so far to say that, with the exception of Africa, most students desiring an M.Sc. degree can obtain a solid degree at home or in a neighboring country in Asia and Latin America. The wide gap between the cost of an M.Sc. in India and other parts of the world partially explains why an increasing number of Africans are enrolled in Indian universities. The number of universities introducing sandwich M.Sc. and Ph.Ds is increasing because of donor pressure. But the lack of a definitive assessment of the sandwich program, together with evidence of delayed degree completion and high transaction costs, means that the jury is still out on sandwich graduate programs.

The *sixth* lesson is that country studies provide some insights on how to extract more research output from African universities. Since academics in African universities typically spend about 25 percent of their time on research, how can their research be focused on high priority national problems rather than turning out what Vice-Chancellor Francis Idachaba of Kogi State University in Nigeria has called a “thick slug of consultancy reports for donors.” The starting point is that one should expect only a trickle of research output from African universities that only offer B.Sc. programs. The key to greater research output is to invest public resources in strengthening graduate programs and research facilities in order to increase the number of graduate students who can work in research partnerships with their academic advisors. The Brazilian country study revealed that the Federal University of Ceará produced 335 M.Sc. theses between 1973 to 1989. The graduate student academic research team is a low cost and proven way to carry out research in Brazil, India, Denmark and many other countries.

The *seventh* lesson from the global overview flows from the rapid increase in the area planted to GM crops in Brazil, India and China. By contrast, South Africa is currently the only one of 53 countries in all of Africa that is growing GM crops (Table 3). This is an important issue because of the widening technology gap between Africa, Asia and Latin America. To be sure, the GM debate is surrounded by uncertainty and politics – both in terms of using food aid from countries that do not have “identity preserved supply chains” and in terms of the fear of environmental and health risks associated with growing GM crop varieties. There is also intense political concern among African governments about a loss of access to European markets. This poses the question: what types of accelerated human capital improvement programs are needed to enable African nations to close some of the GM gaps between Africa and India, China, Malaysia, Brazil and Chile (Eicher, Maredia and Sithole-Niang 2006)? What essential equipment is needed for biotech research labs? How should GM research be organized so as to spread the fixed costs of labs and equipment over a number of countries? Also, what can be done to generate science-based information on biotechnology that can better inform African policymakers?

Table 3. Seven Case Studies: Projections of the Timeline for the Release of GM Crops to Smallholder Farmers in Africa¹

Crop	Target Country/Region	Problem Addressed	Research Started (Year)	Projected Time of Delivering GM Crops to Smallholder Farmers after 2006
Sweet potato	Kenya	Feathery Mottle Virus	1991	8 or more years
Potato	Egypt ² South Africa	Potato Tuber Moth	1993	4 or more years
Maize	Kenya	Maize Stem Borers	1999	4 or more years
Banana	Uganda	Banana Weevil and Diseases	2000	7 or more years
Cowpea	West Africa	Pod Borer	2001	8 or more years
Cassava	Kenya, Nigeria, Malawi	Cassava Mosaic Virus	2001	8 or more years
Cotton	Major cotton growing countries	Cotton Bollworms	2000	5 or more years

Source: Eicher, Maredia and Sithole-Niang (2006).

1. Excluding South Africa where GM crops are grown commercially.
2. Michigan State University Bt potato research with Egyptian scientists was discontinued in 2001 and shifted to a partnership with the Agricultural Research Counsel in South Africa.

Post Script

From the 1960s to the 1980s, Africa's universities performed a valuable service by increasing the output of teachers, researchers and civil servants. But over the past 15 years, African universities and faculties of agriculture have been hard hit as a high percentage of senior academics (the scientists who set the tone, direction and quality of the educational experience and mentor younger scholars) have migrated to NGOs, the private sector and overseas posts (BIFAD 2003 and IAC 2004). Since the first generation of African scientists, teachers and managers has by-and-large retired, we can pose several questions: How and where will the next generation be trained? By distance learning or sandwich programs? In national or regional centers of excellence? In Africa or overseas?

Without question, the African human capital crisis is severe. It is not amenable to a quick fix, and bodes ill for the future. African scholars and researchers, with their unacceptably low salaries and inflation-riddled retirement programs, working with outmoded scientific infrastructure and thin operating budgets, are poorly equipped to train the continent's next generation of agricultural scientists. Africa's human capital challenge calls for a renewed African and donor financial commitment along with new partnerships to expand postgraduate training within Africa, drive down the cost of graduate education, improve the quality of the university experience, and increase the quantity of research output by African universities.

This study has identified some noteworthy initiatives by scholars in universities outside Africa to help Africans gain greater access to electronically available knowledge, develop distance education courses, and mentor graduate students when they are in the field carrying out their

research thousands of miles from their home university. *Appendix A* discusses how three electronic innovations (TEEAL, AGORA, and HINARI) can help African scientists, teachers and students gain access to the global scientific literature. *Appendix B* summarizes nine innovations in agricultural higher education, including distance education, a joint graduate program of African universities (CMAAE and AERC), and various African partnerships with overseas universities.

5. HARD CHOICES AND GOOD PRACTICES

The eight country studies have raised questions about the adequacy of the knowledge base for generating a set of recommendations for Africa based on demonstrated good practices from other countries. For example, it is easy for the IAC (2004) study to recommend a regional center of excellence without citing any regional success stories in Africa. Likewise, other commission reports have endorsed the sandwich model for graduate training because it is cheaper than the conventional models where a student takes all his courses overseas. But many issues that require empirical study still surround the sandwich model. Moreover, hard choices on how to increase the connectivity between AET institutions and the NARS and CGIAR centers remain pending. As T.W. Schultz once noted, the relationships between the IARCs and local universities are “all too tenuous.” For these and other reasons, this chapter points out a number of hard choices that require further study and debate, and then discusses good practices pertinent to these decisions.

Hard Choices

1. *AET Reforms in Africa.* How should AET reform be initiated? In proceeding with an AET program for Africa, the case studies of the United States, Japan, Denmark and the Netherlands have pointed out the critical importance of internally motivated and executed reforms. The case studies have emphasized the crucial role of decentralized decision-making as a means of mobilizing the voices of farmers in the political process. One of the difficult challenges facing donors is the need to press for educational quality reforms at a time when the number of universities in Africa (e.g. 75 in Nigeria) is increasingly almost weekly. The global evidence suggests that African educators should study how AET reforms were motivated, planned and executed in Brazil, China and Malaysia over the past 40 years. For instance, when EMBRAPA was set up in the early 1970s, it was given authority to cut more than one-half of the 6,700 scientists in its labor force. The new leadership of EMBRAPA then proceeded to send 1,000 scientists (the same number as India at the time) for local and overseas training. Likewise, in China when the political leadership issued a call to build a modern agricultural research system, the entire scientific labor force was divided in half. Scientists in the most talented pool were given a large increase in salaries and improved incentives such as housing allowances and the ability to pursue non-government employment for several months a year. The bottom line is that African educational and scientific communities must take the lead in pressing for reforms and relevant incentives as the starting point in negotiations. But this process will take time.

India is a good example of the need for an “extended period of political activity” to get a new educational system off the ground (Goldsmith1988). In 1948, a government report called for a major initiative to strengthen rural universities in India. Because of the skepticism about the

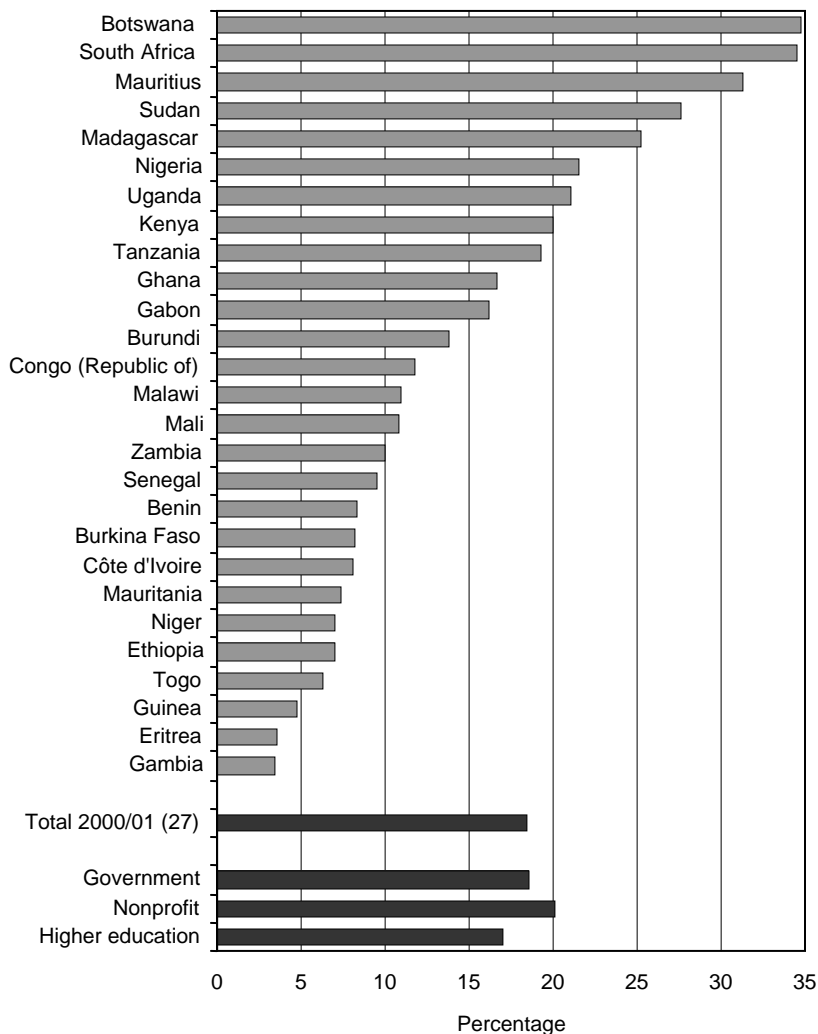
Land Grant model, the Rockefeller Foundation awarded travel grants for Indian educators to visit universities in the United States for two to three months. In 1954, when negotiations bogged down, the governments of India and the United States set up an Indo-American team to study the reform of rural education and the Indian member of the team visited the United States for three months (Goldsmith 1988). Later, when the discussions ebbed, a second Indo-American team was formed in 1959. In all, it took a decade of intense discussion, travel grants and joint committees to generate the internal political consensus among Indians to launch the first SAU in 1960. The message for donors is the need for discussion and debate on the reforms that will be carried out as part and parcel of the funding package.

2. *Regional Centers of Excellence, Critical Mass and Small Countries.* Is there merit in the regional center of excellence model? The global experience has much to offer concerning the interrelated questions of regional centers and the “small country problem.” Small countries throughout the world have often made institutional decisions on the basis of historical, economic and political factors. Because of linguistic and historical differences, Belgium has four faculties of agriculture while its neighbor, the Netherlands has one world class university of agriculture at Wageningen. Because biotechnology research has such high fixed costs of laboratories, it is an appealing option to set up regional partnerships to incorporate the participation of scientists from small countries (Eyzaguirre and Okello 1993).

A rich body of literature surrounds the regional center of excellence model. Unfortunately, the high degree of risk associated with this model has not been given enough attention in this literature. For example, civil unrest in the Ivory Coast and in Zimbabwe highlights the danger of concentrating capacity-building programs in several countries in Africa. Experience has shown that even though donors may underwrite a regional institution of higher education for a decade or longer, it has been difficult to get national political leaders to make a financial commitment to continue the program after foreign aid is finished. A recent evaluation of a GTZ financed M.Sc. project for 13 years in southern Africa is sobering in this regard (Wollny et al. 2002).

3. *Gender Debates.* How can women contribute more effectively to agricultural development? Thirty years ago, Dunstan Spencer, an agricultural economist from Sierra Leone, studied the impact of a donor rice project on the hours worked by men, women and children in villages throughout Sierra Leone (Spencer 1976). Spencer’s research findings shifted the debate from Boserup’s concern over the number of hours worked by women to important issues such as the returns per hour of work by men, women and children. But the gender debate of the 1970s shifted to empowerment and gender balance issues. A new World Bank book, *The Other Half of Gender: Men’s Issues in Development* by Corries and Bannor (2006), brings the gender development debate full circle from a much needed focus on empowering women to a more comprehensive framework that considers gender as a system that affects both men and women (and children). In one of the country studies – Malaysia – females occupy 34 percent of the agricultural research positions, the same percentage as the two highest countries in Africa (Botswana and South Africa (Figure 2). In 2000, Stads and Beintema (2006) studied the position of women in 27 countries in Africa and found that an average of 18 percent of the researchers in the 27 country sample in Africa were female as compared with 20 percent in Latin America.

Figure 2—Africa: Share of female agricultural research staff by country, 2000



Source: Nienke M. Beintema and Gert-Jan Stads, 2006

Compiled by authors from datasets underlying the ASTI Country Briefs.

Several important initiatives to increase gender mainstreaming are currently underway in Africa. In 1990, Winrock International launched a program to enhance the future prospects of African women agriculturalists. To date, 37 women from nine African countries have been awarded scholarships to pursue degrees at the B.Sc. or M.Sc. levels. As of 2004, a total of 15 scholars had completed their degrees. Another innovative project to assist women in Africa is the AWLAE (African Women Leaders in Agriculture and Environment). The project is based in Wageningen University and is funded by the Dutch government. It currently supports 20 women from 12 African countries who are doing a Ph.D. at Wageningen on topics related to food in Africa and the impact of HIV/AIDS on agriculture.

But surprisingly, some 30 years after the seminal papers by Spencer and Pala, the gender issue seems to have become a political football, bouncing from empowerment to gender balance.

Meanwhile, little research is underway on strategic topics such as the following: Why do female researchers occupy less than 10 percent of the agricultural research staff in 12 countries in Africa (Figure 2)?⁴⁶ Why do a large number of African countries make so little use of the intellectual power of women to address their fundamental problems in science and technology? In this light, the gender program at Wageningen is a brilliant innovation.

4. Sandwich Programs. Can sandwich graduate programs be part of the solution? Sandwich programs have been used for about 15 years by universities in Eastern and Southern Africa in cooperation with other African and overseas universities. The three goals of the sandwich programs are to reduce the cost of M.Sc. and Ph.D. programs, increase the percentage of students who return home after degree completion, and build the capacity of African universities to offer some of the postgraduate courses for “sandwich students” before they go overseas for additional course work and the development of a research proposal. Wageningen University and universities in Sweden have been pioneers in the development of sandwich programs. Here are the 2006 guidelines for a sandwich Ph.D. student at Wageningen University:

Foreign Ph.D. candidates who are not employed by Wageningen University but have a grant only spend the initial and last 6-8 months of the 4-year Ph.D. Programme in Wageningen. The first period is spent elaborating on the proposal, studying the literature and following courses, with the thesis being finalized in the last 6-8 months. In the intermediate period, the Ph.D. candidate performs his/her research in the country of origin. These Ph.D. candidates must have the support of both their home institute and their supervisor at Wageningen University. The actual research takes place in the Ph.D. candidate’s own country under local supervision. During this period, contact with the supervisor in Wageningen is by email and annual visits (Wageningen 2006).

The results of various sandwich programs have been met with enthusiasm by donors but mixed evaluation by some academic staff members. The system is best suited for students who are carrying out field research, while it is of less value to a student specializing in plant breeding or molecular biology who requires access to a lab or expensive equipment. Also, academics report significant delays in degree completion because of the frequent lack of local funds to support field research and the high transaction costs involved in managing the system, including dual reporting and joint supervision. An in-depth assessment of the sandwich program experience is needed to guide African and donor policies on this issue.

5. Basic Research in Agriculture. What portion of government and donor funding for agriculture should be allocated to basic research? One of the tough questions for African policy makers and donors to address is whether to increase their support for basic research on food crops that might have a payoff several decades or longer down the road. Both Worthington (1958) and later Odhiambo (1967) made the case for basic research in agriculture at the beginning of Africa’s independence in 1960. But with increasingly frequency, researchers at national and CGIAR research stations are being pulled downstream by donors to work on today’s problems. However, the present “downstream focused research” of both the NARS and the

⁴⁶ For more information on gender, see the pioneering studies by Dunstan Spencer (1976); Achola Pala (1976) Karl et al (1997); Stads and Beintema (2006). For a literature review on women and science, see Sheridan (1998).

CGIAR has produced only a few “islands of success” in Africa in terms of high-yielding food crops (Haggblade 2005). Since donors have drawn CGIAR scientists downstream to work on applied problems (e.g., variety testing), one of the hard choices facing African governments and donors is whether to shift more funding and personnel to upstream/ basic research.

Cassava comes to mind as a crop in need of basic research thrust because it is the second most important food staple in Africa. The current cassava varieties have their origins in research by H.C. Storey in 1935 that involved importing mosaic-resistant varieties from Java to the British colonial research station at Amani in Tanzania (then Tanganyika). Soon after the CGIAR sponsored International Institute of Tropical Agriculture (IITA) was opened in Nigeria in 1970, a young plant breeder, S.K.Hahn, set up a cassava research program. After six years of research, he hit the jackpot with the release of a variety TMS (Tropical Manioc Selection) that was resistant to mosaic virus and increased on-farm cassava yields in Nigeria by 40 percent without fertilizer (Nweke, Spencer and Blackie 2002).⁴⁷ Hahn admits that his TMS varieties were critically dependent on Storey’s basic research on mosaic disease some 40 years earlier. However, only currently a handful of scientists presently work on cassava research in Africa. By contrast, Brazil (the original home of manioc) had 23 researchers working on cassava and fruit crops in 2001 (Matos 2001). Without question, Storey’s pioneering basic research on mosaic disease in the mid-1930s was directly linked to the subsequent development and release of the TMS varieties in Nigeria in the mid-1970s. Basic research frequently creates the knowledge reservoir from which applied break-throughs later emanate.

A high-level team of scientists should be commissioned to study the reasons why the CGIAR centers in Africa are being side-tracked by donors into fire-fighting tasks rather than focusing on basic research on food crops that was the CGIAR system’s original mandate. Is it because the neglect of agricultural higher education has eroded African capacities for basic research? If an independent team is appointed, the starting point is reading the 1950 book by H.C Storey, *Basic Research in Agriculture: A Brief History of Research at Amani, 1928-1947*.

Good Practices

1. *Rebuilding Intellectual Leadership.* The preparation of this paper on the evolution of global trends in AET has drawn on the papers by the World Bank’s AKIS team, including Byerlee and Alex (1998), Alex and Byerlee (1999) and Van Crowder and Anderson (1997). The papers highlight differences between the theory and practice of preparing and implementing comprehensive agricultural service projects because of the legacy of path dependence, entrenched extension and research services, and delays in project preparation produced by the involvement of multiple ministries. The publications on financing agricultural research (Byerlee and Echeverria 2005; McIntire 1998) and agricultural extension (Rivera and Zijp 2002; Anderson, Feder and Ganguly 2006) are of enduring value. Since USAID and the FAO have cut back the numbers of staff dealing with rural institutions, the Bank might usefully consider reactivating its AKIS knowledge team. If it were to do so, an early task would be research on rural institutions with emphasis on the co-evolution of institutions and technology over time, including appropriate AET models for different types of countries in Africa. For example, there

⁴⁷ Manioc is the Portuguese word for cassava which is also known today as tapioca.

is still no definitive study of the Farmer Field School Model in Africa even though the FAO and many bilateral organizations are up- scaling it.

2. *Constructing Knowledge and Innovation Systems.* Whether one uses a knowledge or innovation system is immaterial because the operative word is the *system*. The goal is to develop a knowledge/innovation system where the managers of the system can communicate and cooperate (often across ministerial lines), motivated by the common belief that increasing agricultural productivity can help improve the welfare of all members of society. Both public and the private sectors are potential participants in this system. The choice of public or private depends on a nation's history, institutions and political philosophy.

3. *Centralization and Decentralization.* Bonnen (1998) points out “one of the clear lessons from successful agricultural development throughout the world over is the necessity for a centralized national investment in agricultural research, complemented and coordinated with a decentralized capacity for adapting agricultural research to the highly variable local ecospheres within which agriculture is practiced.”

4. *Ministry of Agriculture or Ministry of Education?* In my judgment, the skills and experience of both the education and agriculture ministries should be brought to bear in conceptualizing, planning and implementing AET projects. But in most countries the Ministry of Agriculture should be given responsibility to implement at least two of the three core components because the transaction costs are high when these components are managed by separate ministries. The ideal model would be to have all three managed by the Ministry of Agriculture because one decision-maker could make the difficult choices earlier than when two or three ministries are involved. But this is a difficult goal to achieve in practice.⁴⁸ The best practice would be to prepare and implement joint AET and research projects.

5. *Managing the Transition.* Managing the transition from overseas to local graduate programs is a complex undertaking that would involve institutionalizing all M.Sc. training within Africa over a decade as well as training 1,000 PhDs at home and abroad over a 15 year period. About half of the 1,000 will probably need to be trained abroad, especially during years 1-10 when local Ph.D. programs are being established. It would be a mistake, in my judgment, to design an AET human capital investment plan based on training all Ph.D.s in all fields of agriculture solely within Africa.

6. *Faculty of Agriculture Capacity Building.* The easy AET task is to train students as one component of donor - financed research or extension projects. The difficult and needed task is to strengthen the training and research capacity within African faculties of Agriculture. Training should be treated as one component of strengthening faculties of agriculture.

⁴⁸ A recent World Bank review of 28 of its AET projects in the Africa Region for FY 98-04 and found that 27 were managed by agricultural specialists in the Bank and only one was implemented with the involvement of Education sector specialists from the Bank (Rygenstad et al 2005).

6. OPERATIONAL RECOMMENDATIONS FOR WORLD BANK AET INVESTMENTS

The goal of this section is to propose some operational recommendations appropriate for World Bank AET investments in Africa. Since development is basically a learning process, we begin by drawing on some insights from the Green Revolution experience of the 1960s and 1970s. In response to daunting communication problems in Asia at the time, the scientific and donor communities set up a number of temporary institutions, such as the Agricultural Development Council (ADC), to increase the connectivity between researchers, policymakers and academics and students in Asia and universities around the world. Poor communication infrastructure also prompted the use of annual professional meetings in different Asian countries to discuss new problems and solutions from countries in the ADC network.

But the world has changed considerably since the Green Revolution days of the 1960s. New technological progress (ICT, distance learning;-Appendix A) forces us to pose the question of *how* will future African scientists be trained instead of simply *where* will they be trained? Likewise, while biotechnology can boost food production, the introduction of GM crops raises a number of legal, political, economic, health and medical issues that must be addressed and resolved country by country. The GM crops also raise questions about the design of curricula to meet the skill mix required for students to compete in a global economy. Among the issues that add to the difficulty of planning and executing an AET program are HIV, globalization, and global warming. Appendix B contains an illustrative list of nine partnerships with universities within Africa and partnerships between African and global institutions that are designed to improve the performance of AET institutions.

Insights from Asia's Human Capital Support Institutions

India's food crisis of the 1960s and similar crises in Indonesia, Pakistan, Thailand and the Philippines spawned the development of three temporary regional support institutions to strengthen the human capital base in Asia.⁴⁹ The institutions were set up to cover the Asian region and they can provide some insights on why new AET initiatives by the Bank should start with Africa-wide initiatives followed by sub-regional and national initiatives.

The first institution, the Agricultural Development Council (ADC) of New York, was created in 1953 and personally financed by John D. Rockefeller 3rd to assist in accelerating agricultural development in Asia.⁵⁰ The ADC was expanded during the Green Revolution era (Stevenson and Locke 1989). Over a period of 32 years, the Council maintained a cadre of about a dozen agricultural specialists (Representatives), who were posted on long-term (5 to 10 years and longer) assignments in New Delhi, Bangkok and other Asian capitals and university campuses (Wharton 1969). The ADC Representatives offered fellowships, mentoring, and small research grants to Asian students. They also provided travel grants, research grants, and sabbatical leave support for Asian faculty members with special emphasis on building socio-economics capacity. The ADC representatives taught, carried out research, selected students for overseas study, and

⁴⁹ A former Director of Agriculture at the World Bank reported that the Bank spent about 30 percent of its annual budget on agriculture from 1974 to 1984 (Yudelman 1985).

⁵⁰ The first phase was for 15 years. Rockefeller decided that the first evaluation of the ADC should not be completed until year 15 because this type of program would require 10 to 15 years to achieve some meaningful results.

mentored them upon their return. Because of the personal attention and effective mentoring, the ADC provided fellowships for 532 Asian students for overseas study over the 32-year life of the Council. An impressive 91 percent of the students returned home (Stevenson and Locke 1989, p.75).⁵¹ The total expenditure of the ADC over its three-decade existence was \$100 million (expenses adjusted to 1985 dollars).

The second institutional innovation was the establishment in 1958 of the Economics Institute (EI) at the University of Colorado under the sponsorship of the American Economics Association.⁵² The goal was to help mainly Asian graduate students in economics and agricultural economics learn English and take refresher courses in economic theory and quantitative methods at the University of Colorado before they moved to a U.S. university to pursue M.Sc. and Ph.D. programs. The EI program represented a major innovation in international education because it provided for the first time, in a foreign student orientation program, refresher and supplementary training in the student's field of specialization in addition to English language training (Owen and Cross 1983). The program was limited to graduate students. The EI later expanded its geographical coverage to include students from around the world and an array of academic disciplines, including business administration. The refresher programs were tailor-made for each student and they typically lasted for a semester or two based on the progress of the individual student. Because of the dwindling number of students pursuing graduate study in agricultural economics and economics in the United States during the 1990s, enrollment declined and the Economics Institute was closed in 2002 after training 13,000 students over a 34-year period.

The success of the Economics Institute in providing English language training for Asian students poses the question: Who can provide English language training for potential graduate students, especially in Mozambique, Angola and Anglophone/Francophone West Africa? The Bank's operational response along these lines should be to help individual bilateral donors take on this important function – one donor for the English language program in Lusophone Africa and another donor in francophone West Africa.⁵³

The third institutional innovation to assist Asian students in closing the knowledge gap was the Franklin Book Program.⁵⁴ The program drew on local currency from the sale of U.S. food aid to reprint popular American textbooks on inexpensive paper in India and make them available at

⁵¹ The ADC as a rule did not publish books but the long-time Director of the ADC, Arthur Mosher, wrote an influential book, *Getting Agriculture Moving* (1966) that was read by Presidents and peasants. The book was translated into 17 languages and used in Extension courses around the world. The book sold for about \$5 in 1970.

⁵² The Institute was initially based at the University of Wisconsin in 1958 and thereafter moved to the University of Colorado.

⁵³ A researcher with 25 years of experience in Francophone Africa had this to say about the demand for English language training in francophone West Africa, "In my experience with working with colleagues from faculties of agriculture in Francophone Africa, they have always emphasized the importance for themselves and their students of developing their capacities in English in order to have access to much of the scientific literature on agriculture and to participate in the global scientific debates. In a recent project to assist Mali's College of Agriculture and Natural Resources (IPR/IFRA), our Malian colleagues requested that this be a key part of the project; hence, "we helped them establish a language lab where faculty and students could study English, and they hired an English professor to lead the classes" (Staatz 2006). Also employer surveys in Ghana and Nigeria have found that employers are unhappy with graduates' poor dominance of the English language. For these reasons, English language training should be considered in Anglophone and Francophone West Africa.

⁵⁴ Franklin was a U.S. publisher

bargain prices to libraries, graduate students and academic staff throughout Asia.⁵⁵ A World Bank researcher should study the history of the Franklin Book program and see if a South African publisher might rise to the challenge. Since many books in agriculture cost \$50 to \$100 each, African students sit in their university library and tear out the book chapters or journal articles because it is financially impossible for them to purchase books.

These three *temporary institutions* helped Asia build its human capital base to solve the food crisis of the 1960s and 1970s. African policymakers, scientists and donors should learn from Asia's experience in using temporary institutions to foster human capital improvement.

The Way Forward

Today discussions abound concerning the merits of the sandwich programs, pilot projects, and biotechnology networks in Africa. But most of these sidestep the big picture questions. They are micro responses to a massive continental problem. *I suggest raising the stakes and discussing the merits of a large-scale human capital and capacity-building plan to ensure that all M.Sc. training will be available in strong M.Sc. programs in Africa within a ten year period.* The next challenge is how to manage the transition between overseas and Africa-based Ph.D. training for 750 to 1,000 African Ph.Ds in the full spectrum of agricultural and related disciplines over the coming 15 years. Because of the present lack of high quality Ph.D. programs in Africa, there will be a need to train about half of these Ph.Ds overseas during the next ten years. This is a rough estimate and it should be verified in a special World Bank inventory of the disciplines, output and quality of existing Ph.D. programs.

Setting Realistic Goals for AET Investments in Africa

Based on the global literature review and the experience of a number of donors and African countries, it is proposed that the World Bank prepare an *African Agricultural Education and Training Plan* with a 30-year time frame for strengthening AET in Africa. The first step in the preparation of the Plan is to draw on the current studies commissioned by the Bank and to develop the goals to be achieved during Phase I covering 15 years. When the goals are agreed, then the division of labor among the donor community and African organizations can be sorted out. The elements of a possible 15-year Phase I and its year by year outputs are:

Preparatory Year. The Bank project manager will set up an advisory committee, arrange meetings with share holders, and visit a dozen African countries to meet key academics, policy-makers and donors in Anglophone, Francophone and Lusophone countries. Prepare a concept paper to establish an African-based organization similar to the ADC of Asia.⁵⁶ Hire a President for this regional non-governmental organization and develop a strategy and operational plan.

⁵⁵ The Eicher/Witt textbook *Agriculture in Economic Development* was published by McGraw-Hill in 1964 and sold for USD 8.00 in the United States. The book was reprinted in India and sold for 8 rupees (equivalent to USD 1.00) in the 1970s.

⁵⁶ Project designers could benefit from discussions with the second President of the ADC-Professor Vernor Ruttan University of Minnesota and Professor Emeritus Clifton R. Wharton JR former ADC Fellow in Asia for 12 years and then President of Michigan State University.

Year 1-10. Encourage a donor(s) to develop and implement an English Language training programs – one for Lusophone and one for Francophone countries. Level the information playing field by securing a donor or a foundation to finance the implementation of Cornell’s TEEAL proposal to blanket Africa with 500 TEEAL and AGORA electronic collections of scientific literature. Review the performance and financial needs of AERC and CMAAE

Years 1-10. Strengthen two-year Schools of Agriculture for extension agents and Faculties of Agriculture offering BSc degrees in various fields of agriculture. Encourage bilateral donors to help these institutions to upgrade their schools of agriculture for extension workers and B.Sc. granting Faculties of Agriculture.⁵⁷

Years 1-8. Select one African country offering M.Sc. programs as a pilot country and experiment with distance education through new course modules and other innovations with an aim of finding out how to train virtually all African M.Sc. students within Africa in 10 years.

Years 1-15. The World Bank itself should concentrate on building postgraduate capacity by helping underwrite the development of a program of competitive capacity-building grants for developing Ph.D. training and research programs in selected regions of Africa. Also develop partnerships and twinning agreements with universities inside and outside Africa. Allow 12 to 18 months to set up these partnerships.

Years 1-15. Focus on the development of a few competitive Ph.D. programs in selected areas of agriculture. Initially target South Africa, Uganda (Makerere 2006, 2006a), and Nigeria (Idachaba 2006) in this undertaking. Carry out a study of Ph.D. capacity building in these countries. Each country participating in the *African AET Plan* will be requested to prepare a Business Plan, including a frank discussion of needed internal reforms and when they will be carried out. Unless the reforms go hand and hand with capacity-building grants, the AET training goals are likely to be paper targets. Special attention would be given to the incentive systems that will encourage graduates to remain in the African scientific labor force for 20 to 30 years.

Years 5, 10 and 14. Evaluate the Bank’s progress in improving postgraduate training and building AET capacity in Africa. Prepare Phase 2 of the Plan covering years 16-30.

Summary

Global experience with building AET capacity in four industrial countries and four developing countries outside Africa has demonstrated that it is possible to construct productive and financially sustainable AET and research systems. This favorable global AET experience, together with the renewed interest of donors in African agricultural development, present a timely opportunity for the World Bank to step forward and provide global leadership in launching an *Africa Agricultural Education and Training Plan* with a USD 1 billion budget for Phase I activities over the first fifteen-year period.

⁵⁷ An example is NORAD’s new institutional collaborative agreement to support Bunda College cooperation with the Norwegian University of Life Sciences (UMB), previously Agricultural University of Norway (Wisborg 2006).

The six major outputs of the Phase I activities would be:

1. By the end of year 2, university libraries and research stations throughout Africa will be strengthened through TEEAL and AGORA's access to scientific journals.
2. By year two, small research grants will be available to academic staff in faculties of agriculture and science on a competitive basis.
3. By year two, sabbatical leave will be available for members of faculties of agriculture on a competitive basis.
4. By year three, competitive grant schemes will provide funding for research that is highlighted by cooperation between graduate students, academic staff and researchers in CGIAR centers.
5. During years 1-10, the capacity of M.Sc. programs in African universities will be strengthened so that by year 10 there will be no need for African students to leave the continent for M.Sc. degree programs in the major specializations in agriculture.
6. By year 15, strong Ph.D. programs in the major fields of Agriculture will be in place in several universities in Africa and the next generation of 1,000 African Ph.D.s will have been trained in Africa and overseas universities in the full range of agricultural disciplines.

The World Bank has been a bystander in African AET programs over the past decade. Latin American and Asian experiences have demonstrated that it is possible to nurture African faculties and schools of agriculture and to mobilize local and donor financing to recruit and retain outstanding teachers and scientists for long and productive careers. The preparation of an *Africa AET Plan* is a complicated undertaking. It will require consultation and cooperation among African organizations, academics, and policymakers, as well as donors and foundations. World Bank leadership is needed in this important and long-neglected aspect of agricultural capacity building for economic growth.

APPENDIX A

Access to the Global Scientific Literature: TEEAL and AGORA.

Over the past decade, the Rockefeller Foundation has supported the work of librarians at the Mann Library at Cornell University in developing TEEAL (The Essential Electronic Agricultural Library), an electronic library of 110 scientific journals from 68 major publishers that are made available free of charge to users in poor countries. The TEEAL system is available on CDs or a Local Area Network (LAN). African institutions like TEEAL because of its high quality and the fact that it does not rely on phone, internet connectivity or bandwidth, making it a workable solution for research stations and agricultural schools that cannot yet offer reliable and affordable internet access to the majority of their academic staff and students. While TEEAL remains a key resource for many institutions in Africa, in the long run it is hoped that most institutions will be able to migrate to AGORA and HINARI. Improving access to the Internet is the key to this migration and, of course, improved Internet also facilitates better communication among researchers.

Two other journal delivery programs available via the Internet are having an increasingly important impact in Africa:

- 1) AGORA (Access to Global Online Research in Agriculture) www.aginternetwork.org; and
- 2) HINARI (Health Internet work Access to Research Initiative) www.who.int/hinari.

AGORA and HINARI are a partnership led by the Food and Agriculture Organization and World Health Organization, respectively, in which international publishers of research journals in biomedicine, health, agriculture and the environment offer free or at very low cost access to the full text of more than 3,000 journals to researchers, students, practitioners, economists and policy makers in 103 developing countries. Yale University and Cornell University are the key collaborating partners. The AGORA program works closely with TEEAL with the intention of helping users migrate from TEEAL to AGORA as new technology becomes available.

For qualifying institutions in 69 of the countries where the annual per capita GNP was US\$1000 or less in December 2000, access to the entire collection is free (Phase1). For institutions in 44 countries where the GNP was between \$1001 and \$3000, an annual fee of \$1000 is collected (Phase 2). As of 2006, 1407 institutions in 65 Phase 1 countries were registered for HINARI; and 763 institutions from 44 Phase 2 countries. For AGORA there are 777 institutions registered in 64 Phase 1 countries. Phase 2 of AGORA will be launched in the 3rd quarter of 2006. In March 2006, the number of articles downloaded from HINARI peaked at about 325,000. AGORA downloads from Phase 1 countries average 20,000 a month.

An independent evaluation of AGORA and HINARI, completed in June 2006, concluded that HINARI and AGORA are contributing to the development of national public policy and enabling students to pursue health and agricultural studies in ways inconceivable in their absence. In many universities, HINARI/AGORA has become the principal research tool for students engaged in

writing their thesis or dissertation. HINARI and AGORA are also instrumental in enabling academic and research institutions to interact and even compete on an equal footing with their counterparts in the developed world. The report urges development agencies to increase funding and technical support to AGORA and HINARI to increase training opportunities and to overcome the key challenge of inadequate Internet and insufficient computers and related technology.

With the financial support of donors and foundations, a total of 70 TEEAL sets have been purchased over the past seven years and donated to African institutions. But the transaction costs have been high in passing the hat to donors and foundations and requesting them to purchase one set at a time and donate it to an African institution. Therefore, Cornell librarians have prepared a Concept Paper to scale up this initiative by blanketing Africa with 500 TEEAL sets for universities, schools of agriculture, and research stations. The 500 sets would be distributed during the first two years of a six-year project. The total cost of the project is \$9.8 million, including the training of librarians in Africa on how to provide the technical backstopping.

For a copy of the TEEAL proposal, contact Mary Ochs at Email: mao4@Cornell.edu

APPENDIX B

Innovations and Partnerships in AET

1. ***Collaborative M.Sc. Program in Agricultural and Applied Economics (CMAAE)***.⁵⁸ This capacity-building initiative is spearheaded by the African Agricultural Economics Educational Network. Its demand-driven program was developed through an intensive 12 month planning exercise by 16 departments of Agricultural Economics in 12 countries in Eastern, Central and Southern Africa. The students enroll in accredited universities for the first two semesters to take core courses before the successful students converge at the Department of Agricultural Economics at the University of Pretoria to spend one semester taking specialization and elective courses such as Agribusiness, supply chain management, environmental economics and food policy analysis. CMAAE has three capacity-building components: teaching, research, and dissemination. CMAAE is unique in terms of approach to applied postgraduate economics education. The program structure comprises four areas of specialization namely: agriculture and rural development; agricultural policy and trade; agribusiness management; and environment and natural resource management, which make it different from other present and past postgraduate courses in economics in Africa. All students also pursue a novel course in “Institutional and Behavioral Economics” so that they can better adapt more conventional analysis to the political and economic realities of the region. For details contact cmaae@aercafrica.org

2. ***African Economic Research Consortium (AERC)***. The AERC is a pioneering African led-effort that was established in 1988 to scale up African capacity to conduct policy- relevant economic research. In 1993, the AERC introduced a Collaborative Masters Program in Economics (CMAP) with 17 universities participating. Today, 21 universities in 17 countries of Africa are participating in CMAP. In 2002, the AERC launched a collaborative Ph.D. Program in Economics (CPP). The Ph.D. program combines course work in an African university with field research punctuated by periodic workshops that bring together students, academic staff and visiting professors from overseas universities to review the research of enrolled students. One of the achievements of the AERC has been the reduction in the average cost of the master’s program from \$26,000 to \$15,000 per year in Africa. Contact: www.aerc.africa.org

3. ***Master of Agribusiness (MAB)***. Ten years ago, Kansas State University launched a distance education MAB program for students working full time in agribusiness jobs who lacked the resources to quit their job and pursue a full-time MBA on the campus of Kansas State University in Manhattan, Kansas. Professor Alan Featherstone launched the MAB program in 1988 with a class of ten students, mainly from Kansas and the Great Plains states. Today, the tenth class consists of 20-25 students from the United States and many students abroad. Lectures are 40 to 60 minutes in length. MAB students earn a master’s degree in 2.5 years while doing coursework using the internet, CD-ROM and classrooms. Course lectures are delivered via a CD-Rom provided for each course. Students visit the Kansas State campus for two weeks each year where they meet other students and faculty, receive training on technology used in the course, and

⁵⁸ Thirty years ago, a seminar was held in Nairobi on post-graduate training in Agricultural Economics at African Universities (Thimm 1976).

interact with agribusiness leaders. Recently, the program received a grant from the United States Department of Agriculture to expand the course to cover three additional geographical areas, including sub-Saharan Africa. Contact: afeather@mail.agecon.ksu.edu

4. African Consortium for Training in Applied Economics and Policy Analysis (ACTAEP). The premise of this proposal is the need to train a critical mass of African agricultural economists at the Ph.D. level who understand the challenges of African agriculture. The membership of the proposed consortium of universities preparing this proposal includes: the University of the Free State, University of KwaZulu-Natal, the University of Pretoria, University of Stellenbosch, Purdue University and the University of Minnesota. The proposed Ph.D. initiative can be summarized as follows:

- Two years of Ph.D. level courses in agricultural economics at Purdue University or the University of Minnesota.
- Field research in Africa on an African economic problem.
- One to two years of data processing and completing the dissertation.
- The advisory committee will include members from the host South African University as well as Americans and members of national and international organizations.
- The South African host institution will grant the Ph.D.

Contact: JoosteA.SCI@mail.uovs.ac.za

5. African Center for Crop Improvement (ACCI). The University of KwaZulu-Natal (formerly the University of Natal) in Durban, South Africa has a well-deserved reputation in plant breeding. Because its courses are taught in English, many agricultural specialists from Zimbabwe, Malawi, and Zambia have studied at Natal. In 2002, the Rockefeller Foundation agreed to sponsor 50 African plant scientists to pursue a Ph.D. at UKZN in plant breeding and applied biotechnology. The program produces cohorts of crop scientists who live and work in 11 Southern African countries. Upon completing the five-year PhD program, the cohorts, each with an average of eight scientists, will have studied for two years at the Center, conducted field research in their home countries, and returned to the Center to finish their Doctoral theses.

Cornell University has been a partner with the ACCI for four years, providing lectures, faculty consultations, and access to library resources. Cornell's Transnational Learning program has worked with the ACCI students and staff to establish a methodology for delivering lectures in electronic form from Cornell to KwaZulu-Natal so that the ACCI students may benefit from lectures given on the Cornell campus. Transnational Learning complements those digital lecture modules with live video-conferences that allow the students to ask questions of the professors regarding the lecture content, discuss related topics in an international context, and obtain advice on how to approach their research from different perspectives. Transnational Learning has delivered several hundred hours of digital modules to the ACCI over four years. Contact: Prof. Mark Laing, University of Kwazulu-Natal, laing@ukzn.ac.za or Prof. Ronnie Coffman, Cornell University, wrc2@cornell.edu.

6. The Center for Global Trade Analysis (GTAP). Purdue University is the home of GTAP, a global network of researchers carrying out research on international economic policy issues. The

program encourages collaboration among academia, the public sector and the private sector worldwide. Purdue researchers have developed a global trade model (GTAP) that can be assessed by teachers and researchers in rich and poor countries because access to GTAP is free of charge. The Center now links 4000 scientists and analysts around the world with free access to trade policy research findings that can boost the trade content in courses in economics and agricultural economics in African universities and help African trade researchers develop human capital chains with fellow researchers throughout the world. This is an example of how the electronic era can help African researchers by providing a level playing field comparable with that of researchers in high income countries. See: www.gtap.agecon.purdue.edu

7. Imperial College London Distance Learning Program. Wye College pioneered distance education courses in agriculture and rural development starting in the 1980s (Wye College is now part of Imperial College London). Currently, 800 students are enrolled in Imperial College distance learning programs. Of these about 250 are African nationals resident in Africa. In 2005, 21 of the 86 graduates were African nationals. The total cost of a two-year M.Sc. degree was \$15,200 in 2006. The Imperial College offers M.Sc. programs in Agricultural Economics, Rural Development and Sustainable Development. Postgraduate and Certificate programs are also available. The M.Sc. in Sustainable Development has now entered its second year with an enrollment of 220 students. See: www.imperial.ac.uk/distancelearning

8. The Global Open Food and Agriculture University (GO-FAU). In 2005, the Consultative Group on International Agricultural Research (CGIAR) inaugurated a distance-learning initiative to develop course modules in agro-ecology, agricultural/agribusiness and made them available to partner universities to help strengthen existing M.Sc. programs; short-term M.Sc.-level agricultural courses; and new agricultural M.Sc. distance programs. In November 2005, Imperial College signed a collaborative agreement with IFPRI in support of the CGIAR's Global Open Agricultural and Food University. The Vice-Chancellor of Imperial College London has committed EU 500,000 of the University's own resources to help launch the Imperial/IFPRI collaborative project. Details can be found at ifpri@cgiar.org

9. CRSP Model of Capacity Building through Degree Training. Through funding from USAID, U.S. universities have been engaged for the past 30 years in human resource capacity building in developing countries through the Collaborative Research Support Programs (CRSPs). Under the CRSP model, M.Sc. and Ph.D. degree training is an integral part of CRSP supported collaborative research projects both in the U.S. and host country universities. Collaborators identify the trainees based on the host country training needs and the universities' admissibility criteria. The training occurs under the direct supervision of CRSP researchers, which ensures that the training activity directly contributes to CRSP research goals and objectives, as well as to institutional capacity-building in partner host countries. Involvement in a CRSP research program fosters the student-mentor relationship between the trainee and the university professor, which leads to a continued collaborative research relationship between the U.S. and the host country institution beyond the formal training program. The integration of training with an on-going research program often leads to cost-sharing by the university in the form of reduced tuition costs, reduction in overhead costs, and/or partial funding from other sources to support the thesis research costs of completing a graduate degree.

REFERENCES

- Abdullah, Rusian. 2005. A Decade of Oil Palm Gene Manipulation: Where are we now? Paper presented at the 9th International Conference on Agricultural Biotechnology Research, Ravello, Italy. July 6-10.
- Ackello-Ogutu, C. and Wilfred Mwangi. 1995. Training of Agricultural Economists in Eastern and Southern Africa. In G.H. Peters and D.D. Hedley eds., *Agricultural Competitiveness: Market Forces and Policy Choice: Proceedings of the Twenty-Second International Conference of Agricultural Economists*, Harare, Zimbabwe, 22-29 August 1994. Aldershot UK: Dartmouth. Pp. 540-553.
- Agency for International Development (USAID). 1985. *Plan for Supporting Agricultural Research and Faculties of Agriculture in Africa*. Washington D.C.: USAID.
- Alex Gary and Derek Byerlee. 1999. Investing in Integration of Universities into National Agricultural Research and Extension Systems. Washington D.C.: World Bank. Draft.
- Alex, G., D. Byerlee, M. Helene-Collion, and W. Rivera. 2004. Extension and Rural Development: Converging Views on Institutional Approaches? ARD Discussion Paper #4. The World Bank.
- Anderson, Jock and Gershon Feder. 2004. Agricultural Extension: Good Intentions and Hard Realities. *The World Bank Research Observer*. 19(1): 41 - 60.
- Anderson, Jock R., G. Feder and S. Ganguly. 2006. The rise and fall of Training and Visit extension: An Asian mini-drama with an African epilogue? In A.W. Van den Ban and R.K. Samanta eds., *Changing Roles of Agricultural Extension in Asian Nations*, New Delhi: B.R. Publishing Company.
- Atsain, Achi. 2006. E-mail. June 14.
- Beintema, Nienke. M. and G. J. Stads. 2006. Agricultural R&D in Sub-Saharan Africa: An Era of Stagnation. Washington D.C.: ISNAR. August.
- Beintema, Nienke. M., P.G. Pardey, and J. Roseboom. 1998. *Educating Agricultural Researchers: A Review of the Role of African Universities*. EPTD Discussion Paper No. 36. Washington, D.C.: IFPRI and ISNAR.
- Beintema, Nienke. M., A. F. D. Avila, and P. G. Pardey. 2001. Agricultural R&D in Brazil: Policy, Investments, and Institutional Profile. Washington, D.C.: IFPRI, Embrapa, and FONTAGRO.
- BIFAD (Board for International Food and Agricultural Development). 2003. *Renewing USAID Investment in Global Long-Term Training and Capacity Building in Agriculture and Rural Development*. Washington, D.C.: BIFAD, June.
- Blackie, M.J. 1984. A Regional Support Program for Faculties of Agriculture in the SADCC Region. A Report prepared for USAIDD/Harare. Harare, University of Zimbabwe. Draft 2. May.
- Bloom, Roger. 2003. E-mail. October 7.

- Bloom, David, David Canning and Kevin Chan. 2005. *Higher Education and Economic Development in Africa*. Washington D.C.: World Bank.
- Bonnen, J.T. 1998. "Agricultural Development: Transforming Human Capital, Technology, and Institutions. In *International Agricultural Development*, Third Edition, C.K. Eicher and J.M. Staatz eds. Baltimore: Johns Hopkins University Press: 271-286.
- Bonnen, James T. 1962. Some observations on the organizational nature of a great technological pay off. *Journal of Farm Economics*: 44(5):1279-1294.
- Brush, E.G., Merrill-Sands, D., Gapasin, D.P., and Mabesa, V.L. 1995. *Women Scientists and Managers in Agricultural Research in the Philippines*. ISNAR Research Report No. 7. The Hague: International Services for Agricultural Research.
- Busch, Lawrence. 1988. *Universities for development: report of the joint Indo-U.S. impact evaluation of the Indian agricultural universities*. AID Project Impact Evaluation No. 68. Washington, D.C.: U.S. Agency for International Development.
- Buttel, Frederick H. 1985. The Land-grant System: A Sociological Perspective on Value Conflicts and Ethical Issues. In *Agriculture and Human Values*. Spring. 78-85.
- Buurma, J. S. 2001. Dutch Agricultural Development and its importance to China: Case Study: The Evolution of Dutch Greenhouse Horticulture. Agricultural Economics Research Institute (LEI).
- Byerlee, Derek. 1993. Technology Adaptation and Adoption: The Experience of Seed-Fertilizer Technology and Beyond. In *Review of Marketing and Agricultural Economics*. 61(2): 311-326
- Byerlee, Derek and Gary Alex. 1998. Towards more effective use of external assistance in building agricultural research systems. In *Financing Agricultural Research: A Source Book*. Edited by Steven Tabor, William Janssen and Hilarion Bruneau. The Hague, ISNAR: 97-114.
- Byerlee, Derek and Gary E. Alex. 1998. *Strengthening National Agricultural Research System: Policy Issues and Good Practice*. The World Bank, Washington, D.C.
- Byerlee, Derek and Ruben Echeverria, eds. 2002. *Agricultural Research Policy in an Era of Privatization*, New York: CABI Publishing.
- Castillo, Gelia T. 1997. Research Partnerships: Issues, Lessons, Results and Dreams for Sustainable Development. ODI Agricultural Research and Extension Network Paper No. 71. London: ODI.
- CGIAR Science Council. 2006. *Evaluation and Impact of Training in the CGIAR*. Rome: Science Council Secretariat, FAO.
- Chipeta, Sanne. 2004. Denmark: The Role of Livestock Advisory Service and Skills Development. In *Volume 5. National Strategy and Reform Process: Case Studies of International Initiatives*. William Rivera and Gary Alex eds. Washington: World Bank.
- Cleaver, Kevin. 2003. Donor Role to Implement Hunger Task Force Recommendations, Speech presented at the 2003 World Food Prize International Symposium, October 16-17, Des Moines, Iowa. November 14.

- Coleman, James S. and D. Court. 1983. *University Development in the Third World. The Rockefeller Foundation Experience*. Oxford: Pergamon Press.
- Court, David. 1994. Ph.D. Fellowships: The Rockefeller Foundation Experience. In *Ph.D. Education in Economics in Sub-Saharan Africa: Lessons and Prospects*. Edited by J.C. Fine et al. Nairobi: East African Publishers, 123-152.
- Crowder, L. Van and J. Anderson. 1997. Linking Research, Extension and Education: Why is the Problem so Persistent and Pervasive? *European Journal of Agricultural Economics and Extension*. 3(4):241-249.
- De Vries, J., and G. Toenniessen. 2001. *Securing the Harvest: Biotechnology, Breeding and Seed Systems for African Crops*. Wallingford, UK: CAB International.
- DFID. 2006. *Eliminating World Poverty: Making Governance Work for the Poor*. London: DFID
- Devarajan, Shantayanan, David R. Dollar and Torgny Holmgren. Eds. 2001. *AID and Reform in Africa: Lessons from Ten Case Studies*. Washington D.C.: World Bank.
- Dione, Josue. 1995. Human Capital Investment for Agricultural Competitiveness in West Africa. In G.H. Peters and D.D. Hedley eds. *Agricultural Competitiveness: Market Forces and Policy Choice: Proceedings of the Twenty-Second International Conference of Agricultural Economics*, Harare, Zimbabwe, 22-29 August 1994. Aldershot UK: Dartmouth. Pp. 605-618.
- Djurfeldt, Goran and Hans Holmen et al. 2005. *The African Food Crisis: Lessons from the Asian Green Revolution*, Cambridge, Ma.: CABI Publishing.
- Easter, William, S. Bisaliah and John O. Dunbar. 1989. After Twenty-Five Years of Institution Building, The State of Agricultural Universities in India Face New Challenges. *American Journal of Agricultural Economics* 71(5): 1200-1205
- Echeverria, Ruben G. and Howard Elliott. 2002. Financing Agricultural Research by Competitive Funds. In *Agricultural Research Policy in an Era of Privatization*. Derek Byerlee and Ruben Echeverria, eds. New York: CABI Publishing: 265-286.
- Eicher, Carl K. 1984. International Technology Transfer and the African Farmer: Theory and Practice. Working Paper 3/84. Harare: Zimbabwe: Department of Land Management, University of Zimbabwe.
- Eicher, Carl K. 1990. Building African Scientific Capacity for Agricultural Development. *Agricultural Economics* 4(2): 117-143.
- Eicher, Carl K. 1995. Zimbabwe's Maize-Based Green Revolution: Preconditions for Replication. *World Development* 23(5): 805-818.
- Eicher, Carl K. 1999. *Institutions and The African Farmer*. Distinguished Economist Lecture. Mexico D.F. CIMMYT.
- Eicher, Carl K. 2003. Flashback: Fifty Years of Donor Aid To African Agriculture. Paper presented at an International Policy Conference "Successes in African Agriculture: Building for the Future", sponsored by InWent, IFPRI, NEPAD and CTA, Pretoria, South Africa, December 1-3. Accessed at www.ifpri.org/events/conferences/2003/120103/papers/paper16.pdf

- Eicher, Carl K. 2004. Africa: Building a Science Base for Agricultural Development. Background Paper No 4 commissioned by the InterAcademy Council (IAC) Study Panel on Science and Technology Strategies for Improving Agricultural Productivity and Food Security in Africa. Amsterdam: InterAcademy Council. www.interacademycouncil.net.
- Eicher, Carl K., and Mandivamba Rukuni. 2003. *The CGIAR in Africa: Past, Present and Future*. Paper prepared for a meta-evaluation of the CGIAR. Washington D.C.: OED, World Bank.
- Eicher, Carl K. and Lawrence Witt, eds. 1964. *Agriculture in Economic Development*. New York: McGraw-Hill.
- Eicher, Carl K., Karim Maredia and Idah Sithole-Niang. 2006. Crop Biotechnology and the African Farmer. *Food Policy*. 31(6).
- Eyzaguirre, Pablo B. and Andrew E. Okello. 1993. Agricultural research systems in small countries: implications for public policy and administration. In *Public Administration and Development*, (13): 233-247.
- Fan, S., and N. Rao. 2003. Public Spending in developing Countries: Trends, Determination, and Impact. Environment, Production and Technology Division Discussion Paper 99. International Food Policy Research Institute, Washington, D.C.
- FARA (Forum for Agricultural Research in Africa). 2006. Framework for African Agricultural Productivity (FAAP). ACCRA: FARA, AU and NEPAD. Accra: FARA.
- Ferleger, Lou. 1990. Uplifting American Agriculture: Experiment Station Scientists and the Office of Experiment Stations in the Early Years After the Hatch Act. *Agricultural History*. 64(2): 5-23.
- Fienup, Darrell F. and Harold M. Riley. 1980. *Training Agricultural Economists for Work in International Development*. New York: Agricultural Development Council.
- Fine, Jeffrey C., William Lyakurwa, and Anne Gordon Drabek. eds. 1994. PhD. Education in economics in Sub-Saharan Africa: lessons and prospects. Nairobi: East African Educational Publishers Ltd.
- Ford Foundation. 1959. *India's Food Crisis and Steps to Meet it*. New Delhi: Ford Foundation.
- Fox, Roger. 2006. E-mail. 2/7/2006.
- Friedmann, Karen J. 1974. Danish Agricultural Policy, 1870-1970: The Flowering and Decline of A Liberal Policy. *Food Research Institute Studies*. Vol. 13(3): 224-238.
- Gaillard, Jacques and Lawrence Busch. 1993. French and American agricultural science for the third world. *Science and Public Policy*, volume 20(4): 222-234.
- Gallagher, Kevin. D., Arnoud R. Braun, and Deborah Duveskog. 2006. Demystifying Farmer Field School Concepts. *ECAPAPA Newsletter*. 9(6): 2006.
- Goldsmith, Arthur A. 1988. The Management of Institutional Innovation: Lessons from Transferring the Land Grant model to India. *Public Administration and Development*. (8):317-330.
- Goldsmith, Arthur. 1990. *Building Agricultural Research Institutions: Transferring The Land Grant Model to India and Nigeria*. Boulder, Co.: Westview Press.

- Guner, Nihat and Todd C. Wehner. 2003. Survey of U.S. Land-Grant Universities for Training of Plant Breeding Students. *Crop Science*. 43(6):1938-1944.
- Hadwiger, D.F. 1982. *The Politics of Agricultural Research*. Lincoln, NB: University of Nebraska Press.
- Haggard, H. Rider. 1917. *Rural Denmark and its Lessons*. London: Longmans, Green and Company.
- Haggblade, Steven. 2005. From Roller Coasters to Rocket Ships: the Role of Technology in African Agricultural Success. In *The African Food Crisis: Lessons from the Asian Green Revolution*. Edited by G. Djurfeldt, et al. Cambridge, Ma: CABI Publishing.
- Hall, Andrew, Geoffrey Bockett, Sarah Taylor et al. 2001. Why Research Partnerships Really Matter: Innovation Theory, Institutional Arrangements and Implications for Developing New Technology for the Poor. *World Development* 29 (5):783-797.
- Hansen, Gary E. 1989. *Universities for Development: Lessons for Enhancing the Role of Agricultural Universities in Developing Countries*. AID Evaluation Occasional Paper No. 31. Washington, D.C.: USAID.
- Hansen, Gary E. 1990. *Beyond The Neoclassical University: Agricultural Higher Education in the Developing World an Interpretive Essay*. AID Program Evaluation Report No. 20. Washington D.C.: USAID. January.
- Harberger, Arnold C. 1998. Letter to a Younger Generation. *Journal of Applied Economics*, Vol. I, No. 1: 1-33. CEMA.
- Hardin, C.M. 1952. *The Politics of Agriculture*. Glencoe, IL: Free Press.
- Hardin, Lowell. 2006. E-mail May 6.
- Hashim, Mohd Yusuf. 1992. *The National Research System in Malaysia*. ISNAR Working Paper No. 41. The Hague: International Service for National Agricultural Research.
- Hayami, Yujiro. 1975. *A Century of Agricultural Growth in Japan: Its Relevance to Asian Development*. Minneapolis and Tokyo: University of Minnesota Press and University of Tokoyo Press.
- Hayami, Yujiro. 1988. *Japanese Agriculture Under Siege: The Political Economy of Agricultural Policies*, New York: St. Martin's Press
- Hayami, Yujiro and Vernon Ruttan. 1985. *Agricultural Development: An International Perspective*, Revised Edition, Baltimore: Johns Hopkins University Press.
- Herd, Robert W. 2006. Does Aid to Higher Education Contribute to Agricultural Development? Staff Paper 2006-04. Ithaca, N.Y.: Department of Applied Economics and Management, Ithaca, N.Y.: Cornell University.
- Holdcroft, L. 1984. The Rise and Fall of Community Development, 1950–65: A Critical Assessment. In C.K. Eicher and J.M. Staatz. eds., *Agricultural Development in the Third World*. Baltimore, Maryland: Johns Hopkins University Press: 46–58.
- Huang, Jikun, Ruifa Hu, Carl Pray and Scott Rozelle. 2002. Reforming China's Agricultural Research System. In *Agricultural Research Policy in an Era of Privatization*. Derek Byerlee and Ruben Echeverria, eds. New York: CABI Publishing: 245-263.

- Idachaba, F.S. 1995. Human Capital and African Agricultural Development. In G.H. Peters and D.D. Hedley eds., *Agricultural Competitiveness: Market Forces and Policy Choice: Proceedings of the Twenty-Second International Conference of Agricultural Economists*, Harare, Zimbabwe, 22-29 August 1994. Aldershot UK: Dartmouth. Pp. 540-553.
- Idachaba, Francis. 2006. E-mail June 19.
- Indian Council on Agricultural Research. 1955. *Report of Joint Indo-American Team on Agricultural Research and Education*: New Delhi.
- Indian Council of Agricultural Research. 1997. *Education for Agriculture: Bridge to a century of hope on the farm front: Report of the Committee on Agricultural Education: Part – A Recommendations*. New Delhi: Education Division, Indian Council of Agricultural Research.
- InterAcademy Council. 2004. *Realizing the Promise and Potential of African Agriculture: Science and Technology Strategies for Improving Agricultural Productivity and Food Security in Africa*. Amsterdam: The Royal Netherlands Academy of Arts and Sciences
- Jaycox, E.V.K. 1992. *West Africa*. May 18-24.
- Jenkins, Glenn P. and Andrew Kwok-Kong Lai. 1992. Malaysia. In *The Political Economy of Agricultural Pricing Policy. Vol.2. Asia*. Anne O. Krueger, Maurice Schiff and Alberto Valdes. Eds. Baltimore: Johns Hopkins University Press: 67-106.
- Jensen, Einar. 1937. *Danish Agriculture, Its Economic Development; A Description and Economic Analysis Centering on the Free Trade Epoch, 1870-1930*. Copenhagen: J.H. Schultz Forlag.
- Johnson, G. L., and B.N. Okigbo. 1989. "Institution-Building Lessons from USAID's Agricultural Faculty Development Projects in Nigeria." *American Journal of Agricultural Economics* 71(5): 1211-1218.
- Jones, Monty. 2004. From Asia to Africa: NERICA Fighting Africa's War Against Poverty and Hunger. Paper presented at the World Food Prize Celebration, October 14-15, Des Moines, Iowa.
- Jones, R. B., and M.J. Blackie. 1991. An Approach to the Development of Expanded Postgraduate Training for Agricultural Scientists within the Southern African Development Coordination Conference Region. *Agricultural Systems* 35:251-264.
- Kane, Sam and Carl K. Eicher. 2004. Foreign Aid and the African Farmer. Staff Paper 2004-13. East Lansing MI.: Dept. of Agricultural Economics, Michigan State University. http://agecon.lib.umn.edu/cgi-in/pdf_view.pl?papered=14820&ftype=.pdf
- Kansas State University. 1974. A Terminal Report on Contract AID/afr 830 at Ahmadu Bello University, Zaria, Nigeria 1963-1974. Manhattan, Kansas: International Agricultural Programs, Kansas State University.
- Kapur, Devesh and John McHale. 2005. *Give Us Your Best and Brightest: The Global Hunt for Talent and Its Impact in the Developing World*. Washington D.C.: Center for Global Development.

- Karl, Marilee, et al. 1997. Higher agricultural education and opportunities in rural development for women: An overview and summary of five case-studies. Rome: FAO.
- Kloppenborg, Jack. 1988. *First the Seed: the Political Economy of Plant Biotechnology*, New York: Cambridge University Press: 141-148
- Koizumi, Junichiro. 2006. Africa – The Home of Self-Endeavor. Statement at the African Union, Addis Ababa: Africa Union May 1.
- Korstanje, Robert. 2006. Email. February 22.
- Labaste, Patrick. ed. 2005. The European Horticulture Market: Opportunities for Sub-Saharan African Exporters. World Bank Working Paper No. 63. Washington, D.C.: World Bank.
- Lele, Uma and Arthur A. Goldsmith. 1989. Development of National Agricultural Research Capability: India's Experience with the Rockefeller Foundation and its Significance for Africa. *Economic Development and Cultural Change* 37: 305-44.
- Levy, Daniel C. 2005. *To Export Progress: The Golden Age of University Assistance in the Americas*. Indianapolis: Indiana University Press.
- Levy, S. ed. 2005. *Starter Packs: A Strategy to Fight Hunger in Developing Countries? Lessons from the Malawi Experience 1998-2003*. Cambridge, Ma.: CABI Publishing International.
- Lewis, W. Arthur. 1953. Report on Industrialization in the Gold Coast. Accra: Government Printer
- Lynam, J.K., and M.J. Blackie. 1994. "Building Effective Agricultural Research Capacity: The African Challenge." In *Agricultural Technology: Policy Issues for the International Community*, J.R. Anderson, ed. Wallingford, UK: CAB International, pp 106-134
- Macedo, J., M.C.M. Porto, E. Contini, and A.F.D. Avila. 2002. *Brazil Country Paper for the CGIAR Meta Evaluation*. OED Working Paper. Washington, D.C.: The World Bank.
- Makerere University. 2006. *Partnerships in National Development: Building for the Future Together*. Kampala: Makerere University. April
- Makerere University. 2006a. *Makerere University: Harmonized Reporting System: Brief to Stakeholders*. Kampala: Makerere University. April.
- Marcus, Alan I. 1985. *Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges, and Experiment Stations, 1870-1890*. Ames: Iowa State University Press.
- Maredia, M.K. and D. A. Raitzer. 2006. *CGIAR and NARS Partner Research in Africa: Evidence of Impact To-date*. Rome, Italy: Science Council Secretariat, FAO.
- Matos, Aristoteles Pires de. 2001. E-mail. 02/08/2006.
- McIntire, John. 1998. Coping with Fiscal Stress in Developing-country agricultural Research. In S.R. Tabor, W. Janssen, and H. Bruneau, eds. *Financing Agricultural Research: A Sourcebook*. The Hague: International Service for National Agricultural Research: 81-96.
- Mehta, S.L. and B.N. Mathur. 1999. *50 Years of Agricultural Education in India*. New Delhi: Education Division, India Council of Agricultural Research.

- Mellor, John W. 1976. *The New Economics of Growth: A Strategy for India and the Developing World*. Ithaca: Cornell University Press.
- Minot, Nicholas. 1994. Annotated Bibliography of Postgraduate Training in Agriculture in Developing Countries. East Lansing, Mi.: Department of Agricultural Economics, Michigan State University.
- Montgomery, Roger. 1978. A Report on Five S.E. Asian Universities with Graduate Programs in Economics/Agricultural Economics. March 18.
- Moseman, Albert. 1970. *Building Agricultural Research Systems in the Developing Nations*. New York: The Agricultural Development Council, Inc.
- Mosher, Arthur T. 1957. *Technical Co-Operation in Latin-American Agriculture*. Chicago: The University of Chicago Press.
- Mosher, Arthur. 1966. *Getting Agriculture Moving: Essentials for Development and Modernization*. New York: Praeger.
- Mrema, G.C. 1997. "Agricultural Research Systems in the ECA Sub-Region." In *Development of a Long Term Strategic Plan for Agricultural Research in The Eastern and Central African Region*, G.C. Mrema, ed. Kampala, Uganda: ASARECA.
- Mulder, Martin and Hendrik Kupper. 2003. The Future of Agricultural Education: The case of The Netherlands. *Journal of Agricultural Education and Extension*. Vol.12(2), Fall.
- Nelson Richard R. 2005. *Technology, Institutions, and Economic Growth*. Cambridge: Harvard University Press.
- Ness, Gayl D. 1961. Cooperative development and industrial capitalism In England and Denmark. *Berkeley Journal of Sociology*. Spring: 1-15.
- Nweke, Felix I., Dunstan S.C. Spencer and John K. Lynam. eds. 2002. *The Cassava Transformation: Africa's Best Kept Secret*. East Lansing, Michigan: Michigan State University Press.
- Oda, Leila. 2006. E-mail. 5/19/2006.
- Odhiambo, T.R. 1967. "East Africa: Science for Development." *Science* 158: 876-881.
- Ogura, Takekazu. 1970 *Agricultural Development in Modern Japan*. Tokyo. Fuji Publishing.
- Olson, R.V. 1965. University teaching and research in agriculture and in veterinary medicine: requirements analysis, Zaria: Ahmadu Bello University, Nigeria
- Oniang'o, Ruth and Carl K. Eicher. 2004. Universities and Agricultural Development in Africa: Insights from Kenya. In *Transformation of Agricultural Research Systems in Africa: Lessons from Kenya*. Eds. Cyrus G. Ndiritu, John K. Lynam and Adiel N. Mbabu. East Lansing: Michigan: Michigan State University Press: 231-258.
- Otto, John. 2000. Email to Felix Nweke, East Lansing, Michigan. November 1. CSIR, Accra.
- Owen, Wyn F. and Larry R. Cross. 1983. Foreign Students in Agricultural Economics from the Perspective of the Economics Institute. *American Journal of Agricultural Economics*. 65(5):1136-41

- Oyer, Edwin B. and Emil Javier. 2004. Cornell University's Cooperative Agricultural Activities with Institutions in the Republic of the Philippines. Ithaca: Cornell University. Draft.
- Ozden, Calgar and Maurice Schiff. Eds. 2006. *International Migration, Remittances and the Brain Drain*. Washington D.C.: World Bank and Palgrave.
- Pala, Achola. 1976. *African Women in Rural Development: Research Trends and Priorities*. Washington, D.C.: Overseas Liaison Committee, American Council on Education.
- Pal, B.P. 1974. The India Agricultural Research Institute – The All India Agricultural Research Programs. In *Strategies for Agricultural Development in Developing Countries*. New York: The Rockefeller Foundation. Pp 90-123.
- Pardey, P.G., and N.M. Beintema, et al. 2006. *Agricultural Research: A Growing Global Divide?* Washington, DC: IFPRI.
- Pastore, Jose and Eliseu R.A. Alves. 1977. Reforming the Brazilian Agricultural Research System. In *Resource Allocation and Productivity in National and International Agricultural Research*. Thomas M. Arndt, Dana Dalrymple and Vernon W. Ruttan, eds. Minneapolis: University of Minnesota Press: 394-403.
- Pino, John A. 1974. Graduate Training for National Development: A Look at the Rockefeller Foundation Approach. In *Strategies for Agricultural Development in Developing Countries*. New York: Rockefeller Foundation.
- Price, Edwin and Conrad Evans. 1989. Ethiopia: Alemaya University of Agriculture: A.I.D. Project Impact Evaluation Report No. 71. Oklahoma State University. Washington D.C.: U.S. Agency for International Development.
- Purcell, Dennis L. and Jock R. Anderson. 1997. *Agricultural Extension and Research: Achievements and Problems in National Systems*. Washington, D.C.: The World Bank.
- Randhawa, M.S. 1986. *A History of Agriculture in India*. Vol. IV. 1947-1981. New Delhi: Indian Council of Agricultural Research.
- Reardon, T., C.P. Timmer, C.B. Barret and J.A. Berdegue. 2003. The rise of supermarkets in Africa, Asia and Latin America. *American Journal of Agricultural Economics*. 85(5): 1140-1146.
- Rivera, W.M. and W.Zijp.2002.*Contracting for Agricultural Extension: International Case Studies and Emerging Practices*. New York: CABI Publishers.
- Rice, Edward B.1974.Extension in the Andes: An evaluation of official U.S. assistance to agricultural extension services in Central and America. Cambridge MA: MIT Press.
- Rockefeller Foundation. 1974. *Strategies for agricultural education in developing countries: Agricultural Education Conference*. New York: Rockefeller Foundation.
- Roling, N. A. and M.A.E.Wagemakers.Eds.1998.*Facilitating Sustainable Agriculture: Participatory Learning and Adaptive Management in times of Environmental Uncertainty*. Cambridge: Cambridge University Press.
- Roling, Niels.1988. *Extension Science: Information Systems in Agricultural Development*. Cambridge: Cambridge University Press.

- Roseboom, Johannes. 2004a. Case Study of the Financing of Agricultural Research in Brazil. Washington, D.C.: World Bank, July.
- Roseboom, Johannes. 2004b. Case Study of the Financing of Agricultural Research in Chile. Washington, D.C.: World Bank, July.
- Roseboom, Johannes and Hans Ruttan. 1998. The Transformation of the Dutch Agricultural Research System: An Unfinished Agenda. *World Development*. 26(6), 1113-1126.
- Rukuni, Mandivamba. 1996. A Framework for Crafting Demand-Driven National Agricultural Research Institutions in Southern Africa. Staff Paper No. 96-76. East Lansing: Department of Agricultural Economics, Michigan State University.
- Rukuni, Mandivamba, Malcolm J. Blackie and Carl K. Eicher. 1998. Crafting Smallholder-Driven Agricultural Research Systems in Southern Africa. *World Development* 26(6):1073-1087, June.
- Ruttan, Vernon W. 1982. *Agricultural Research Policy*. Minneapolis: University of Minnesota Press.
- Ruttan, Vernon. 1991. Statement at a “Seminar on Strategies for the Future of Africa. African development: lessons from Asia: proceedings of a Seminar on Strategies for the Future of Africa sponsored by the Africa Bureau, U.S. Agency for International Development and Winrock International at the Radisson Hotel, Baltimore, Maryland, June , 1991. Arlington, VA: Winrock. p. 195.
- Ruttan, Vernon and Carl E. Pray, eds. 1987. *Policy for Agricultural Research*. Boulder: Westview Press.
- Rygenstad, Hild, Riikka Rajalahti, and Eija Pehu. 2005. Agricultural Education and Training in Sub-Saharan Africa. FY 98-04 Washington D.C.: World Bank. Jan 16.
- Saint, William S. 1992. *Universities in Africa: Strategies for Stabilization and Revitalization*. Technical Paper No. 194. Washington, D.C.: The World Bank.
- Sanders, John. 2006. E-mail 2/09/2006.
- Sanders, John H., Richard L. Meyer, Roger W. Fox, and Fernando C. Peres. 1989. Agricultural University Institution Building in Brazil: Successes, Problems, and Lessons for Other Countries. *American Journal of Agricultural Economics*. 71(5):1206-1210.
- Sauer, Richard J. and Carl E. Pray. 1987. Mobilizing Support for Agricultural Research at the Minnesota Agricultural Experiment Station. In *Agricultural Research Policy in an Era of Privatization*. Derek Byerlee and Ruben Echeverria eds. New York: CABI.
- Schuh, G. Edward. 1970. *The Agricultural Development of Brazil*. Praeger Publishers, New York.
- Schuh, G. Edward. 2006. Notes on the Development of Institutions of Higher Education for Agriculture in Brazil. Minneapolis: University of Minnesota, February 26.
- Schultz, Theodore W. 1964. *Transforming Traditional Agriculture*. New Haven: Yale University Press

- Schultz, Theodore W. 1964a. Economic Growth from Traditional Agriculture, In *Agricultural Sciences for Developing Nations*. Washington, D.C.: American Association for the Advancement of Science: 185-205.
- Schultz, Theodore W. 1965. *Economic Crises in World Agriculture*. Ann Arbor: University of Michigan Press.
- Schultz, Theodore W. 1984. The Economics of Agricultural Research. In *Agricultural Development in the Third World*. Edited by Carl K. Eicher & John M. Staatz. Johns Hopkins University Press. Baltimore. 335-347.
- Sheridan, B. 1998. *Strangers in a strange land: a literature review of women in science*. CGIAR Gender Program Working Paper No. 17. Boston and Washington, D.C.: Simmons Institute for Leadership and Change and CGIAR Secretariat.
- Simpson, Brent. 2006. E-mail. 7/13/06.
- Simpson, Brent. 2006. E-mail. 7/24/06.
- Spencer, Dunstan. 1976. *African Women in Agricultural Development: A Case Study in Sierra Leone*. Washington, D.C.: Overseas Liaison Committee, American Council in Education.
- Springet, Cristin. 2005. E-mail. April 13, 2005.
- Staatz, John. 2006. E-mail. 7/24/06.
- Stads, Gert-Jan and Nienke M. Beintema. 2006. Women Scientists in Sub-Saharan African Agricultural R&D. Washington, D.C.: IFPRI. June.
- Stads, Gert-Jan, Arffin Tawang and Nienke Beitema. 2005. *Malaysia*. ASTI Country Brief no 30. Washington, D.C.: IFPRI. November.
- Steady, Filomina Chioma. 2006. *Women and Collective Action in Africa. Development, Democratization and, Empowerment, with Special Focus on Sierra Leone*. New York: Palgrave Macmillan
- Stern, Elliot, Lucia de Vaccaro and John Lynam. 2006. *Evaluation and Impact of Training in the CGIAR*. Rome: Science Council Secretariat, FAO. March
- Stevenson, Russell and Virginia O. Locke. 1989. *The Agricultural Development Council: A History*. Morrilton. AR: Winrock.
- Storey, H.H., 1950. *Basic Research in Agriculture: A Brief History of Research at Amani 1928-1947*. Nairobi: East African Standard Limited.
- Swaminathan, M.S. 2004. Building Impact-Oriented R&D Institutions: Lessons from the National Research System in India, Rome: *GFAR Newsletter*. Issue 9.
- Swanson, Burton E., 1986. The Contribution of U.S. Universities to Training Foreign Agricultural Scientists. In *The Agricultural Scientific Enterprise: A System in Transition*. Lawrence Busch and William B. Lacy, eds. Boulder: Westview: 229-238.
- Tetty, Wisdom J. and Korbla P. Puplampu. 2006. *The African Diaspora in Canada: Negotiating Identity and Belonging*. Calgary: University of Calgary Press.
- Thimm, H.U.ed.1976.*African Seminar: Postgraduate Training in Agricultural Economics, Nairobi, 22 July-4 August*. Bonn. German Foundation for International Development.

- Toen, Ronaldt. 2006. E-mail to Robert Korstanje, 2/24/06.
- Tollens, Eric. 2006. E-mail. April 3.
- Turk, Kenneth L. 1974. *The Cornell-Los Baños Story: two decades of cooperation in agricultural education and research between Cornell University and the University of the Philippines*. Ithaca, N.Y.: New York State College of Agriculture and Life Sciences at Cornell University.
- USAID. 1985. *Plan for Supporting Agricultural Research and Faculties of Agriculture in Africa*. Washington, D.C.: USAID.
- USAID. 1986. Southern Africa Regional Agricultural Training. PID. Cable. USAID. Harare. April 1.
- USIS. 1986. Backgrounder. Bangkok: USIS October 15.
- Van den Ban, A.W. 1987. Communication Systems Between Agricultural Research and the Farmers. *Journal of Extension Systems*. Vol. 3, June, 1987.
- Van den Ban, A.W. 1988. Small Farmer Development: Experiences in the Netherlands. *Quarterly Journal of International Agriculture*. Vol. 24. July-December. 315-227.
- Van den Ban, A.W. and R. K. Samanta eds. 2006. *Changing Roles of Agricultural Extension in Asian Nations*. New Delhi: B.R. Publishing House.
- van der Meer, Kees. 2002. Public-Private cooperation in Agricultural Research: Examples from the Netherlands. In *Agricultural Research Policy in an Era of Privatization*. Edited by Derek Byerlee and Ruben Echeverria. New York: CABI Publishing: 123-136.
- Venezian, E. 1993. A Case of University Participation in National Agricultural Research: the Faculty of Agriculture, Catholic University of Chile. In FAO, *The Role of Universities in National agricultural Research Systems: Report of the FAO Expert Consultation*, 10-22 March 1991. Rome. FAO
- Wadia, F.K. 1997. Progress of Agricultural Education In India. *Journal of the Indian School of Political Economy*. 9(2): 286-308.
- Wageningen University. 2006. Wageningen University Ph.D. Programme Wageningen: Wageningen University.
- Walker, Tom. 2006. E-mail. April 4.
- Wharton, Clifton R. Jr. 1959. *The U.S. Graduate Training of Asian Agricultural Economists*. New York: The Council on Economic and Cultural Affairs.
- Wharton, Clifton R. 1969. The Green Revolution: Cornucopia or Pandora's Box. *Foreign Affairs*. 47:464-76.
- Wielinga, H.E. 2000. Rural Extension in Vital Networks: The Changing Role of Extension in Dutch Agriculture. *Journal of International Agricultural and Extension Education* (7)1: 23-36.

- Wielinga, H.E. 2006. Intermediate Roles in Privatized Extension Systems: The Dutch Case. In: Langeveld, H. and N.G. Roling. eds (2006): *Changing European Farming Systems for a Better Future*, pp.381-385. Proceedings of the European IFSA Conference, Wageningen 2006. Wageningen: Academic Publishers.
- Wijnands, Jo. 2005. *Sustainable International Networks in the flower Industry: Bridging Empirical Findings and Theoretical Approaches*. The Hague: International Society for Horticultural Science.
- Wilcock, David C. and George R. McDowell. 1986. *Building Colleges of Agriculture in Africa: U.S. University Experiences and Implications for Future Projects*. Occasional Paper no 7. Washington, D.C.: USAID/BIFAD. May
- Willett, A. 1998. Agricultural Education Review: Support for Agricultural Education in the World Bank and by Other Donors. Washington D.C.: World Bank.
- Wisborg, Paul. 2006. Travel Report. UMB. January 28-February 4, 2006.
- Wollny, C., M. Chagunda, K. Molapong, W. Richter and P. Mumba. 2002. Africa-German Co-operation in Higher Education supported by the German Technical Co-operation Agency (GTZ). Experiences and lessons learned. DIES I. South-North-Dialogue on Innovative Strategies in International Postgraduate Education: Challenges, Obstacles and Best Practices. 25th February – 1st March 2002, Bonn/Berlin. German Academic Exchange Service (DAAD), Bonn, pp 48-59.
- World Bank. 1981. *Accelerated Development in Sub-Saharan Africa: An Agenda for Action*. (The Berg Report) Washington, D.C.: World Bank.
- World Bank. 1981a. *Agricultural Research: Sector Policy Paper*. Washington D.C.: World Bank.
- World Bank. 1992. *World Bank Assistance to Agricultural Higher Education 1964-1990*. Operations Evaluation Department. Report No. 10751. June
- World Bank. 1999. *Integrating Universities into National Agricultural Research and Extension Systems: Good Practice for Investment in Agricultural University Programs*. Washington, D.C.: The World Bank. March 6.
- World Bank. 2005. *Agricultural Growth for the Poor: An Agenda for Development*. Washington, D.C.: World Bank.
- World Bank. 2005a. *An Independent Review of World Bank Support to Capacity building in Africa: The Case of Ethiopia*: Washington, D.C.: World Bank Operations Evaluation Department, April.
- World Bank. 2005b. *Supporting NEPAD's African Agricultural Productivity Program*. Washington D.C.: World Bank. Draft. February 23.
- World Bank. 2005c. *Capacity Building in Africa: An OED Evaluation of World Bank Support*. Washington, D.C.: World Bank Operations Evaluation Department.
- World Bank. 2006. *India: National Agricultural Innovation Project. Project Appraisal document* Report No: 34908-In. Washington, D.C.: World Bank.

World Bank. 2006. *Meeting the Challenge of Africa's Development: A World Bank Group Action Plan*. Washington, D.C.: Africa Region, World Bank. September 26.

Worthington, E. Barton. 1958. *Science in the development of Africa; a review of the contribution of physical and biological knowledge south of the Sahara*. London, Commission for Technical Co-operation in Africa South of the Sahara.

Yudelman, Montague. 1985. *The World Bank and Agricultural Development – An Insider's View*. WRI Paper #1. Washington, D.C.: World Resources Institute.