Staff Paper

Africa's Unfinished Business: Building Sustainable Agricultural Research Systems

Carl K. Eicher

Staff Paper 2001-10 **May 8, 2001**

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

AFRICA'S UNFINISHED BUSINESS: BUILDING SUSTAINABLE AGRICULTURAL RESEARCH SYSTEMS

Carl K. Eicher
Dept. of Agricultural Economics
Michigan State University

Staff Paper No. 2001-10 **May 8, 2001**

ceicher@msu.edu

44 pages

AFRICA'S UNFINISHED BUSINESS: BUILDING SUSTAINABLE AGRICULTURAL RESEARCH SYSTEMS[1]

Carl K. Eicher[2]

[1] Revised Version of a paper presented at an ASARECA Retreat, Continental Hotel, Mombasa, Kenya, February 19, 2001. Research for this paper has been supported by the W.K. Kellogg Foundation.

[2] University Distinguished Professor Emeritus, Michigan State University, East Lansing, Michigan 48824-1039. E-mail: ceicher@msu.edu

Africa's Unfinished Business: Building Sustainable Agricultural Research Systems

The true measure of the success of a program of international and technical collaboration is not in its accomplishments during the period it is in force but rather in what happens after foreign aid has been withdrawn.

– George Harrar, 1967

I. INTRODUCTION

I feel doubly privileged to be invited to this Mombasa Retreat because it is well-known that ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa) is the shining star in the galaxy of seven regional research organizations (SROs). ASARECA is a dynamic organization that is being taken seriously by members of the donor community.

But I must confess straightaway that I have participated in more failures than successes in institution-building projects in Africa over the past forty years. My first experience dates back to the early l960s when I spent three exciting years helping to construct a Land Grant- type of university at the University of Nigeria. But the Land Grant model never took root in an environment where both research and extension were entrenched in the Ministry of Agriculture (Johnson and Okigbo, l989). In Senegal , I helped design the socio-economic component of a $106 million multi-donor, six-year project to strengthen ISRA, the NARS (National Agricultural Research System) of Senegal (Eicher, 1982). But the ISRA project turned out to be much too large, complex and financially unsustainable (Eicher, 1985). Despite these failures in Nigeria, Senegal and a number of other countries, I take refuge in the idea that institution-building should be viewed as a learning process – learning by doing and learning from others. What I have gained in maturity has more than offset what has been lost in excitement.

Professor Mrema directed me to prepare a 'frank' paper that "looks into the future with an eye on the past." Therefore, I shall leapfrog over a discussion of the strategic role of agriculture in development and the performance of African agriculture and move directly to an

analysis of Africa's unfinished business: building a sustainable agricultural research foundation (Lynam and Blackie, 1994).

Professor Thomas Odhiambo was ahead of his time with his article, "East Africa: Science for Development" (Odhiambo, 1967). He called for the coordination of national and regional science policies in East Africa and urged African governments to dramatically increase their investment in science education, starting in primary schools. Much has happened in Africa in the intervening three decades. The number of universities has grown at a rapid pace and the percentage of African scientists in NARS increased from 10 percent in the sixties to around 90 percent in the early nineties (Pardey et al. 1997). But during this same period, the number of scientists and administrative costs of the NARS increased at a faster pace than the growth of funds to support them. As a result, spending per scientist declined by 34 percent from 1961 to 1991 (Pardey et al. 1999). One example of high administrative overhead is an African NARS that currently has nineteen Assistant Directors in its headquarters.

The 1980s can be described as a golden decade for agricultural research in Africa. The World Bank made its first loan for agricultural research in Africa (Sudan) in 1979. ISNAR was set up in 1980 followed by SPAAR in 1985, and the donor community invested US$ 4 billion in agricultural research in Africa from 1980 to 2000 (McCalla, 2000). However, by the mid-nineties, there was a slowdown in donor funding for agricultural research and questions were raised about the poor performance of NARS. The slowdown is troublesome because many NARS in Africa are heavily dependent on foreign aid (an average of 40 percent) for their budgets and because the NARS of Africa are considered to be the weak link in the global agricultural research system (Pardey et al. 1997). Faced with a slowdown in foreign aid, managers of NARS in Africa are in a quandary over how to downsize their organizations while seeking to maintain quality, retain gifted researchers and pursue new sources of financing.

This paper addresses four questions:

- What lessons can be drawn from the "rise and decline" of NARS in Africa?
- What can African research managers learn from some of the successful reforms of NARS in Asia and Latin America over the past 10 to 15 years?
- What are the major challenges facing the NARS in the ASARECA region in the coming 10-20 years?
- What are the critical reforms and the incentives needed to develop pluralistic, accountable, productive and financially self-sustaining NARS in AFRICA?

II. THE AGRICULTURAL KNOWLEDGE TRIANGLE

A number of specialists in institutions have recommended using a systems approach to coordinating and sequencing inter-linked investments in agricultural research, extension and education. This approach has been called an agricultural knowledge system (Roling, 1986), agricultural knowledge information system (AKIS), (World Bank, 2001) and what I call the agricultural knowledge triangle (Eicher, 1999). Three key pillars -- research, extension and agricultural higher education---make up the agricultural knowledge triangle (system). The development and diffusion of new technology is critically dependent upon the joint performance of these three pillars. Since the pillars are complementary investments, they should be planned and sequenced as a system rather than as separate entities. Also, since these pillars are risky and have long- term payoffs, the government, rather than individuals or private firms, is usually the main investor at early stages of economic development. As a result, government investments in research produce public goods such as new technology that spills over and benefits more than one socio-economic group and future generations (Kaul et al. 1999; Dalrymple, 2001; Alston et al. 2001; Anderson, 2000).

The economic case for coordinating and sequencing investments in research, extension and education is straight-forward. The returns to investment in agricultural research will be low if extension agents and seed and fertilizer companies are not available to diffuse new technology and turn it into commercial success. Likewise, the returns to investment in extension will be low if extension agents are not continuously recharged with new technology from public and private research organizations. Finally, since the quality of scientific human capital is the main determinant of research productivity, the returns to investment in national research services will be low if the research agency is not reinvigorated with a continuous flow of well-trained university graduates. These examples point up the need to craft agricultural research triangles that promote *interaction* and *cooperation* between research, extension and universities.

However, instead of investing in all three pillars of the triangle, most donors have pursued a pillar by pillar approach to helping African nations strengthen agricultural institutions.

Why? Even when comprehensive donor projects have embraced research, extension and higher education, these projects have proven to be difficult to coordinate and implement in Africa. Also, the bureaucracy of donor and international organizations makes it difficult to prepare and implement projects covering the three institutions represented in the knowledge triangle. A former extension specialist in the World Bank describes the bureaucratic difficulties in preparing and implementing joint research, extension and agricultural higher education projects:

> "The Bank's involvement with the development of higher agricultural education at the university level in Africa has been minimal…within the Bank, the Agricultural Divisions have no responsibility for universities, which are the responsibility of the Education Divisions…It is not therefore surprising that the Bank projects in extension and research do not provide support to higher agricultural education" (Venkatesan, 1991).

What has been the record of donor investments in separate extension, research and higher education institutions across the African landscape? The pillar by pillar approach to institution building has created poorly sequenced, dysfunctional, and generally oversized and unsustainable agricultural institutions in Africa. Has there been an under-investment in one of the three pillars? The World Bank reviewed its global expenditures on agricultural research, extension and higher agricultural education and found that, over the 1987-97 period, agricultural higher education received about 2 percent while agricultural research and extension together received 98 percent of the Bank's $4.8 billion of global investments in agricultural education, research and training (Table 1). How did African higher education fare in this $4.8 billion package? During the 1987-97 period, the Bank made six agricultural higher education loans totaling $108 million, including three for Africa: Ghana, Uganda and Ethiopia (Willett, 1998).

To summarize, many donor specialists and academics have encouraged African nations to build national agricultural knowledge triangles (systems). But in practice, this has proven to be difficult because most donor agencies are unwilling to finance agricultural education projects. Also, it has proven difficult to implement comprehensive projects embracing all three pillars when the directors of research and extension departments and Vice Chancellors and Rectors report to different ministries.

III. THE RISE AND DECLINE OF NARS IN AFRICA: 1960-2000

FALSE STARTS IN HISTORICAL PERSPECTIVE

Before we examine the rise and decline of NARS in Africa, it is important to acknowledge three strongly held beliefs about development in the early sixties and how these beliefs continue to reinforce large inward looking NARS today. At independence, most African leaders believed that the state---not the private sector---should be the central planner, financier, entrepreneur, and risk-taker in generating jobs and "bringing development to the people." This belief in a large and powerful state was consistent with the bureaucratic norms of the agricultural service programs that were planned at the center. The highly centralized T &V extension model that was introduced in Africa in the late seventies was compatible with the prevailing view of the role of the state in top down development planning.

The second belief concerns the time and ability of donors to speed up the development process through large infusions of foreign aid. Back in the sixties, most African leaders articulated a vision of becoming modern industrial nations in one generation. Many western development economists believed that foreign aid could close the gap between rich and poor nations in one generation, i.e., around year 2000. But institution building is an accretionary process that unfolds over a period of many decades. For example, it took 70 years (1855 to 1925) for Michigan State University to produce its first Ph.D. graduate. EMBRAPA, the NARS of Brazil, is now being lionized for its sterling research system, but it should be kept in mind that Brazil has been independent for 179 years! How long will it take African nations to develop its human capital capacity in biotechnology? Can it be done in 5 to 10 years? I cannot think of a single African agricultural economist who is currently specializing in the economics of biotechnology.

The third false belief that accompanied independence was a conviction that one model of extension, food production or university could be introduced, scaled-up and sustained in an African nation. Various models have been introduced, including T & V extension, Land Grant Universities and the SG 2000 Food Production model. The Land Grand model was discontinued in the 1980s and the T &V model was quietly abandoned in the late 1990s after the Bank had aggressively promoted it in some 30 countries in Africa. These false beliefs in a large state sector, an unrealistic time frame and "the single model fits Africa", help explain why it has been so difficult to craft country-specific, sustainable institutions in Africa since independence.

How do we reconcile the decline of NARS and reduction in donor support for research in Africa in the 1990s with the numerous studies showing high rates of return to agricultural research in Africa (Oehmke and Crawford, 1996)? This is an important issue because many donor projects to strengthen NARS in Africa typically Justify the investment by pointing out that the annual rate of return on agricultural research projects in Asia is 20 to 30 percent, well above the World Bank's decision rule of requiring a minimum projected return of 10 percent on new projects.

I discovered the potential value and the shortcomings of rate of return studies a decade ago when Daniel Karanja (1990) tallied up the cost and returns of investments in hybrid maize research in Kenya from 1953 to 1988. He found that the annual rate of return on the investment in hybrid maize research in Kenya was 68 percent over the 35 years period. However, when Karanja completed his study in 1990, Kenya's maize research program had lost its momentum in terms of the release of new hybrids, and I concluded that while Kenya's maize research program was an economic success, it was an institutional failure. I also concluded that I had erred in not helping Mr. Karanja figure out the kinds of data that he should have collected to unravel the institutional puzzles surrounding the slowdown in the release of new varieties:

> The collapse of maize research in Kenya in the 1980s and early nineties , despite the high average annual rate of return to investment in hybrid maize research (68 percent) from 1953-1988, illustrates why rate of return calculations must be supplemented with a rigorous analysis of the institutional factors that influence the scientific discovery process and the ultimate productivity and financial sustainability of the research program (Eicher, 1991).

REFLECTIONS ON THE 'DECLINE OF NARS'

The history of agricultural research in Africa represents the unfolding of a learning process and the search for a new paradigm for the development of national agricultural research systems (Byerlee, 1998). Since the strengths and weaknesses of the colonial research strategies have been documented (Eicher, 1989), my focus is on the rise and decline of NARS from 1960 to the year 2000. Four factors have contributed to the rise and decline of NARS in Africa since independence. The first is an array of factors – historical, political, macro economic, and ideological – that have undervalued the role of a strong science base in development and the need to develop a strong national capacity to borrow and or develop new technology, and turn it into commercial success. The lack of African political support for research is a chronic problem which has been partially offset by increased donor support for research to a point where foreign

aid is now paying for an average of 40 percent of the budget of African NARS. This high degree of donor dependency has enabled African research managers and scientists to postpone building partnership with farmer groups and the private sector. The generous level of foreign aid to agricultural research has also postponed the mobilization of domestic financial resources to finance the core budgets of NARS in Africa.

The second major factor contributing to the poor performance and the decline of many NARS is attributed to an array of project design problems such as preparing projects that are too large, too complex, and for too short a time span. In addition, many donor-financed projects are bereft of ideas on how to assist in building human capital chains, human capital ladders, local financial mobilization, and the development of peer-reviewed research programs. These design problems have plagued donor-supported projects over the past two decades (Eicher, 1982, 1985, 1989, 1999).

Inflated size is a serious problem in donor-assisted projects for NARS in Africa. But large projects are partially a function of donor guidelines and incentives to prepare and manage large projects. In the 1960s and 1970s, for example, African governments were encouraged to spend one to two percent of their agricultural GDP on agricultural research – the same level as most industrial countries. Fortunately, this simple guideline is no longer used in donor circles because of the realization that money is not a substitute for time in building scientific capacity. Another indirect contributor to the preparation of large projects is the uncritical use of high rate of return estimates from research projects in industrial and Asian countries. But *ex post* rate of return studies are a backward looking assessment and they provide no guidance on the future financial and scientific sustainability of a NARS. To summarize, both the average percentage of agricultural GDP that is spent on research and the uncritical use of rate of return studies have contributed to inflated and financially unsustainable donor projects intended to strengthen NARS.

The third factor contributing to the decline of NARS is the institutional coordination problem, i.e. the coordination and sequencing of investments in research, extension and higher education. The experience in Uganda and Burkina Faso illustrates the difficulty in coordinating concurrent investments in the three pillars. In 1993, the World Bank agreed to finance the Uganda Agricultural Research and Training Project which included research, extension and agricultural education. However, the original idea of financing a single agricultural services project, was dropped at an early stage of project preparation because “the readiness for

implementation of each component was different." In Burkina Faso, analysts had difficulty in preparing a Research and Agricultural Services Project because donors quarreled over three competing extension models. Finally, donors have little interest in investing in agricultural higher education in Africa.

To summarize, it has proven difficult for African governments and donors to design, prepare and implement umbrella projects incorporating research, extension, and agricultural education because of bureaucratic problems between agriculturalists and educators in donor headquarters, and competition among universities and research and extension departments in Africa. Sadly, donors, as much as national governments, actively oppose real coordination. As a result, a comprehensive approach to building agricultural knowledge systems will not be forthcoming until African scientists, educators and extension specialists stand up and say "enough" (Blackie, 2001). The way forward is for African agriculturalists to seize the initiative and provide leadership in crafting country-specific agricultural knowledge systems.

The fourth factor contributing to the poor design of many projects to assist NARS is the financial sustainability problem and the tendency for donors to contribute to the expansion of a NARS beyond its capacity to be financed after donor aid is phased out. When I was on sabbatical leave at ISNAR in the Hague in 1988, Emil Javier, ISNAR Senior Research Officer and now Chairman of TAC, noted that many donor experts were looking through the wrong end of the scientific telescope by asking how to finance an expanded NARS instead of figuring out what size NARS can ultimately be financed from national sources and how to curb NARS expansion. Javier urged me to study the connection between the size of a NARS (number of scientists, number of research stations and number of commodity research programs) and the financial sustainability of a NARS. As a result of Javier's prodding, I prepared an ISNAR report, Sustainable Institutions for African Agricultural Development and I defined a sustainable NARS as one that has "the ability to mobilize domestic political support to pay the salaries and required operating costs of the core scientific staff from national sources" (Eicher, 1989, p.25). When I prepared my study in 1989, I examined the donor projections of support for agricultural research in Africa and concluded that there was a high probability that transferring an average of $300 million a year into the NARS (of Africa) over the next five years will overload the NARS with buildings, equipment and increased recurrent costs. I concluded that this rapid build up of foreign aid may "postpone the day of reckoning"—i.e., the need to develop African political support to finance the core costs of NARS from domestic sources (Eicher, 1989, p.25).

AFRICAN UNIVERSITIES IN THE BIOTECHNOLOGY AGE

Looking ahead, it is important to discuss the role of African universities in building scientific capacity in food and agriculture because they are being asked to increase the output of post-graduate students and make a bigger contribution to agricultural research. But post-graduate training in agriculture is in its infancy. Most of the faculties of agriculture in African universities are only 30 to 40 years old. African universities performed brilliantly in increasing the output of undergraduates from 1960 to 1980 (Ajayi et al. 1996). In 1996, there were around 160 universities in Africa, with roughly half in three countries: Nigeria, 37; South Africa, 21; and Sudan, 21 (Beintema et al. 1998). But the decline of the undergraduate educational experience is encouraging students of affluent African families to go overseas for their studies. Part of the quality problems is attributed to financial pressures and part is attributed to the time that it takes to build quality post graduate degree programs and sustain these programs decade after decade.

Three strategies have been used to introduce and strengthen agricultural education in Africa. The first was the introduction of the U.S. Land Grant University model in the 1960s and 1970s with its triple mission of research, extension and teaching. U.S. universities, with USAID support, helped set up a number of new universities in Africa that embodied some of the Land Grant ideas. Also, a number of two year agricultural colleges were upgraded into four year universities. But the research and outreach missions of the Land Grant model were in conflict with entrenched research and extension departments in Ministries of Agriculture. The Land Grant model collapsed in practice and many of these new universities were converted into all-purpose universities with primary attention given to undergraduate teaching. Because of the failure of Land Grant model in Africa in the sixties and seventies, delegations from Nigeria and Tanzania visited India and studied the State Agricultural model. Subsequently, three universities of agriculture based on the Indian model were set up in Nigeria but they all are experiencing difficulties (Idachaba, 1999). After a Tanzanian delegation visited India, the Sokoine University of Agriculture in Tanzania was established by upgrading the Faculty of Agriculture at Morogoro into a University with emphasis on agriculture, forestry and veterinary medicine. Both the U.S. Land Grant and the Indian State Agricultural University models have foundered in Africa, once again proving that imported institutional models have a high failure rate.

The second big university experiment was the 20 year global University Development Program financed by the Rockefeller Foundation from 1963 until 1983. Three African

universities (Nairobi, Ibadan and Kinshasa) participated in this 12 country global experiment under the theme of "universities for development." The Foundation terminated the program after 20 years because of mixed results and unexpected political difficulties in a number of countries such as the Congo and Nigeria. This experience points out the amount of time that it takes to develop strong postgraduate programs, adequate infrastructure, a motivated and well-paid academic staff, and adequate indigenous financial support to ensure sustainability (Coleman and Court, 1993).

The third institutional innovation in agricultural higher education was an attempt to mobilize African academic staff with advanced degrees to carry out agricultural research of mutual interest to NARS and Ministries of Agriculture. Mrema reports that:

> 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).

The World Bank has incorporated funding mechanisms (Agricultural Research Funds and Competitive Grant Schemes) into NARS projects in order to tap into this pool of university talent for research (Oniang'o and Eicher, 1998). Competitive Grant Schemes are now in operation in World Bank-financed projects in Malawi, Kenya, Ghana and a number of other countries. Although these funding mechanisms have been conceptualized as a method of "integrating universities into the NARS" (Byerlee and Alex, 1998), there have been many problems in "the NARS/university relationship" (Castillo, 1997). Conflict and misunderstanding are common in relationships between the strong (NARS) and the weak (faculties of agriculture (Castillo, 1997).. A professor at an African university recently summed up the university/NARS relationship as follows: "At present, academics and NARS staff view each other as competitors."

Today, there is agreement that African agricultural universities and faculties of agriculture have the primary responsibility to train and mentor the next generation of extension leaders, researchers and teachers. But one cannot avoid coming to grips with three harsh realities. First, there has been a sharp drop in the quality of the educational experience in many universities in Africa. Second, HIV/AIDS is wiping out many of the younger agricultural scientists and teachers even before they have completed their post graduate studies. Finally, African universities are ill-equipped to train the next generation of scientists to compete with scientists in other continents in a world of rapid scientific progress. Yet despite these difficulties, some universities in Africa have mounted aggressive reforms, including raising student fees,

privatizing catering services, setting up university consulting services, expanding distance education programs, and adding new courses in horticulture, agribusiness and marketing. These universities include the following: Makerere University (World Bank, 1999), University of Dar es Salaam, the University of Pretoria and the University of Lagos. African governments should study the pay off to long-term (40 to 60 year) capacity-building projects in Latin America. In Brazil, for example, three fourths of EMPRAPA's scientists are pursuing M.Sc. degrees and more than half of those pursuing Ph.D. degrees are now enrolled in local universities (Beintema et al. 2000a).

AGRICULTURAL EXTENSION AND THE PRIVATIZATION DEBATE

The role of agricultural extension is vital to the diffusion of new technology yet extension is currently moribund in many African nations. This dilemma can be best understood in historical perspective.

Three models of agricultural extension have dominated Africa's extension programs since independence. The first is the quantitative model. In the sixties, Western experts assumed that technology from temperate climates could be transferred to Africa provided that the number of extension agents was dramatically increased. Many governments adopted this model and African governments collectively added 36,000 new extension agents (from 21,000 to 57,000) over the 1959 to 1980 period (Judd et al. 1986). The quantitative model collapsed because of poor management, a lack of new technology to extend and problems of financing the expanded system.

The second model of extension---the T&V model---was a highly centralized model that attempted to improve the management of national extension systems. The model was propagated by Daniel Benor, a former Director of Extension in Israel, who helped the World Bank introduce the T&V model in Turkey in the late 1960s, and later in India. The World Bank introduced the T & V model in Africa in the 1980s and Benor served as a Special Advisor to the President and later, Special Advisor to the Vice President for Africa in the Bank. During the eighties, the Bank proudly announced that T&V extension programs were in operation in some 30 African nations.

Kenya has been the testing ground for claims and counterclaims about the performance of the T&V model. The T&V system of agricultural extension management was introduced by the

World Bank in Kenya in 1982. Two Bank projects supported the program until 1998. A recent study by the Operations Evaluation Department (OED) of the Bank concluded that "The performance of the T&V system as applied in Kenya has been disappointing. The system as implemented has been ineffective, inefficient and unsustainable" (Gautam, 1999). The rise and fall of T&V extension in Africa offers a sobering example of the failure of a model that was aggressively promoted in Africa without pilot projects, independent Africa-wide evaluations and without careful attention to its fiscal sustainability. Today, African agriculturalists are more seasoned and less gullible in accepting the proposition that one extension model can serve the diverse needs of 48 countries in Africa.

A third extension model is now emerging in Africa: the private/contract extension (Nielson and Bazeley, 2000; World Bank, 2001; Gemo and Rivera, 2001). The private extension model is now under discussion in Mozambique and in the early stage of implementation in Uganda (NAADS, 2001). Five reasons are driving this intense interest in the privatization model. First, many of the national extension programs are starved for operating funds because of reduced government budgets for the Ministry of Agriculture. Second, after 10 to 20 years of experience with the T & V model, many governments realize that the donor-financed T & V schemes were too large in terms of the number of staff, number of vehicles, etc. to be financed by African governments after foreign aid is phased out. Third, private extension has been effective for export crops where farmers are taxed to finance both research and extension. Fourth, private extension is emerging in rich countries such as the Netherlands, New Zealand and the United States. Fifth, village and church groups have been set up to deliver extension advice in the vacuum created by the collapse of national extension systems. For example, in the Embu district of Kenya, the collapse of the government's artificial insemination program in 1999 and 2000 has been filled by two rival church societies which are offering artificial insemination services to smallholders at substantially higher prices (400 to 1050 KSH) than the nominal sum (40 KSH) previously charged by the government's veterinary extension program.

Nevertheless, there are some tough questions to be addressed in the current debate on the privatization of extension in rural areas where the average per capita GDP is one or two dollars a day and farmers are asked to contribute to the "care and feeding" of a private extension agent? Do we have any examples where the poor have bought their way out of poverty? If not, should donors step in and offer loans to African governments who in turn will make funds available to farmer groups/villages who will sign contracts with private firms to provide extension advice?

After three years of debate and review of alternative extension models, Uganda's Parliament approved a NAADS Act on May 2, 2001 which establishes the institutional framework for the creation of a private extension model -- the National Agricultural Advisory Services Project (NAADS). This model will use pooled funding from donors which will flow to the Treasury to Districts, and Sub-Counties. The Sub-Counties will turn funds over to farmers' organizations which will use the funds to set up contracts with extension agents or NGOs to provide extension services to local farmers. This new model of private extension will be closely observed because it represents a major departure from the traditional government extension model (NAADS 2000).

To summarize, we are witnessing a profound shift away from the centralized T & V model to more pluralistic, open and flexible models of extension. The World Bank has quietly withdrawn its dogmatic support for the T & V (Training and Visit) model of extension amid a cry for more decentralized pluralistic and participatory extension systems. Daniel Benor has left his World Bank post and the Bank is financing a new private extension model in Uganda.

IV. REFORMING NARS IN ASIA AND LATIN AMERICA

> Although our government (the U.S.) has been actively engaged in technical assistance in agriculture throughout Latin America for two decades, the sad truth is that not a single first-class agricultural research center has been developed as a consequence of these activities. - Nobel Laureate, T.W. Schultz, 1964

INTRODUCTION

The historical experience of building and reforming NARS in Asia and Latin America in the fifties and sixties is brilliantly captured in Albert Moseman's Building Agricultural Research Systems in the Developing Nations (1970). Although this classic about viewing institution building as an ongoing learning process has been out of print for many years, it is timely and relevant in Africa today. Five country studies in Asia and Latin America illustrate some of lessons to be drawn from building, reforming and re-reforming NARS. The Latin American studies shows that rapid progress has been achieved in building agricultural research capacity in the region since Schultz's gloomy assessment of 1964.

Japan

The critical role of smallholder agriculture in Japanese economic history is often overlooked by contemporary development specialists and donor agencies because Japan is known today as a nation with a highly subsidized agriculture. But 100 years ago, Japan was a pioneer in developing institutions to support small family farms and it did not subsidize its farmers. Japan's experience is relevant to Africa today because it was a pioneer in Asia in showing how a nation with tiny farms pragmatically pieced together an agricultural knowledge system to undergird a smallholder-led agricultural revolution from 1868 to 1914.

Japan's phenomenal 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, a smallholder farm production model and a reliance on its own resources--not foreign aid (Hayami, 1988). The results were impressive. Japan's smallholder agricultural strategy generated the same long-term annual agricultural growth rate (1.6%) as the U.S. farmers using horses, and later tractors, over the 100 year period, 1880 to 1980 (Hayami and Ruttan, 1985).

Soon after Emperor Meiji assumed the reigns of power in 1868, he established a new government called the Meiji Restoration, which committed Japan to rapid modernization based on compulsory universal primary education (1872) and imported agricultural and industrial technology from the US and Western Europe. To achieve rapid modernization through technology borrowing, Emperor Meiji dispatched a high-level mission headed by Vice President Iwakura to tour the United States and Europe for 22 months (not 22 days) from 1871-1873. Members of the mission filled hundreds of notebooks with information on every facet of industry and farming in the U.S., including a meticulous analysis of large-scale mechanized farms, equipped with horses and reapers. The Mission then visited eight European nations, including Germany, where they were fascinated with the embryonic research on chemical fertilizer and science-based agriculture.

Japan then hired teachers from the United States and England to teach in its newly-established agricultural colleges. Nevertheless, in the early 1880s after less than a decade of experimenting with imported technology in industry and agriculture, the Meiji government came to the conclusion that foreign technology was a stunning success in industry, but a failure in agriculture. The economic failure of the American model of large-scale farming in Japan prompted the Meiji government to set up a Ministry of Agriculture in 1881 mandated to develop a new agricultural strategy to increase yields on small farms through the application of chemical fertilizer and improved seeds.

Japan pragmatically started an extension service by hiring veteran farmers and charging them with spreading improved farm practices throughout the country and mobilizing farmers as a political force. In 189l, the veteran farmers met in Tokyo and established a new organization, the Agricultural Society of Japan, to extend technical information to farmers modeled after the Royal Agricultural Society of England. 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 membership and group action to acquire political power for farm people. Africa has much to learn about this experience.

To summarize, Japan pragmatically pieced together the three AKIS pillars through a trial and error process over a period of four-to-five decades. But unlike many African countries over the past forty years, Japan enjoyed political stability and it relied on its own creativity and

resources to experiment, restructure and develop its country-specific agricultural knowledge system, rather than one based on foreign models and the whims of foreign aid.

Malaysia

Malaysia's development experience is a "rags to riches" story that is underreported in the development literature, partially because it eschewed foreign aid, foreign experts and foreign models. At independence in 1957, Malaysia's per capita GDP was $350, the same as Ghana's.

Rubber claimed the lion's share of the agricultural research budget from 1925 until the Malaysian Agricultural Research Institute (MARDI) was established in 1971 (Ruttan, 1982). Malaysia increased its agriculture research staff from 100 officers at independence in 1957 to 1,000 in the 1980s. In the late 1960s, Malaysia embarked on a massive agricultural diversification program away from rubber and Malaysian scientists skillfully borrowed hybrid oil palm seedlings from the Congo and used them to developed hybrids suitable for Malaysian agro-ecologies. At independence in 1960,Nigeria was the world's leading oil palm exporter, but Malaysia's dynamic R & D program enabled it to expand oil palm production and replace Nigeria as the world's leading oil palm exporter (Eicher, 1989).

In the early 1980s, long before donors urged African nations to liberalize markets and increase exports of non-traditional crops, Malaysia had embarked on a global search for new domestic and international markets for its farm products. When I visited Malaysia in 1988, I met with Dr. Hashim Noor, one of my former students, who was director of MARDI's Socio-Economic Department that employed 57 of the 1000 scientists in MARDI. I was impressed with MARDI's socio-economic research on value-added crops, including a study of taxicabs burning palm oil diesel fuel, research on rubber carpets for airport runways and for ferreting out new global markets for oil palm by commissioning studies of consumer tastes in Germany for various cooking oils. The Socio-Economic unit also commissioned Japanese consulting firms to interview Japanese consumers about their papaya preferences. After the preference studies were completed, MARDI breeders spent the next 12 years perfecting a sweet (hand-sized) papaya geared to Japanese and Hawaiian palates.

Today, Malaysia's per capita GNP is US$3670 compared with $390 in Ghana.

India

India's buildup of its agricultural research system since independence is one of the best-documented stories in the scientific world. This buildup was aided by the threat of famine, dedicated Indian leadership, the serendipitous availability of high-yielding wheat varieties from Mexico in the mid sixties, and the long-term assistance from USAID and the Rockefeller and Ford Foundations to strengthen India's agricultural knowledge system.

In 1956, the threat of famine prompted the Government of India to invite a team of Rockefeller Foundation scientists to figure out how to strengthen its wheat research program. In the early sixties, India agreed to import high yielding wheat varieties from Mexico, followed by high yielding rice varieties from IRRI in the Philippines. The rest is history. India became self-sufficient in food in 1981.

Without question, agricultural scientists enjoyed unusual access to political leaders in Asia in the 1960s because of the threat of famine in the region. F.F. Hill, an agricultural economist and Vice President of the Ford Foundation, and Norman Borlaug, a wheat breeder from the Rockefeller Foundation in Mexico, made numerous joint visits to Asia and aggressively made the case for a science-based agriculture in the political arenas in India and Pakistan. Hill and Borlaug made a practice of meeting with the Head of State after the completion of their fact-finding missions to India and Pakistan. On October 16th 1968, Hill and Borlaug discussed the findings of their field visits with the President of Pakistan. Two days later, they prepared a memorandum for President Khan and stressed the need to build strong national agricultural institutions:

> Pakistan cannot rely solely on innovations from the International Center for Maize and Wheat Improvement (Mexico) and the International Rice Research Institute (Philippines) and other outside sources. It must continually test and adapt what it can get from abroad, but it must innovate as well. The nature of agricultural production and the underlying biological sciences dictate the need for a strong agricultural science base within Pakistan. This means that Pakistan must produce increasing numbers of well-trained young scientists in her universities. It must develop and support agricultural research organizations that will provide young scientists opportunities and encouragement to make the maximum contributions of which they are capable (Hill and Borlaug, 1968).

India is a textbook example of how a poor country can eschew the pillar by pillar approach to institution-building and concurrently build an interactive agricultural knowledge system. During the sixties and seventies, the Ford Foundation financed a large scale extension

buildup, the Rockefeller Foundation helped strengthen agricultural research and USAID helped conceptualize and finance a new institutional innovation – State Agricultural Universities. Since the World Bank, Japan, the EU and other major donors were not on the scene in India in the early sixties, donor coordination was relatively easy to achieve among the USAID and the two American Foundations (Lele and Goldsmith, 89).

Today, India has a large, self-confident, inward-looking NARS with 18 percent of its agricultural research being done by the private sector. However, the inward looking posture of India's NARS stands in sharp contrast with EMBRAPA in Brazil.

Brazil

Brazil initiated a public research program for farmers about 150 years ago (Ruttan, 1982). In 1972, Brazil set up EMBRAPA (Brazilian National Agricultural Research Corporation) to coordinate its national research program (Yeganiantz, 1984). Today, Brazil has 18 percent of its labor force in agriculture, and 5000 full-time equivalent (FTE) agricultural researchers, roughly half of whom are in EMBRAPA (Beintema et al. 2000a). The other half are in state research organizations and the private sector. Today, one half of Brazil's researchers have a Ph.D., one third have a M.Sc. and the balance have B.Sc. degrees. Brazil's agricultural research budget was US$ 325 million in year 2000 (Portugal, 2000). Agriculture R&D expenditures per scientist increased at an average annual rate of l.3 percent from $143,000 in the late seventies to $202,000 in 1996 (in 1993 dollars) (Beintema et al. 2000a).

Since EMBRAPA's inception some 30 years ago, Brazil's economy grew rapidly in the seventies followed by economic crises in the eighties (the currency was devalued four times in the 1986-1994 period). But EMPRAPA's management team skillfully managed its core research programs despite these wide swings in government expenditures on research.

EMBRAPA's human capital improvement program is one of the most impressive in the developing world. In 1963, USAID financed collaborative agreements between four Brazilian and four U.S. counterpart universities to strengthen agricultural higher education in Brazil (Sanders et al. 1989). After a decade of strengthening undergraduate education, the four university contracts were extended another four years to strengthen post graduate education. When EMBRAPA was formed in 1972, it launched a massive human capital improvement program and spent about 20 percent of its total budget from 1974-82 on various training

programs in Brazil and abroad. EMBRAPA had an average of more than 300 researchers enrolled each year in post-graduate training programs in the late 1970s and through the 1980s.

Today, EMBRAPA is an outward-looking organization with 1562 alliances with local, regional and international organizations (Portugal, 2000). EMBRAPA and the state universities and private sector are deeply involved in developing new technology to support the expansion of agricultural exports (mainly coffee, soybeans and sugar) and value-added activities such as gourmet coffee for overseas consumers.

Many NARS in Africa have been urged to increase their research on traditional and non-traditional export commodities. The contrasting experience of Brazil and Malawi illustrates how aggressively Brazilian scientists have moved to compete in global gourmet coffee markets. Brazil has long been known as a producer of cheap Robusta coffee that is used in the manufacture of instant coffee. However, because of the rapid increase of Robusta exports from Vietnam and other countries, Brazilian coffee growers and the Brazilian Specialty Coffee Association recently teamed up with several international coffee buyers (Illycaffe SpA of Italy and Starbucks Corp. of Seattle) and formed a Coffee Alliance to improve the quality of Brazilian coffee for overseas specialty markets. Brazil has introduced new Arabica varieties along with new methods of drying and processing coffee. In late 2000, the Coffee Alliance developed a gourmet coffee Internet auction, and foreign buyers paid Brazil US$1.38 a pound at a time when the world coffee price was at a seven year low of 65 cents a pound (Wall Street Journal, 2001).

Turning to Malawi, coffee has been the principal cash crop for smallholders in northern Malawi since the 1950s. In 1971, the Government of Malawi set up a Smallholder Coffee Authority (monopoly) and gave it exclusive control over buying coffee from small holders and processing and marketing it. The Coffee Authority quickly abolished village cooperatives, and took over their coffee processing activities and then "taxed" smallholders by paying them a small fraction of the world price of coffee. Malawian smallholders responded to this draconian "coffee tax" by discontinuing the maintenance of their coffee trees and made weekly treks to the lowlands to grow tobacco (Buccola and McCandlish, 1999).

In the early nineties, the Malawian government announced a liberalization plan to phase out the Coffee Authority and allow private firms to buy coffee from farmers and cooperatives. In 1994, the principal secretary of the Ministry of Agriculture assured an American investor (a former Peace Corps volunteer in Malawi) that the Smallholder Coffee Authority would soon be disbanded and he warmly endorsed the plan of the potential American investor to set up the

African Gourmet Coffee Company and purchase coffee from smallholders in Malawi for gourmet markets in the United States. In 1995, the African Gourmet Company offered Malawian farmers US$1.88 per kg. of green coffee (about a 400 percent increase over what the Coffee Authority had paid farmers in 1994). The Coffee Authority responded by raising its farm price from US$.043 to US$1.10 per kg. Although the Coffee Authority offered farmers a lower price than the African Gourmet Coffee Company, the Authority still was able to purchase 90 percent of the 1995 crop because it controlled the village level processing plants to which farmers brought their coffee. In 1996, the Coffee Authority had a staff of 657 employees, rows of houses for its extension staff and a fleet of four-wheel drive vehicles). Although, the Coffee Authority continued to lose money, it resisted being dismantled. After two years of operation, the fledgling African Gourmet Coffee Company experienced cash flow problems and closed its operations in Malawi. This case study illustrates the large gap between the theory and practice of liberalization programs and how far Malawi is behind Brazil and Viet Nam in helping small-holders compete in global markets.

Today, Brazil is a powerhouse in the global agricultural research arena. Brazil's agricultural research budget was $325 million in year 2000, slightly less than the $340 million for the entire CGIAR research system (Portugal, 2000). More importantly, foreign aid contributed only 1.6% of Brazil's agricultural research budget in 1999 (Beitema, 2000a). Although T.S. Schultz lamented the weak NARS in Latin America in the 1960s, today he would undoubtedly point with pride to the strong NARS in Brazil, Chile, Argentina and Uruguay.

Uruguay

Since the early 1980s, most of the NARS in Latin America have been pressured by their governments to restructure their agricultural research agencies and find alternative sources of funding. Uruguay is a small country of three million people and it has much in common with many countries in Africa. In 1989, the government established the National Agricultural Research Institute (INIA) as the country's principal agricultural R&D agency, but it has allowed INIA to remain an autonomous institution (Echeverria, 2000). Today, there are six agricultural R&D agencies in Uruguay and INIA employs about 40 percent of the total scientists in the country. INIA has 328 full time scientists and its annual agricultural R&D expenditure per scientist is US $117,000, half of that of Brazil (Beintema et al. 2000).

INIA is noted for being a disciplined and well-managed NARS. It has been innovative in generating about 30 percent of its annual budget from a 0.4 percent tax on the value of agricultural products with matching funds provided by the government. INIA has also been innovative in setting up two competitive funding mechanisms, one of which was established with the creation of INIA in the late 1980s. The average funding per approved research proposal was US $34,000 over the 1991-1998 period.

LESSONS FROM LATIN AMERICA AND ASIA

What can Africa learn from the experience of Latin America and Asia? Latin America's experience reinforces the point that developing scientific capacity is an accretionary process that unfolds over many decades. During the early stages of agricultural growth, NARS have been restructured frequently to achieve the desired coverage in terms of agro-ecological areas and an optimal degree of centralization and decentralization of research stations. Also, the decision of Latin American governments to reduce funding to NARS, starting in the early 1980s, turned out to be a blessing in disguise because it forced the managers of NARS to develop new sources of revenue, and to increase their partnerships with universities, NGOs and the private sector.

Today, a new paradigm of agricultural research is emerging in Latin America. Figure 1 represents a stylized sketch of a pluralistic NARS in Latin America and it depicts three levels of interaction. The first level is composed of regional and national commissions charged with laying out the agricultural research policy framework and identifying national research priorities. The second level is financed from a variety of sources, including production taxes on farm products, joint ventures with private firms, competitive grants, etc. The third level is execution. The NARS is still the main actor in implementing national agricultural research programs, but in many cases universities and private firms have increased their importance in the execution of research. This global overview reveals that the NARS of Asia and Latin America have introduced an array of institutional innovations that have made them more pluralistic, accountable and financially sustainable.

This comparative institutional assessment has shown that many Asian and Latin American countries have pragmatically pieced together agricultural knowledge systems over time. Japan and Malaysia had the advantage of building their own systems without the "intrusion" of foreign aid. India received major support from only three major donors in the

1960s and 1970s. This stands in sharp contrast to Zambia's 180 agricultural projects funded by a dozen donors in 1996 (Eicher 1999). Brazil made a decision in the sixties to build the institutional foundation for a modern agriculture and obtained financial support from USAID to finance teaching and research assistance from four American universities. Finally, the financial crises of the 1980s have induced NARS to mobilize new sources of revenue and search for a new paradigm for NARS which has increased the participation of universities and the private sector in research.

Two sobering insights emerge for Africa from this comparative assessment. First, the agricultural science base was much deeper in Asia and Latin America in the sixties. Scientists such as Norman Borlaug and F.F. Hill urged Asian nations to strengthen the agricultural science base in Asia because they argued that it takes the same level of scientific training to develop new technology as it does to become "intelligent borrowers" of new technology from the global system.

The second insight that emerges from this comparative institutional analysis is that it is difficult, but not impossible, for African research managers and scientists to develop effective agricultural knowledge triangles in Africa. If Asia and Latin American can achieve this goal, it can be done in Africa. But the task is more difficult in Africa because of the weak agricultural science base and because foreign aid, as Mellor points out, is being held captive by a myriad of special interests which are promising short run results.

THE SEARCH FOR A NEW NARS PARADIGM IN AN ERA OF DECLINING DONOR SUPPORT

African research managers are well aware that they will have to restructure, and probably downsize their NARS in order to make them more productive, accountable and fiscally sustainable. Africans will have to take the lead in this effort because of the poor performance of many donor-financed agricultural projects in Africa, and the trend of special interest groups to take over the foreign aid agenda and marginalize agriculture. John Mellor sums up the current aid scene and what it means for agriculture:

> Foreign aid is now captive to a myriad of special groups. Today they include child survival, vitamin A, microcredit, poverty, microenterprise (excluding agriculture) empowerment of women, environment, wildlife preservation, and on and on. . . Priorities and

strategy cannot coexist with such a panoply of special interests, each with its own objectives (Mellor, 1998).

In the mid 1990s, after 10 to 15 years of structural adjustment programs and a rapid buildup of donor support for NARS in Africa, donors started to reduce their global support for agriculture and increase their lending for micro-finance, democratization, privatization, rural livelihoods, and poverty alleviation. What explains this shift in donor priorities away from the pursuit of "old fashioned" agricultural growth? Part of the answer is based on the perception that the world food problem has been solved. Part is due to donor ignorance about the strategic role of agriculture at an early stage of development. And part is based on the fact that many donor-supported agricultural projects are not performing well and are unsustainable. For example, the sustainability of the World Bank's agricultural projects was 33 percent in 1999, among the lowest of any sector in the Bank's portfolio.

Another reason for a reduction of donor funding for traditional agricultural projects is the broadening of the scope of what is meant by "rural" to include rural livelihoods, rural health, education and farmer empowerment. However, the adoption of a bottom up participatory and rural livelihood approach to development is dangerously close to the failed community development projects of the 1950s (Holdcroft, 1998) and the IRD (Integrated Rural Development) projects in the 1970s (Binswanger, 1998).

The slowdown in donor lending for NARS is supported by the following data:

- Total overseas development aid to Africa fell from US$ 32 per person in 1990 to $19 in 1998.

- The World Bank lending for agriculture fell to below 10 percent in FY 2000, an all-time low. Bilateral aid (except Japan and Denmark) has declined for agriculture. EU aid to agriculture and rural development averaged 5.9 percent for the 1986-98 period with a sharp shift in 1995 to humanitarian aid and general budget support (Cox and Chapman, 1999).

- The total budget for the CGIAR has been flat at US$ 340 million for the past four years.

- World Bank global expenditure on agricultural research in millions of U.S. dollars has declined: $381, 1997; $559, 1998; $402, 1999; $39, 2000.

- The UNDP is closing its global program for food security and agriculture in order to narrow its focus to areas where it has a comparative advantage.

- World Bank lending for the rural sector in Africa continued its long slide through the 1990s. In FY 1990, commitments totaled about U.S.$ 1 billion (23 new projects), but in FY 2000, they totaled U.S.$ 224 million (8 new projects) (World Bank, 2001a).

Foreign assistance can be viewed in positive and negative terms. In positive terms, foreign aid has trained thousands of agricultural scientists who, in turn, have helped increase the number of universities in Africa and raised the percentage of African scientists in NARS from around 10 percent in 1960 to around 90 percent in 1990. But Africa's heavy and erratic flow of aid to NARS has created dependency and held back the kinds of institutional innovations that have blossomed in Latin America in response to the cutback in government support for agricultural research.

What is urgently needed is a radical rethinking of how can Africa best organize itself to take advantage of the world's rapid scientific progress? Clearly, Africa's scientific community cannot flourish if it continues the present situation where it is heavily dependent on erratic foreign aid for 40 to 60 percent of the budget of its national agricultural research systems. Since the amount of aid for agricultural projects in Africa may continue to decline in the coming decade, the NARS managers and scientists/entrepreneurs will be forced to develop retrenchment programs (in cooperation with ministries of finance and donors), spin off some commodity research programs to producer groups, generate additional revenue through producer levies, pursue contract research and alliances with the private sector and foundations, and generate revenue from the commercialization of NARS products and services.

V. STRENGTHENING NARS: ISSUES FOR DEBATE

The present ad hoc methods of building agricultural research capacity are painfully inadequate, especially in heavily aid-dependent NARS in Africa. Eight issues are ripe for debate among policymakers, research managers and donors in Africa:

1. The Need for Aggressive Decompression

   Many NARS in Africa are suspended in a bubble of foreign aid. One NARS currently has 19 Assistant Directors in its headquarters and 35 field research stations. Many NARS are suffering from the sudden withdrawal of aid and the aftershocks of their rapid expansion. For example, the NARS of the Sudan, The Agricultural Research Council, is reeling from the withdrawal of foreign assistance and the collapse of the Western Sudan agricultural research project. Many faculties of agriculture should be downsized and or consolidated. The Sudan currently has 20 Faculties of Agriculture (Salih, 2001).

   More short term aid projects are not the answer! A recent book, Aid and Reform in Africa (Devarajan et al. 2001), points out that Kenya has received more than $15 billion of foreign assistance from 1970 to 1996. The book further points out that aid financing in the 1980s actually "led to worse economic policies" in Cote d'Ivoire, Kenya, the Democratic Republic of Congo and Nigeria (2001, p.27).

   There is a need for a fundamental rethinking of the role of African governments, private firms, NG0s and donors in the organization and provision of agricultural research, extension and higher education. There is a need for aggressive decompression and opening up of NARS in Africa. But donors have an important obligation to assist in this process by providing bridging funds because excessive and erratic donor aid has been a major contributor to the current crises in many NARS in Africa. The decompression process is now underway in KARI in Kenya, with the assistance of the EU and World Bank in agreement with Kenya's Ministry of Finance, for KARI to retain the salaries of retrenched workers. But at the end of the day, downsizing should be viewed as part of a process of searching for a new NARS paradigm which is built on partnerships with NGOs, universities and the private sector. The goal of

decompression process is to develop an efficient NARS that can be primarily financed from national sources. The need for the decompression of NARS was highlighted in my ISNAR monograph "Sustainable Institutions for African Agricultural Development (1989).

2. The CGIAR and NARS Relationships

The CGIAR has been active in Africa for three decades and it is currently spending about 45 percent of its budget on Africa. Without question, the CGIAR has made important contributions to African agricultural development. Examples include new maize varieties (Byerlee and Eicher, 1997), TMS cassava varieties (Nweke, forthcoming), WARDA's "new rice" (WARDA, 2001) and ILRI's socio-economic research on the livestock revolution (Ehui et al. 2000).

Despite these achievements, the CGIAR/NARS relationships have been festering for some time in Africa. A decade ago, I prepared a critique of the CGIAR system and contended that the CG had taken the wrong turn in the road in the early nineties when it increased the number of CG Centers from 13 to 18 without assurances of increased donor support (Eicher, 1992, 1994). Later, I raised questions about the banal recommendations of the Strong Report of 1998 (Eicher, 1999). Recently, a Change Design and Management Team (CDMT) studied how to strengthen the CG system and prepared a report for the CG's Mid Term Meeting in Durban in May 2001. The report makes seven recommendations, including one to enhance NARS as follows: "the Global Challenge Programs should generally be designed and implemented in such a way that the capabilities of the NARS are fully mobilized" (CDMT 2001). Unfortunately, the CDMT report does not discuss how to strengthen NARS in Africa and enhance the voice of African scientists in figuring out how to develop improved working relationships between the strong (the CG centers) and the weak (the NARS).

It appears that the CDMT panel did not have the time to dig deeply into the special problems of strengthening NARS in Africa. After the Durban 2001 meeting, Africa will remain the Achilles' heel of the CGIAR System.

But amid the tension in African research circles, African scholars and research managers have prepared a list of ten recommendations on how to

improve the CGIAR/NARS relationship in Africa (FARA, 2000). The FARA report is a landmark study that displays the maturation of Africa's scientific community and its political acumen in mobilizing Africans to take charge of the research agenda in Africa, and ultimately, the financing of their own research priorities (CGIAR 2001a).

3. Building Agricultural Knowledge Triangles

There is a big gap between the theory and practice of building agricultural knowledge triangles. We have stressed the need to coordinate and carefully sequence investments in the three pillars of the agricultural knowledge triangle. But in practice, donors have been reluctant to allocate funds to strengthen the agricultural education pillar. Also, because of different "levels of readiness" in African governments for preparing and implementing comprehensive projects to strengthen all three pillars, most donors end up financing research or extension projects. Nevertheless, many Asian and Latin American countries have pragmatically pieced together interactive agricultural knowledge systems and there is no reason why African countries cannot build efficient agricultural knowledge systems. Uganda is currently taking the lead in Africa by restructuring its core agricultural institutions: research, extension and agricultural higher education. Both African governments and donors should pay careful attention to the reforms underway in Asia, Latin America and Uganda.

African research managers should study Brazil's experience over the past forty years in financing and extracting the synergies of a coordinated agricultural knowledge triangle. For example, EMBRAPA, the NARS of Brazil has an annual budget of US $ 325 million, of which only 1.6 percent is derived from foreign aid. Brazil has paid particular attention to human capital improvement. In the 1960s, Brazil requested long term assistance from U.S. universities to help build four agricultural universities. Today, Brazil is an agricultural powerhouse in scientific research and post graduate training in agriculture. Currently, about three fourths of EMPRAPA researchers pursuing M.Sc. degrees and more than half of Embrapa's researchers pursuing Ph.D. students are enrolled in Brazilian universities.

The art of crafting an interactive knowledge system should be viewed as a pragmatic process that unfolds over decades. But the crafting process must be led by African scientists in close cooperation with farmers, politicians and urban leaders who all agree that a dynamic smallholder agriculture can improve the welfare of both rural and urban people.

4. Human Capital: The Crown Jewels of NARS. Human capital improvement strategies are crucial issues because gifted and highly motivated scientists are the core, i.e., "the crown jewels", of a productive NARS. However, in many developing countries, scientists are treated like second class clerks and noodle sellers. In China, one observes that noodle sellers at the entrance of research stations often earn higher incomes than Ph.D. scientists working at the stations. To address the lagging salaries, the Government of China is pursuing a radical reform of its incentive structure for its scientific staff. The scientists are being personally evaluated and placed into two groups: half will be named "elite scientists", given a 500 percent salary increase and charged with developing world class biotechnology capability (Huang et al. 2000). The other half will continue to receive their normal salaries with the expectation that many will retire or pursue different jobs. Turning to Latin America, the average current salary for a senior scientist at EMBRAPA's Tropical Cassava and Fruit Research Station in Brazil is between US$14,500 and US$35,000 per year (Pires de Matos, 2001). In Ghana, the Director of the Cassava Research reported that the salaries for his three cassava researchers were "too low to quote" (Otto, 2000).

Since the NARS of Africa are experiencing difficulties in retaining African scientists, it is timely to examine the incentive structure (monetary and non-monetary) and how it shapes human capital recruitment, mentoring, promotion, rewards, attrition, and degradation. Human capital degradation represents the depreciation of knowledge because of premature death, lack of library and information support systems, and a lack of a career structure which motivates and rewards scientists in challenging careers.

In 1988 when I visited MARDI, the NARS of Malaysia, I discovered that research officers had access to low interest loans for the purchase of a house and a car, a once in a lifetime gift of an airplane ticket to Mecca, and a once in a career

around the world air ticket as a capstone reward for working until the retirement age of 55. Another issue to explore is using information technology to build human capital chains with members of the global scientific community. For example, a visitor to the Cassava Research Station in Brazil notices a computer at the desk of every scientist and ready Web access. How can African NARS replace their training officers (travel agents) with human capital officers who mentor scientists and help them become permanent crown jewels of a NARS?

5. New Sources of Funding. Competitive funding grants have emerged as a much discussed solution to the funding crisis in African NARS (Reifscneider, Byerlee and de Souza, 2000). A number of studies have concluded that competitive funding should be introduced on a pilot basis and viewed as a complement to core funding of a NARS. But setting up and operating a competitive funding program is difficult for small NARS (e.g., fewer than 100 scientists) because of "high administrative costs and limited potential for competition" (Byerlee, 2000).
6. Building Biotechnology Capacity. With the exception of Kenya, Zimbabwe and South Africa, most African nations are at an early stage of biotechnology research (ISNAR, 1999; Cohen, 1999; Qaim et al. 2001). Ethiopia has prepared a twenty-year biotechnology expansion plan, set up an agricultural technology research coordination office and prepared plans to develop an Agricultural Biotechnology Research Institute. But in West Africa, progress is slow. At independence in 1957, Ghana was one of the most economically advanced countries in Africa. Today, Ghana does not have a coordinated national effort in biotechnology.

The critical issues in developing a national policy framework and research priorities will entail close cooperation between the NARS and scientists from a number of university facilities because, with the advent of the biotechnology revolution, the dividing line between agricultural and nonagricultural sciences is becoming blurred. As a result, agricultural researchers will need to seek new knowledge from university scientists at home and abroad in faculties of agriculture, science, environment, law, commerce and social science, as well as from private biotechnology and multinational seed and fertilizer firms. The challenge for the managers of NARS and Deans of Agriculture in Africa is to figure out how their separately-governed research and teaching institutions can

cooperate to build the foundation for biotechnology research. For example, where should a biotechnology research center be located? On a university campus or at a NARS? Byerlee and Fischer (2000) have produced a valuable guide for building biotechnology capacity. This topic requires further debate and experimentation.

7. Policy Research. In a globalized economy, farmers, research managers and marketing firms urgently require policy outlook research on future market prospects. The managers of NARS urgently need the results of rigorous analysis of changing comparative advantage in the context of liberalized global markets. In addition, Grades and Standards are emerging as an important research topic because of the growing role of global food chains in setting quality standards for export commodities (Reardon et al. 2001). But after forty years of pursuing different approaches to building policy analysis capacity in Africa, there is no proven model of how to strengthen policy research in Africa, how to maintain quality and how to finance it over time (Babu, 1997; Gitu, 2000; Omamo, 2000; Rukuni et al. 1998 and Idachaba, 2000). This topic requires further debate and experimentation.

8. Sustainability. The seventh issue ripe for debate is the financial and scientific sustainability problem. At present, economists do not have a practical appraisal tool to determine what size of NARS a borrower should aim for and what are indicators of success in achieving long-term institutional, and financial sustainability. There is a dearth of information on how to analyze the borrower's long term capacity to sustain NARS without donor support (Adoum, 2001). Since the issue of sustainability is masked in the early years of donor projects when donors pay a large share of the project, many NARS have added hundreds of scientists without realizing that once the infrastructure is built, the main cost of research is salaries. Some hard analytical work needs to be done on the tough questions on how to determine the long-term scientific and financial sustainability of a NARS and various extension and university models.

VI. INSIGHTS FOR AFRICAN POLICY MAKERS, RESEARCH MANAGERS AND DONORS

This paper draws on historical and comparative data to address the critical problems facing NARS in Africa. The evidence presented embraces gradualism and learning by doing as a proven pathway to building scientific capacity in food and agriculture. But this requires African resolve, African political leadership, aggressive indigenous resource mobilization and long-term donor assistance over the coming three or four decades. Many NARS in Asia and Latin America have slowly developed pluralistic, and competitive institutions (Byerlee, 1998; Elliott and Echeverria, 2000). This accretionary model of institution-building provides insights for revitalizing the NARS in Africa over the coming decades. But the needed reforms in NARS in Africa should be viewed as part of a continuous process of change. As new problems emerge, new reforms will be necessary (Collion, 1999).

Although there are some similarities between Africa, Asia and Latin America, there are two differences in terms of resources and political support for strengthening the NARS of Africa. First, the threat of famine is not present in Africa as it was in Asia in the 1960s and 1970s. Because of the lack of a famine threat and the ready availability of "food aid subscriptions," many African political leaders tend to view agricultural research as a secondary activity that can be financed by foreign aid. Second, foreign aid accounts for an average of 40 percent (and in a few countries, 60 percent) of NARS budgets in Africa. Africa's experience has shown that erratic project aid can undermine the indigenous discipline that is needed to build fiscally self-sustaining research systems.

Building a modern science base in agriculture in Africa must begin at the political level as China did when the State Council recently issued a decree to pursue a new round of radical reforms in order "to create a modern, responsive, internationally competitive and fiscally sustainable research system" (Huang et al. 2000). To be sure, foreign aid can serve as "handmaiden" in assisting the NARS of Africa, but foreign aid and foreign experts are not a substitute for time, learning by doing and learning from others. In short, building a science-based agriculture is an indigenous-led, accretionary process.

Today, the lack of political commitment in the State House is the biggest single missing factor in building strong and productive NARS in Africa. But there are seeds of hope in Uganda, Kenya and Nigeria. Uganda is providing political leadership in implementing a plan to

modernize agriculture through a major decentralization programs, including the privatization of extension. KARI, the NARS in Kenya is engaged in a major retrenchment of staff that is aided by an agreement that KARI, the EU and the World Bank negotiated with the Government of Kenya. This agreement allows KARI to retain the salaries of retrenched staff to improve the terms and conditions of service of scientists. In Nigeria, under the leadership of President Obasanjo, the government recently announced that the salaries and fringe benefits of agricultural researchers and university professors would be increased tenfold, i.e., from US$1,200 per year to US$12,000 per year (Nweke, 2001). These examples of political leadership in the State House must now be supplemented with building support at the bottom—i.e. with farmers and other clientele groups.

The bottom line is that African scientists – not donors – must take the lead in building country-specific agricultural knowledge systems. This is Africa's challenge for the next 25 to 50 years!

REFERENCES

Adoum, Carol. 2001. "Policies Influencing the Viability of African NARS: Case Studies from West Africa." Washington, D.C. January 7. Draft

Ajayi, J.F. Ade, Lameck K.H. Goma, G. Ampah Johnson, with a contribution by W. Mwotia 1996. *The African Experience With Higher Education*. Athens, Ohio: Ohio University Press.

Alston, Julian M. Philip G. Pardey, and Michael J. Taylor, (eds). 2001. *Agricultural Science* Policy: Changing Global Agendas. Baltimore: Johns Hopkins University Press.

Anderson, Per Pinstrup. 2000. CGIAR: An Instrument for Global Public Goods. Paper prepared for International Centers Week, World Bank. Washington, D.C. October 23.

Arrow, Kenneth J. 1962. "Economic Implications of Learning by Doing," *Review of Economic Studies*," 29 (3):155-173

Babu, S. 1997. "Rethinking Training in Food Policy Analysis: How Relevant is it to Policy Reform?" *Food Policy*, 22(1):1-9.

Beintema, N.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, et al. 2000. "Agricultural R & D in Uruguay: Policy, Investments and Institutional Profile." Washington, D.C.: IFPRI, INIA and FONTAGRA, September.

Beintema, Nienke, et al. 2000a. "Agricultural R & D in Brazil: Policy, Investments and Institutional Profile." Washington, D.C.: IFPRI. December, Draft.

Binswanger, H.P. 1998. Agricultural and Rural Development: Painful Lessons. In C.K. Eicher and J.M. Staatz (eds.), *International Agricultural Development.* Third edition. Baltimore, Maryland: Johns Hopkins University Press. Pp. 287-299.

Blackie, Malcolm. Email, March 15, 2001.

Buccola, Steven T. and James E. McCandlish, 1999. *Rent* Seeking and Rent Dissipation in State Enterprises, Review of Agricultural Economics. 21(2): 358-373.

Byerlee, Derek.l998. The Search for a New Paradigm for the Development of National Agricultural Research Systems. *World Development*. 26(6):1049-1055.

Byerlee, D., and G.E. Alex. 1998. *Strengthening National Agricultural Research Systems: Policy Issues and Good Practice.* Washington, D.C.: World Bank.

Byerlee, Derek and Ken Fischer. 2000. Accessing Modern Science: Policy and Institutional Options for Agricultural Biotechnology in Developing Countries. AKIS Discussion Paper. Washington D.C.: World Bank.

Byerlee, Derek. 2000. "Competitive Funding of Agricultural Research: Lessons and Challenges." Washington D.C.: World Bank.

Castillo, Gelia T. 1997. "Research Partnerships: Issues, Lessons, Results and Dreams for Sustainable Development," Network Paper No. 71. *AgREN*. January, pp.1-9.

CDMT (Change Design and Management Team) 2001. *Design and Managing Change in the CGIAR: Report to the CGIAR Mid-Term Meeting 2001, May 21-25*. Durban, South Africa. Washington DC Change Design and Management Team, CGIAR, World Bank. April.

CGIAR. 2001a. Synthesis Report of the *FARA/CGIAR Consultation on Agricultural Research in SSA: Meeting of the Minds III, Towards a Common Ground*. Paper prepared for the CGIAR mid-term meeting 2001, May 21-25, Durban, South Africa. Washington D.C. CGIAR, World Bank.

Cohen, J.I. (ed.), 1999. *Managing Agricultural Biotechnology: Addressing Research Program Needs and Policy Implications*. Wallingford, U.K.: CABI International.

Coleman, J.S., and D. Court. 1993. *University Development in the Third World: The Rockefeller Foundation Experience*. Oxford: Pergamon Press.

Collion, Marie-Helene. 1999. "Institutional Reforms for Sustainable Funding of Agricultural Research: The Case of Mali and Senegal." Washington, D.C. World Bank. November.

Cox, Aidan and Jenny Chapman, 1999. *The European Community External Cooperation Programmes: Policies, Management and Distribution*. London, Overseas Development Institute.

Dalrymple, Dana G. 2001. "Global Public Goods: Some Outline Notes and References," Washington D.C.: U.S. Agency for International Development, February 2. Draft 8.

Devarajan, Shantayanan, David R. Dollar and Torgny Holmgren. 2001. *AID and Reform in Africa*. Washington DC: World Bank.

Echeverria, R.G. 1998. Will Competitive Funding Improve the Performance of Agricultural Research? Discussion Paper No. 98–16. The Hague: ISNAR.

Echeverria, Ruben.2000. The Institutional Reformulation in the National Agricultural Research System in Uruguay: The Case Study of INIA, Uruguay. Paper presented at the XXIV International Conference of Agricultural Economists, August 13-18, Berlin.

Eicher, C.K. 1982. Reflections on the Design and Implementation of the Senegal Agricultural Research Project. East Lansing, Michigan: Department of Agricultural Economics, Michigan State University.

Eicher, C.K. 1985. "A Mid-Term Assessment of the Senegal Agricultural Research Project: Lessons for Donors." Washington, D.C.: World Bank, May 20, 1985.

Eicher, C.K. 1989. *Sustainable Institutions for African Agricultural Development*. Working Paper No. 19. The Hague: ISNAR.

Eicher, C.K. 1990. Building African Scientific Capacity for Agricultural Development. *Agricultural Economics* 4(2):117–143.

Eicher, C.K. 1991. Maize Research in Kenya: Economic Success and Institutional Failure? East Lansing, MI: Department of Agricultural Economics, Michigan State University, Memorandum, Jan.10.

Eicher, C.K. 1992. *Revitalizing the CGIAR System and NARSs in the Third World.* Staff Paper No. 92-73. East Lansing, MI. Department of Agricultural Economics, Michigan State University.

Eicher, C.K. 1994. Building Productive National and International Agricultural Research Systems. In V.W. Ruttan (ed.), *Agriculture, Environment, and Health: Sustainable Development in the 21st Century.* Minneapolis, University of Minnesota Press. Pp. 77–103.

Eicher, C.K. l999. *Institutions and the African Farmer*. Third Distinguished Economist Lecture. Mexico. D.F. Cimmyt.

Elliott, Howard and Ruben Echeverria. 2000. "Characteristics of Successful Agricultural Research Competitive Grants Programs." In *Competitive Grants in the New Millenium: A Global Workshop for Designers and Practitioners*. Brasilia, May 16-18, Embrapa, IDB and The World Bank, 191-204.

FARA (Forum for Agricultural Research in Africa). 2000. "CGIAR and IARC Governance, Organization and Structure: An African Perspective." Entebbe, Uganda, October 16-17.

Fuglie, K. and D. E. Schimmelpfennig (eds.) 2000. *Public-Private Collaboration in Agriculture Research.* Ames, IA: Iowa State University Press.

Gautam, Madhur, 1999. *World Bank Agricultural Extension Projects in Kenya*. Report No. 19523. Washington, D.C.: World Bank, June 30.

Gemo, H. and W.M. Rivera, 2001. "Mozambique's Move Toward a Pluralistic National System of Rural Extension." *Agricultural Research and Extension Network Paper No. 110*. London: ODI.

Gitu, Kangethe W. 2000. Strengthening The Links Between The Supply and Demand for Agricultural Policy Analysis Results," Paper presented at the ASARECA/ECAPAPA Workshop, Whitesands Hotel, Mombasa, Kenya. November 29.

Harrar, J.G. 1967. A Pattern for International Collaboration in Agriculture, in Strategy Toward the Conquest of Hunger. The Rockefeller Foundation, New York.

Hayami and Ruttan, 1985. *Agricultural Development: An International Perspective.* Revised Edition. Baltimore, Maryland: Johns Hopkins University Press.

Hayami, Yujiro, *Japanese Agriculture Under Siege: The Political Economy of Agricultural Policies*, 1988. New York: St. Martin's Press, p.25.

Hill, F.F. and Norman E. Borlaug.1968. Report to His Excellency Field Marshal Mohammad Ayub Khan, President of Pakistan, Islamad. October 20.

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, J. Kun, Ruifa Hu, Carl Pray and Scotte Rozelle, 2000. "Re-Reforming China's Agricultural Research System." Revised version of a paper presented at the XXIV International Conference of Agricultural Economists, Berlin, August 13-18.

Idachaba, Francis, 1999. Email, April 14.

Idachaba, Francis. 2000. *Agricultural Policy Process in Africa: Role of Policy Analysts*, ECAPAPA Monograph Series No. 2, Entebbe, ECAPAPA. November.

ISNAR. 1999. Assessing the Feasibility of a Regional Initiative on Biotechnology for Agricultural Research in Eastern and Central Africa. The Hague: ISNAR

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.

Judd, M.A., J.K. Boyce, and R.E. Evenson. 1986. Investing in Agricultural Supply: The Determinants of Agricultural Research and Extension Investment. *Economic Development and Cultural Change* 35(1):77-113.

Karanja, Daniel, 1990. "The Rate of Return to Maize Research in Kenya, 1955-88," Unpublished M.Sc. Thesis, East Lansing, Department of Agricultural Economics, Michigan State University.

Kaul, Inge, Isabelle Grunberg and Marc A. Stern. 1999. *Global Public Goods: International Cooperation in the 21st Century*. New York:Oxford.

Lele, U., and A.A. Goldsmith. 1989. The Development of National Agricultural Research Capacity: India's Experience with the Rockefeller Foundation and Its Significance for Africa. *Economic Development and Cultural Change* 37(2):305–343.

Lynam, J.K., and M.J. Blackie 1994. Building Effective Agricultural Research Capacity: The African Challenge. In J.R. Anderson (ed.), *Agricultural Technology: Policy Issues for the International Community.* Wallingford, UK: CAB International. pp. 106–134.

McCalla, Alex F. 2000. *Agriculture in the 21st Century*. Fourth Distinguished Economist Lecture. Mexico D.F.: Cimmyt.

Mellor, J.W. 1998. Foreign Aid and Agriculture-led Development. In C.K. Eicher and J.M. Staatz (eds.), *International Agricultural Development*. Third edition. Baltimore, Maryland: Johns Hopkins University Press. Pp. 55-66.

Moseman, Albert. 1970. *Building Agricultural Research Systems in The Developing Nations*. New York: The Agricultural Development Council.

Mrema, Geoffrey 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*. Geoffrey C. Mrema, ed. Kampala, Uganda: ASARECA.

Nielson, David and Peter Bazeley, 2000. "The Search for Impact and Whether 'Outreach' is The Answer." Washington, D.C. April

Nweke, F.I. Forthcoming. *The Cassava Transformation: Africa's Best Kept Secret*. East Lansing, Michigan: Michigan State University Press.

Nweke, F.I. Personal Discussions, April 3, 2001.

Odhiambo, Thomas R. 1967. "East Africa: Science for Development" *Science*." vol.158.Nov l7: 876-881.

Oehmke, James F. and Eric C. Crawford. 1996. The Impact of Agricultural Technology in Sub-Saharan Africa, *Journal of African Economies* 5(2):271-292.

Omamo, S.W. 2000. Policy Research on African Agriculture: Trends, Gaps and Challenges. Nairobi, The Rockefeller Foundation, December, Draft.

Oniang'o, Ruth and Carl K. Eicher. 1998. "Universities and Agricultural Development in Africa:Insights from Kenya.". Paper presented at a conference at the Bellagio Study and Conference Center, Bellagio, Italy, October 19-23, l998

Otto, John. 2000. Email to Felix Nweke, East Lansing, Michigan. November 1. CSIR, Accra, Ghana.

Pardey, P.G., J. Roseboom, and N.M. Beintema. 1997. Investments in African Agricultural Research. *World Development* 25(3): 409–423.

Pardey, P.G., J. Roseboom, N. Beintema and C. Chan-Kang. 1999. Cost Aspects of African Agricultural Research. EPTD. Discussion Paper No. 42. Washington D.C. and The Hague, IFPRI and ISNAR, April.

Pires, de Matos, A., Pray, C. E., and K. Fuglie, 2000. "The Private Sector and International Technology Transfer in Agriculture," In K. Fuglie and D. E. Schimmelpfennig (eds.), *Public-Private Collaboration in Agricultural Research*, Ames: Iowa State University Press: 269-299.

Portugal, Alberto Duque, 2000. "A NARS Perspective on Research Partnerships: The EMBRAPA Experience," Paper presented at a meeting of GFAR 2000, May 21-23, 2000. Dresden, Germany.

Qaim, Matin, Anatole F. Krattinger,and Joachim von Braun, (eds) .2000. *Agricultura*l *Biotechnology in Developing Countries:Towards Optimizing the Benefits for the Poor*. Boston, MA: Kluwer Academic Publishers.

Reardon, Thomas. et al. 2001. "Global Change in Agrifood Grades and Standards: Agribusiness Strategic Responses in Developing Countries," *International Food and Agribusiness Management Review*. 2(3).

Reifschneider, Francisco, Derek Byerlee and Francisco de Souza. 2000. *Competitive Grants in the New Millennium: A Global Workshop for Designers and Practitioners*. Proceedings of a Workshop, Brasilia, Brazil, May 16-18, Embrapa, IDB and the World Bank.

Roling, N. 1988. *Extension Science: Information Systems in Agricultural Development*. Cambridge, UK: Cambridge University Press.

Rukuni, M., M.J. Blackie, and C.K. Eicher. 1998. Crafting Smallholder-Driven Agricultural Research Systems in Southern Africa. *World Development* 26(6): 1073–1087.

Ruttan, Vernon W. 1992. *Agricultural Research Policy*. Minneapolis: University of Minnesota Press.

Ruttan, Vernon W. 2001. *Technology, Growth and Development: An Induced Innovation Perspective*. New York. Oxford.

Salih, Salih H. 2001. Email March 29, 2001.

Sanders, John H., Richard L. Meyer, Roger W. Fox and Fernando C. Peres. *American Journal of Agricultural Economics*. 71(5):1206-1210.

Sarr, Cheikh Tidiane. 2000. "Sustainable Funding Mechanisms: Case Studies from West Africa." Washington, D.C., December 24.

Schultz, Theodore W. 1964. Transforming Traditional Agriculture. New Haven, Yale University Press.

Venkatesan, V., and J. Kampen. 1998. *Evolution of Agricultural Services in Sub-Saharan Africa: Trends and Prospects.* Discussion Paper No. 390. Washington, D.C.: World Bank.

Wall Street Journal. 2001. February 2, p.B1.

WARDA. 2001. "The New Rice." Bouake,: WARDA

Willett, A. 1998. Agricultural Education Review: Support for Agricultural Education in the Bank and By Other Donors. Executive Summary. Washington, D.C.: World Bank.

World Bank. 1999. Financing Higher Education in Africa: Makerere: The Quiet Revolution. Africa Region. No. 143. Washington, D.C.: World Bank, September.

World Bank. 2001. "Contracting for Extension: Review of Emerging Practices." (AKIS Good Practice Note). Prepared by William M. Rivera, Willem Zijp and Gary Alex. Washington, D.C. World Bank.

World Bank. 2001a. "Africa Rural Development Strategy: Vision to Action Update 2001." Washington D.C.: World Bank. January 8, Draft.

World Bank 2001b. The National Agricultural Advisory Services Project. Washington DC: World Bank.

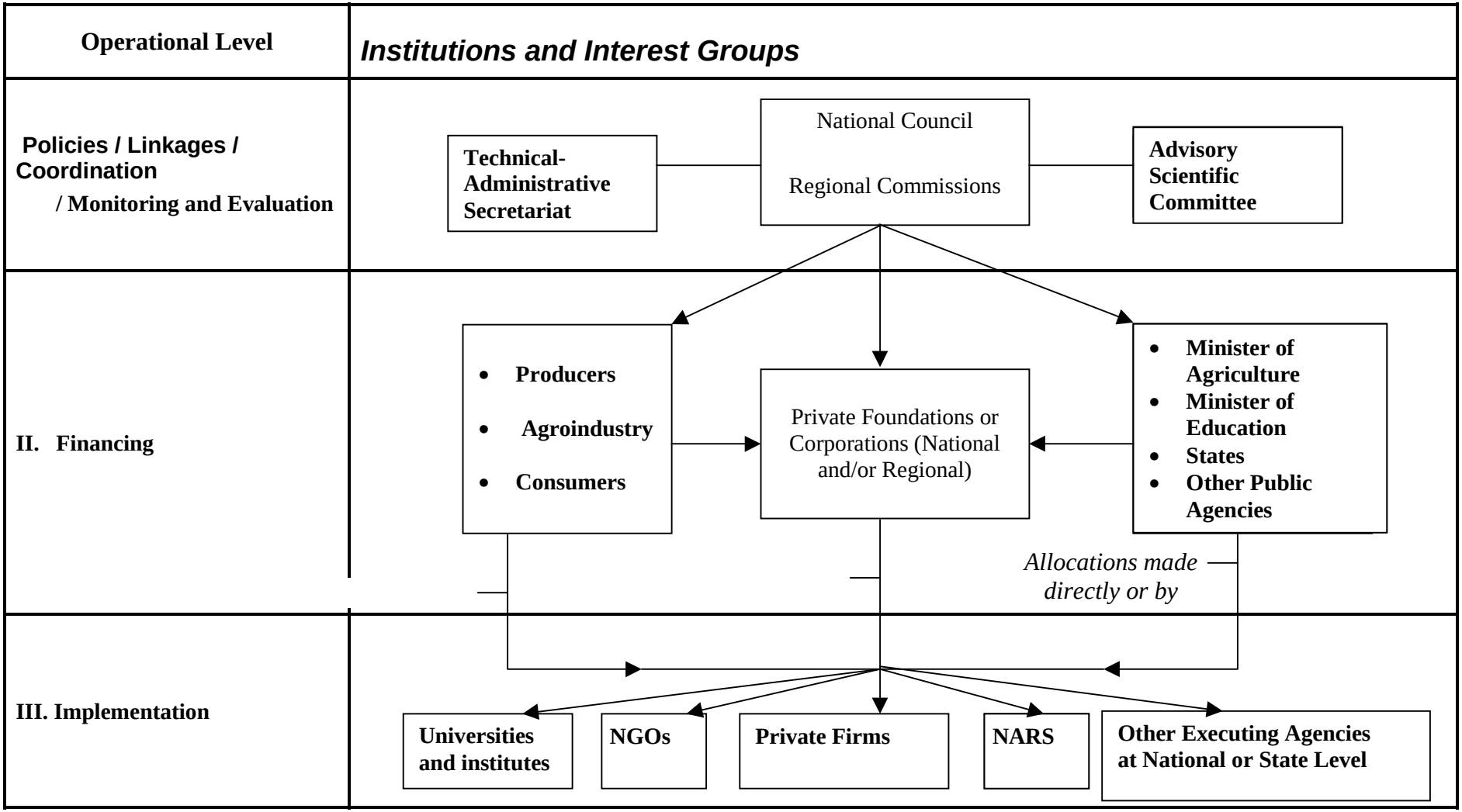
Yeganiantz, Levon. 1984. *Brazilian Agricultural Research*. Brasilia, D.F. Embrapa.

Table 1. World Bank global support for agricultural research, extension, and agricultural higher education, 1987–97

	Mil. US$	Percent
Agricultural research	$2,482	51.50
Agricultural extension	2,229	46.25
Agricultural higher education	108	2.25
Total	$4,819	100.00

Source: Willett 1998.

Figure 1. NATIONAL AGRICULTURAL RESEARCH SYSTEMS IN LATIN AMERICA, 2001



Source: Moscardi and Echeverría, 2001