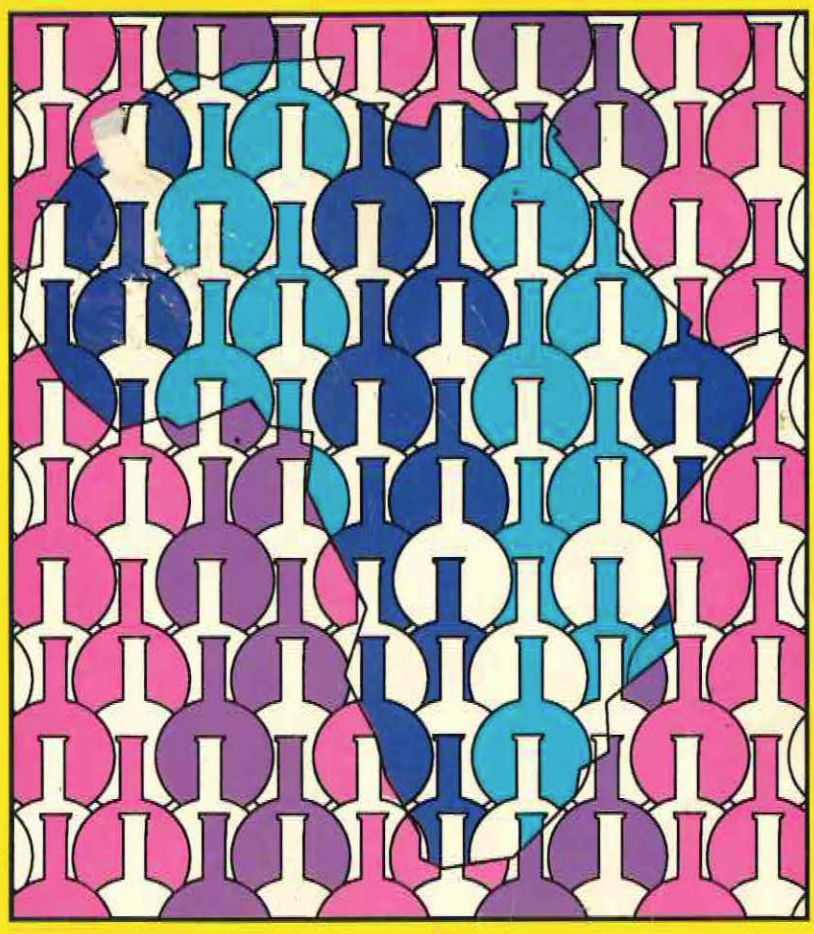

THE NEW CHALLENGE OF SCIENCE AND TECHNOLOGY FOR DEVELOPMENT IN AFRICA

Proceedings of
a Symposium on Scientific Institution Building in Africa
held at the Rockefeller Foundation Conference Center,
Bellagio, Italy, March 14–18, 1988

ICIPE Foundation
African Academy of Sciences
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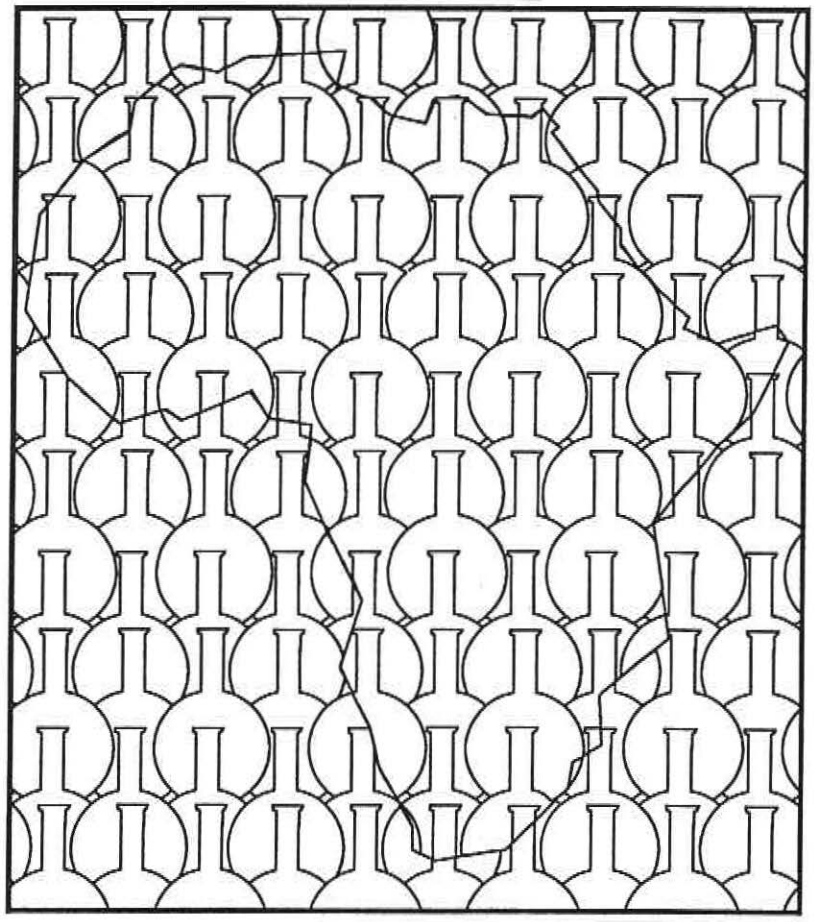

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PREFACE

The ICIPE Foundation and the African Academy of Sciences, with the generous support of several foundations, convened a symposium on scientific institution building in Africa at the Rockefeller Foundation Conference and Study Center in Bellagio, Italy, from March 14–18, 1988. This report summarises the conclusions reached by the participants, who included African scientists and scholars, representatives of public and private donor agencies and academies of sciences, and experts in the role of science and technology in development.

Sponsorship of this study is the last official action of the ICIPE Foundation, which was formed to represent an international consortium of academies of sciences to assist in the establishment of the International Centre of Insect Physiology and Ecology (ICIPE) in Nairobi, Kenya. Founded two decades ago, ICIPE has become a unique "center of excellence" in insect science, combining basic research with applied pest-control programmes, education and training, and outreach programmes in all regions of Africa. From its inception, ICIPE has been a remarkable example of African talent for scientific entrepreneurship and institution building. It has also been an equally remarkable example of international co-operation in science. In the formative years of the ICIPE, the Foundation helped to establish linkages with the international scientific community and funding agencies. Today, ICIPE is not only an African institution, a continuing testament to African initiative and the coming of age of an African science, it is also a major international centre for insect science, linking research programmes in developed and developing countries.

Now that ICIPE no longer needs the institutional and scientific support that was critical in the formative years, the Foundation decided that, as a final task, it would be useful to organise a review of the past, present state, and future prospects for science, technology and learning in Africa. By any standard of measurement, much has been accomplished since the end of the colonial era. There is now an extensive infrastructure of universities and research institutes and a rapidly increasing cadre of educated men and women, scientists, technicians, and educators. With these resources, Africa now seems to have the potential to mount a sustained effort to understand and resolve its own problems and to identify new opportunities. However, the future of science, technology and learning in Africa is seriously at risk: political and economic instability, and decreasing financial support from donor agencies and national governments, have left practically every research institution and every university in a precarious position, and many in an acute state of crisis.
The purpose of the symposium was to analyse and illustrate the disjunction between the potential and the reality, between the inherent vitality and strength of African intellectual resources and the financial and institutional constraints. The Foundation hopes that the report of the symposium will alert the international scientific community, public and private donor agencies, government officials, business executives, and the wider public to the need for sustained financial and institutional support for African science and learning

as the only way for Africans to fulfil their aspirations. As several participants suggested, *a window of opportunity* is now open, but it may not remain open for long.

John Voss, President,
ICIPE Foundation

LIST OF ACRONYMS

AAS	African Academy of Sciences
AAAS	American Association for the Advancement of Science
AAASA	Association for the Advancement of Agricultural Sciences in Africa
AAU	Association of African Universities
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AID	US Agency for International Development
AIDS	Acquired Immuno-Deficiency Syndrome
ARC	Agricultural Research Corporation
ARC	Agricultural Research Council
BOSTID	Board on Science and Technology for International Development
CCTA	Commission de Coopération Technique en Afrique
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Centre for Tropical Agriculture
CIDA	Canadian International Development Agency
CIMMYT	International Maize and Wheat Improvement Centre
CIP	International Potato Centre
CODESRIA	Council for the Development of Economic and Social Reseach in Africa
CRAT	Centre Régional Africain de Technologie
CRC	Cotton Research Corporation
CRENK	Centre Régionnale d'etudes Nucléaires du Kinshasa
CSA	Conseil Scientifique de l'Afrique
DAC	Development Assistance Committee
DCD	OECD's Development Cooperation Directorate
EAAFRO	East African Agriculture and Forestry Research Organisation
EAVRO	East African Veterinary Research Organisation
ECA	United Nations Economic Commission for Africa
ENSUT	Ecole Nationale Supérieure Universitaire de Technologie
FRG	Federal Republic of Germany
GATE	German Appropriate Technology Exchange
GTZ	German Agency for Technical Co-operation
HSIU	Haile Selassie I University
IAR	Institute for Agricultural Research
IBPGR	International Board for Plant Genetic Resources
IBRD	International Bank for Reconstruction and Development
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICIPE	International Centre for Insect Physiology and Ecology
ICRAF	International Council for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDB	Inter-American Development Bank
IDEP	Institut du Développement Economique et de Planification

IDRC	International Development Research Centre
IFCC	Institut Français de Café, du Cacao, et Autres Plantes Stimulantes
IFPRI	International Food Policy Research Institute
IFS	International Foundation for Science
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
ILRAD	International Laboratory for Research on Animal Diseases
INEAC	Institut National pour l'Etude Agronomique du Congo
INERA	Institut National pour l'Enseignement et Recherches Agronomiques
INSAH	Institut du Sahel
IRCT	Institut de Recherche du Coton et des Textiles Exotiques
IRHO	Institut de Recherches pour les Huile et Oléagineux
IRRI	International Rice Research Institute
ISA	Institut Senegalais de Recherches Agricoles
ISNAR	International Service for National Agricultural Research
ITA	Institut de Technologie Alimentaire
LDC	Less-Technologically Developed Country
MDB	Multilateral Development Bank
MIRCEN	Microbiological Resources Centre
MRC	Medical Research Council (UK)
NAS	National Academy of Sciences
NIFOR	Nigerian Institute for Oil Palm Research
NRC	National Research Council
NUFFIC	Netherlands Universities Foundation for International Cooperation
OAU/STRC	Organisation of African Unity/Scientific and Technical Research Commission
OCCGE	Organisation Commune Contre les Grands Endémies
OCLALAV	Organisation Commune de Lutte Antiacridiénne et de Lutte Antiaviaire
ODA	Official Development Assistance
OECD	Organization for Economic Cooperation and Development
R & D	Research & Development
SAREC	Swedish Agency for Research Cooperation
S & T	Science & Technology
UDI	Unilateral Declaration of Independence
UK/ODA	Britain's Overseas Development Administration
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WACRI	West African Cocoa Research Institute
WHO	World Health Organization

INTRODUCTION

The Symposium on Scientific Institution Building in Africa, was sponsored by the ICIPE Foundation and the African Academy of Sciences in co-operation with the U.S. National Research Council-Board on Science and Technology for International Development. Participants gathered at Bellagio for three days of discussion based on presentations by African scholars and by representatives of donor agencies contributing their support to African development.

The Symposium was supported by the John D. and Catherine T. MacArthur Foundation; travel for some of the African participants was supported by the Carnegie Corporation of New York and the Canadian International Development Research Centre, and the Rockefeller Foundation made available the Bellagio Study and Conference Center.

The Symposium was organised on the premise that many African countries are now, 25–30 years after independence, facing new sets of problems created by the economic and demographic conditions arising in the last 10–15 years, exacerbated by drought and conflict. The development of solutions to these problems will require research, mainly done in Africa by Africans. A considerable investment in African research institutions has been made over the past century, and there are many distinguished African scientists and excellent institutions. However, these institutions (with some notable exceptions), suffer from the results of the same problems: many African governments are unable to support them at the levels that were originally conceived when they were set up; many of the African scientists are either drained from the local system by better opportunities elsewhere, or do not have the complex supporting environment required to permit them to sustain their focus on the research issues unless they are receiving external support. There is the need to re-examine the current state of African Research and Development (R & D), and to focus on the role of international co-operation. Research capacity in Africa is only one component of scientific institution building in the larger context of development; Africa's development will depend on the sustained growth of a learned community of well-informed people who are able to analyse, understand, and communicate wisdom to others, especially those in government, agriculture and industry, in what Professor Thomas Odhiambo calls "knowledge-driven development". Research, however, provides a convenient focus if it is seen in this larger sense. The Symposium, because of limitations in time and numbers of participants, concentrated primarily on agriculture, health and university education and training.

A second premise is that international co-operation to assist African countries overcome their economic difficulties is both morally required and also in the economic and political self-interest of the industrial countries, for whom future markets for manufactured goods and services will be important, as will a reduced potential for conflict that might involve the major (or indeed minor regional) powers. Recent experience shows that this is recognised by the

donor countries, and even those that are cutting their total technical assistance budgets are maintaining Africa as a priority region. The level of donor support overall, however, is insufficient, and more is, unfortunately, provided in aggregate for military and relief purposes than for development, or given in disproportionate amounts to countries for political gain, rather than to meet needs. Most African governments, for their part, have given signs of willingness to change past policies, to provide more incentives to producers, and to seek new ways of solving their problems.

This Symposium is, therefore, based on the premise that more effective support is required to strengthen African scientific institutions and their research capabilities, that it will contribute to solving long term developmental problems, and that an examination of past experience will provide useful information on how future efforts should be focused by African scientists and planners, and through international co-operation.

The presentations and discussions led to a striking convergence of views. It became apparent that all participants, from their widely differing perspectives and experiences, found they shared a remarkably common perception of the evolution of Science and Technology (S & T) institutions, of their importance, of what had gone wrong with them, and what fresh approach was needed to create an effective S & T institutional capacity in Africa. Although no particular information that emerged from the presentations or discussions was especially new or unexpected, the very fact of this convergence of perceptions, shared by African scholars and donor agency representatives, at a time when many donors are evaluating the effectiveness of their programmes and projects, is believed to signal the opening of an important new *window of opportunity* in African development. Because of the economic and ecological plight of many countries, and because the window may not remain open long before the shape of future co-operation becomes fixed, it is urgent to re-emphasise the importance of African scientific institutions to the future of economic and social development, and in particular to re-orient all levels of education towards creating a science-based African culture.

To this end, it was agreed that the meeting could most usefully contribute to promoting and reshaping support for new approaches to African S & T institutional capacity building, by circulating the following concise statement of these shared perceptions to African governments and the donor agencies that are assisting them. It does not offer detailed recommendations—these will require more specific discussions among many more people than was possible during three days—but rather defines the context for new directions and opportunities from what has been learned from the past three decades of African scientific and technological development.

CONCLUSIONS

SUMMARY OF CONCLUSIONS

1. The need to maintain momentum of past successes

A number of African universities have built fine faculties of science and technology and have produced some of Africa's most outstanding scientists, engineers, and social scientists. Also, several national and regional research institutes were established in many countries, particularly in the 1960s. The total number of these institutions was considerable, as were the numbers of scientists trained. The 1968 Abidjan Conference convened by the US National Academy of Sciences focused on agricultural research priorities for economic development throughout Africa by bringing together African scientists from 36 countries with those from co-operating institutions elsewhere to identify the key issues for donors. The subsequent 1974 NAS study of African agricultural research capabilities identified over 300 research institutions in independent sub-Saharan Africa. World-class research was carried out, and is still being carried out, at a number of centres. There were many successful R & D efforts, including those identified by the preparatory planning meeting for the Symposium, where research carried out in Africa led to many notable achievements, including the development of effective biological control of the cassava mealy-bug, identification of sustainable intercropping systems, selection (by private research organisations) of tea and coffee varieties suitable for the Kenya highlands, and cocoa, rubber, and oil palm for the forests of West Africa. Agricultural and medical research has a respectable African heritage, particularly in the early years following independence.

Subsequently, however, support for universities as research centres weakened in many countries. In aggregate, therefore, Africa's S & T institutions have not, for many reasons, been able to maintain the momentum of the initial years and provide the high quality of relevant teaching and research that the problems of economic and social development require. Most important, frustration with the slow pace of development in the face of new and mounting problems has led to pressures for "quick fixes" and external solutions which supplant longer term solutions and continued focus on creating the capacity for Africans to solve their own problems.

2. The importance of the macropolitical and sociocultural forces

The expansion and creation of African institutions—universities, governmental research institutes, regional organisations, and programmes—worked well in a period of relative affluence following independence in which national and donor budgets were able to increase or at least keep level. It was a

time when African leaders and donors together gave high priority to education and institution building. The last decade or so, however, has been a period during which the scientific and research infrastructure has deteriorated markedly in many countries. This has seriously limited their ability to solve long-term problems of sustainable agriculture, health, and natural resource management. Although governments have acknowledged the importance of science, technology, and research (in the Lagos Plan of Action, and in the recent Kilimanjaro Declaration of the Second Conference on the Application of S & T to Development in Africa—CASTAFRICA II), political realities have directed higher priority to other needs, such as broad-based elementary education and subsidised support of a growing urban population. Similarly, balance of payments and fiscal crises related to the payment of oil bills and other debts have diverted attention and resources to immediate needs.

3. The increasingly vulnerable economic position since 1974

New conditions determining agricultural development arose from a combination of factors. The economic problems that beset many African countries have roots that reach back into the colonial period in which some critical assumptions and investments were made. These problems assumed crisis proportions in many countries following the precipitous rise in oil prices in late 1973–1974, since few African countries have their own oil resources. Most earn foreign exchange from traditional agricultural export commodities in a system originally designed to benefit the former colonial powers, and they are still subject to the vagaries of international markets for these commodities. They suffered disproportionately from their inability to adjust their economies to meet the new conditions in which more foreign exchange was needed to pay for the oil, while less was earned as slumping industrial economies reduced imports of their commodities. Loans were required to tide the fragile economies through the crisis, and interest and loan repayments added an increasing burden. Moreover, their inept or unfortunate political and economic decisions, which can be absorbed by wealthier countries, are in Africa exacerbated by drought, poverty, and internal and external conflict. Inexorable population growth more than paced growth of food production, particularly with the increased prices of oil-based fertiliser and other inputs, including mechanisation and transportation.

It was no longer economically feasible in most locations to continue promoting agricultural development based on inexpensive, mechanised production dependent on cheap energy, towards which much research and development on "modernisation" of agriculture was directed. Nor was it possible, because of shortage of arable land, to contemplate a return to the long natural fallow on which the restoration of fertility depended in traditional farming systems. In addition, many countries experienced a sustained period of drought, causing losses of crops and livestock and even human lives in a manner that had not been experienced since the 1930s. Examining the causes of this phenomenon led to growing recognition of the complexity of the African environment, the diversity of its microecological systems, and the consequent need to develop more effective systems of crop rotation and agroforestry that can be continued indefinitely on the same land and can generate economic surpluses. These needs could only be met through research, much of which is

not currently being adequately supported—in soil and water management; soil microbiology and nutrient cycling; and collection, selection, and distribution of suitable germplasm. Moreover, the research must be done in Africa, mainly by African institutions, because of its inherent site-specificity, and is qualitatively and quantitatively different from much research carried out hitherto. This is because of the constraint of reducing the dependency on expensive imported chemicals, because of a need to add value to local products prior to export, and therefore because of the need for more integrated research involving natural and social sciences.

4. Lack of commitment to S & T at political, public or commercial level

Among the characteristics that distinguish many African countries from their counterparts in Latin America and Asia are: (1) the absence of commitment to S & T at top levels of government and demand for S & T by the public at large; and (2) the absence of a middle layer between these two strata—a small-business, entrepreneurial, adaptive, product-developing, technical level—which both demands and produces, adapts and adopts commercial technology. In many countries, most industry involving modern technology is "turnkey"; cottage industry and entrepreneurship flourishes, but few of the goods and services provided involve any R & D, and most of the tools, components, and materials in small manufacture (except "traditional" crafts) are imported—where that is permitted—because they are cheaper and perceived, not always accurately, to be better quality. The absence of these key elements of the nascent industrial sector is believed to be responsible for the failure to sustain earlier achievements in building S & T capacity, since there is insufficient public and private commitment to and demand for S & T.

5. The central role of education in science

The importance of S & T to development has led to a growing recognition of the urgent need to promote the evolution of a science-driven African culture, based on a science-oriented educational system. Traditional African society was, and in many places still is, based on a system in which technology for successful exploitation of natural resources was passed from parents to children, and through guilds of craftsmen to apprentices. This system sustained African society until the colonial period, during which it was widely superseded by an introduced system of education, in which mission schools played an important local role, and training for the colonial administration was provided at metropolitan universities. During this period the economic exploitation of agricultural commodities was based largely on plantation systems, with technical support from expatriate commercial firms and technical institutes. Prior to and following independence, the colonial powers belatedly placed increasing emphasis on creating educational centres at local universities for training Africans to assume the mantle of governance and administration. In many countries, following independence, the agricultural enterprises that were the mainstays of the economies were nationalised and taken over as governmental or parastatal enterprises, or their holdings broken up and turned over to smallholders. At the same time, the importance of education as a means of advancement was translated into a public demand for

universal free education. The thirst for education is a striking characteristic and powerful political force in African countries, and large percentages of national budgets not directed to oil purchases, debt repayments, and military forces were and are spent on education.

However, for the most part, the educational systems are now not able to foster excellence, nor to reward innovation and achievement, largely because they are overwhelmed by the numbers of pupils. Teachers are poorly paid and poorly trained; learning is often by rote, and there is little quality science and mathematics, or local relevance, in the curricula. There is, therefore, a need to direct serious attention to changing education policies, as a recent World Bank study has recommended, to improve the quality and relevance—the functional coherence—of the educational systems. Resource-poor countries ultimately must rely on their human talent. Excellence must be recognised and fostered in S & T as it is in sport.

6. The key role of the universities

Educational policies in Africa will have to recognise the key role of the universities where the new teachers will be produced to staff and lead the functionally coherent educational system that will foster and will in turn be supported by a science-based culture.

Following the heyday of the 1950s and 1960s when the major investment by African governments and donors was made in university development, budgets tightened and student numbers grew. At the same time, universities were asked (and many faculties gladly volunteered) to take on additional responsibilities to contribute to socio-economic change—tasks for which they were ill-suited. The "development university" attempted to play a direct, short-term interventionist role in national development, beyond training people, to justify its budget and special status in society. By and large, these efforts were unsuccessful because they involved idealistic notions of income redistribution and sharing political power in ways that were not possible—and even counterproductive—because of the disillusionment they engendered. They brought the universities into conflict with government, rather than establishing the partnership that was intended. Research in the social sciences, encouraged by US foundations, was seldom successfully integrated with that of the agriculture and health sectors.

Universities should return to their primary function: the pursuit of knowledge, and its dissemination to students and to society. Research is an intrinsic and fundamental part of this process, if the universities are to attract and retain high-calibre staff and students and become self-sustaining. The knowledge produced through this research must be relevant and linked to long term socio-economic development objectives, and the research sustained and managed to encourage excellence. It must be clear, however, that support for excellence need not imply support for the ivory tower. It is senseless to idolise and promote excellence in sport while at the same time denying facilities to talented students and faculty depriving them of the resources and working conditions they require.

7. The need to protect, regionalise, or internationalise research centres, to insulate them and their budgets from capricious government cuts

The national research systems that have been set up with the support of donor agencies over the past 25 years have not, by and large, been successful. They have often had a narrow focus and have primarily aimed at short-term solutions to specific problems, rather than at strengthening capabilities to solve generic problems. In some cases, they have created an isolated layer of modern research that is neither supported by a broad base of technically trained personnel nor derived from a science-based culture in which, ideally, a motivated extension service would transfer suitably adapted technology from the international centres to a willing peasantry. The work produced in government institutes, unlike that in the universities, is seldom subjected to the scrutiny of peer review, and this has protected mediocrity. Their budgets have generally been drastically cut in response to government revenue shortfalls, and while their budgets may look adequate on paper, seldom is the money actually available for equipment, periodicals, fieldwork, or anything else beyond salaries—and often these are not paid on time. The systems have been able to retain good people only as long as better opportunities were not available elsewhere. The entire apparatus of government research has tended to collapse when donor support phased out.

There is an important role for applied research centres focused on areas that require continual, service-oriented assistance to be produced on a routine basis. Much commodity-oriented research falls into this category. A good deal of this applied research should be returned to the private sector, as it was during colonial days, and where it still flourishes in some places—for example, the Tea Research Foundation in Kenya. In many cases, however, industry is still in government hands, and until this changes, there is an important role for donor agencies in helping to strengthen good research facilities, both at government institutes and within the universities, and give them a margin of insulation from the instability of government budgetary support. It may also make sense to support the more effective of these applied research centres to play a regional role in serving the needs of smaller countries, as some of them did in the past.

8. The need for continuity in support of research

The history of African R & D in universities, and in national and regional institutions, is marked by a lack of firm government support for research. As we have seen above, much of this is due to changes in economic circumstances, as well as to ideology and political instability. There is also instability in the support of R & D by the donors. Seldom are donors able to support institution-building consistently and flexibly over the long haul. "Donor fatigue" is a common phenomenon. So is faddism: as one donor develops a new strategy for supporting development, others follow suit, with the result that there may be neither the consistency that allows time for success, nor the variety that permits selectivity and comparison among different approaches. There is need for donor innovation to respond to the new opportunities presented by

development in technology (such as in biotechnology, computer and informatics technology), while at the same time guarding against overcorrection and wide swings in direction in policies and programmes.

9. Future directions in international co-operation

Africans and African scientists are going through a difficult period, some of this is due to global political and economic forces beyond their control; some also results from an openness to accept foreign ideas, institutions, and development objectives—that have often placed them in a transitional state midway between traditions to which they cannot wholly return—and a modern, science-based society at which they have not yet arrived. It has been barely a generation since most Africans gained political independence. More time and refocused assistance from abroad are needed to help them overcome present difficulties and achieve their cultural and economic independence. The international scientific community and the donor community have special roles to play in providing carefully sustained support to Africans as they reorient their educational systems and strengthen their scientific and technological institutions and capacities. This need has already been recognised and accepted by African governments and is featured prominently in the Lagos Plan of Action and again, explicitly with regard to S & T, in the 1987 Kilimanjaro Declaration of CASTAFRICA II.

In this context, the following specific objectives for refocused international co-operation to strengthen African S & T institutions emerged from the Bellagio discussions as the basis for future government-donor agency attention:

1. The objective of donor co-operation in this area should be to continue building excellence and relevance in S & T required for guiding investment decisions, identifying basic development problems and their solutions, and linking African institutions to world development. A strategy for achieving this objective should expand the intensive efforts already under way in some countries to assist Africans as they redefine the missions of their universities and research establishments in terms of achieving excellence and relevance through recognising first-class talent and providing adequate support for it. This would involve, in particular, promoting the infusion of young scientists into the S & T institutions. This would be strengthened by continuing efforts to create networks of institutions and scientists in Africa with counterparts elsewhere. Related to these efforts is the need to develop research managers/leaders to "nurture an enabling environment" and to create a critical mass of activity including influencing policy, building constituencies, creating demand, building staff capacities, and guiding strategic planning processes.

   Programme elements of this strategy will thus include such activities as:
   - identifying and organising support for African S & T leadership;
   - providing post-doctoral programmes for Africans with the potential to lead R & D work;
   - identifying ways to reward achievements in S & T and motivate involvement on African development problems;

- increasing long term technical co-operation on R & D with donors providing support for recurrent costs;
- supporting publishing ventures on important work on research and teaching in Africa by Africans and others;
- facilitating African linkages in S & T, free movement of scientists and scientific information, and strengthening S & T rapport and communications with the African public and politicians, (perhaps through the creation of an African "Charter for Science and Technology") that would focus attention on these needs;
- creating linkages with the international S & T community (including such elements as asynchronous computer-linked communication networks) to help overcome the isolation of the African researcher; and
- undertaking renewed African-led programmes to strengthen the S & T education base in African educational systems and in African societies in general.

2. The programme should also assist African governments to provide the necessary enabling environment by establishing an acceptable public policy towards S & T and its goals in development, including the concept of three levels of technology—high technology, middle-enterprise applications, and village-level requirements. The S & T policy should reflect the importance of interrelating the S & T and political communities, and of quality apolitical leadership as the key to influencing and coping with political, economic, and social policy and the environment. Effective arrangements and agreements should be developed among teaching, research and delivery of services.
3. Issues to be addressed in future co-operative studies that relate to government policies include such topical problems as how to offset "talent seepage" and attract outstanding African scientists to return from abroad; the form of future technical co-operation, reflecting the changes in institutional, individual competencies and development problems ahead; the steps to be taken to promote broad participation in redefining the mission of the universities and research institutes in African development and stimulate greater commitment to S & T.

DISCUSSION

INTRODUCTION

In his opening remarks, Dr. John Voss, President of the ICIPE Foundation reviewed the history of the creation of ICIPE, and the role played by the ICIPE Foundation in supporting ICIPE. Now that ICIPE is recognised as an important on-going and successful African scientific institution, the Foundation had decided its role was no longer critical and that it should therefore dissolve itself. Since the Bellagio meeting would be the final activity it undertook, it was entirely appropriate that this meeting should be devoted to an examination of scientific institution building in Africa both because of the relevance of the ICIPE experience, and the need to look at successful mechanisms for supporting African institutions.

The meeting was designed with the intention of producing a publication about ideas. Participants would analyse and discuss the first drafts of papers, critique ideas and suggest additional topics and authors with a view to promoting and producing three things:

1. a more extensive inquiry into the background and history of African S & T institution building;
2. ideas for the donor agencies; and
3. a public awareness among politicians and the scientific community.

On behalf of the ICIPE Foundation, Dr. Voss thanked the meeting hosts, the Rockefeller Foundation, the sponsors, the African Academy and the US National Academy of Sciences, the organisations providing the funding, the MacArthur Foundation, the Carnegie Corporation of New York and the International Development Research Centre and finally the participants.

OVERVIEW AND THE ICIPE EXPERIENCE

Prof. T.R. Odhiambo, President of the African Academy of Sciences, reviewed the history of ICIPE, summarised in a paper prepared for the 15th Anniversary of ICIPE by V. Rabinowitch (1986). In 1970 the genesis of ICIPE was to bring scientists from the academies of the industrial countries together with African colleagues in the tropical context to create a mission to solve pest management problems in developing countries. The issues were: excellence and relevance. The purpose was to foster basic research and motivation of scientists in Africa to create a new amalgam which was lacking at that time. The ingredients were: clear purpose, creative leadership, sound management, worldwide recognition and relevance to Africa and its problems. R & D are vital for development; this is obvious in the developed world, not so obvious in LDCs. Support for research requires strategic decisions affecting investment involving:

- the capacity to identify the R & D required for development;
- the capacity to identify development goals and ask essential questions;
- the ability to assess risks and set priorities; and
- the tactics needed to reach goals.

The ICIPE lesson was clear-cut. It was developing insect science and technology for a continent characterised by resources poverty. The ingredients were: critical mass, intellectual mass, and self-confident, daring, motivated scientists.

Africa needs more time to develop these capabilities. Technical assistance should only be considered to build capacities for Africa. It has failed in Africa in the last 25 years for policy and national development. Prof. Odhiambo recalled Harrison Brown's prophetic insight that technical assistance has made little impact because donors have turned away to focus on solutions rather than creating the capacity for Africans to solve problems. The vital factors for institution building are:

1. a clear, sharply focused mission;
2. recruitment for lst-rate talent and creation of an environment for excellence—this is not always easy, "the democracy of excellence does not always work";
3. the infusion of young scientists. Africa does not have postdoctoral research fellows; they are not favoured—donors do not appreciate the need. There is a seepage of intellect, and therefore the need for a network of support systems for alumni to keep on working in Africa.
4. Good research managers: there is a tradition that good researchers are good managers, but in fact there is the need to give researchers routine training in management to nurture an enabling environment for research and for young researchers; and
5. creation of systems that are useful across the R & D community in Africa, including the following elements:

   (a) *A trust for postgraduate fellowships*: All institutions are experiencing financial problems which cannot all be focused on by a foundation; but perhaps foundations could create a trust for postgraduate fellowships for transborder movement of scientists. What Prof. Odhiambo proposes are $20,000/year postgraduate or postdoctoral fellowships over an 8-year period. That for 1,000 people/year would cost $15–20 million, and in 20 years would have produced 15,000 alumni. The intellectual ferment would be enormous, the talent created powerful, and the impact internationally worthwhile.

   (b) *Incentives*: for individuals to continue to be good working scientists, which might include prizes and awards for achievements in science and science for development;

   (c) *Publishing for science*: to mobilise an African forum and focus for the whole of S & T, which exists internationally but not for Africa;

   (d) *A "charter for science in Africa"*: there is the problem of linkages and free movement of scientists; there is need for a perception among the public and governments that science is important. The charter would emphasise free movement of scientists and scientific materials across borders; both the African Academy and the Pan-

African Union of Science and Technology would help science through the charter to escape national bureaucratic mechanisms preventing movement.

Dr. F.X. Sutton described Prof. Odhiambo's challenges as "daunting". He added a concern for the development of S & T institutions in small African countries. In his review of the history of what has been achieved by the Ford Foundation and Rockefeller Foundations, the most difficult task was to build institutions.

REGIONAL INSTITUTIONS: THE CENTRE RÉGIONAL D'ETUDES NUCLEAIRES DU KINSHASA (CRENK)

Dr. Malu wa Kalenga, Director of the CRENK, summarised his paper describing the creation of the Centre in 1959, with the first nuclear reactor operated in Africa, a 50 KW machine of US design. The centre now has a staff of 154, a third with B. Sc. degrees, 18 Ph. D.'s, all Zaïrois. The centre now runs the most powerful research reactor in Africa, capable of achieving 1600 MW pulsed. The Centre is receiving US technical assistance in high technology, personnel and equipment, for applications in microbiological biotechnology, molecular genetics, etc. The Centre is involved primarily in applied as opposed to basic research, and it must convince the Zaïre government that its research is worth the money to support it.

Lessons learned are: it is possible to build, staff and train and maintain a high-technology centre in Africa. However, it requires public policy acceptance, organisational leadership, political acumen, good day-to-day management of available resources, and good scientific working relations. Institution building in Africa is a combination of art, science and good luck. It needs the right person in the right place at the right time, choosing the right project.

Africa needs three levels of technology transfer:

1. the most advanced, sophisticated technology that the country can absorb, to process and produce goods for the local market and export; in the case of CRENK this means radiological substances;
2. village-level technology for rural self-sufficiency, which will encourage people to stay in the rural areas; and
3. intermediate—"baseline infrastructure technology"—to improve water, housing, transport, etc.

Success is a function of leadership more than anything else. The problems are the overall low productivity and innovation of research people. In response to a question about the regional nature of the centre, Dr. Malu pointed out that very few countries are interested in nuclear energy. They do have people visiting the CRENK from other countries, but only for short term assignments, not on their permanent staff. The university is physically close to the CRENK, and sends a stream of Ph. D. candidates, who work there as associate researchers under an agreement. They produce radioisotopes for local use, and are willing to send them elsewhere; however, transport and communications are difficult, and in many countries it is easier to buy isotopes from the UK or France, than from Zaïre.

RESEARCH AND ADVANCED DEGREES: UNIVERSITIES VS. RESEARCH INSTITUTES

Prof. Odhiambo indicated that an ICIPE task force has been established to look at these issues. ICIPE has a Ph. D. programme in collaboration with 14 universities; ICIPE does the training, and has university representatives on its academic board as the link to the universities. ICIPE also offers special training on biological control leading to the M. Sc. degree, however ICIPE was unable to provide the required 9 months-long coursework, and contracted with River States University in Nigeria to do this. In this way the candidates can be awarded an M. Sc. in 3 years from that university.

The issue is therefore: should ICIPE begin awarding degrees itself, rather than simply offering training to students from universities? Many regional institutions do not award degrees; those who do have become regional centres, e.g.: Harare (Zimbabwe), Rivers State (Nigeria), Abidjan (Cote d'Ivoire) and Khartoum (Sudan).

Whether to award a Ph. D. is still an issue—the task force has not yet reported, and will take one more year; they are visiting the Tata Institute in Bombay and the Rockefeller University and are looking at many different models. It has taken 20 years to establish insect science to this level in Africa.

The CRENK provides training towards graduate degrees, but does not award them. As in the case of the ICIPE, graduate degrees remain a difficult problem.

It was pointed out that there is a slight drift towards degree awarding outside the universities—is this good, bad or neither? It is a function of the relations between the national research system and the university system, between ICIPE and the University of Nairobi, and the equivalency of academic degrees round the world. It is also a problem of student perceptions: they want to go to ICIPE, but would prefer to have their degrees awarded by London or Rockefeller University. The problem of the academic prophet being without honour in his own land is a constant issue. Unless there are diplomats on both sides, the relationship between the university and the research institute is likely to become distorted.

This relationship was pointed out as the one causing continual debate; the question cannot be dealt with generally, since it depends on personalities. The question is, do the institutes (e.g. ICIPE and CRENK) get the right kinds of students and researchers to do their work? What kind of degree or other training is needed to prepare the researchers adequately?

African universities bear the burden of teaching undergraduates, usually an overburden, while the research institutes can become useful degree-training institutions through their specialised research facilities. However, there was a strong feeling that research in the universities is important. Teaching is a short-term process—the students are there only a relatively short time, and should be exposed to the best of teaching and research.

Related to this is a question of quality control: lots of monies are put into unsupervised activities in research institutes. There is a plethora of research institutes outside the universities, assessment of whose performance in terms of international standards of quality control is absent. Teaching suffers at the university when research is cut, and implementation of research results in the

country suffers as a result of the lack of a proper relationship between research and teaching. Dr. D.M. Wai agreed that the absence of research in the university generates mediocrity.

It was also pointed out that there is always a problem of heterogeneity in Africa, and one model should not be applied to all of Africa. Prof. J.N. Ngu observed that in Cameroon there is a tripartite concept consisting of research, teaching and evaluation. This concept acknowledges that there are teachers who do 70–80 percent teaching, others who do 30 percent teaching, and 70 percent research. They have, therefore, revised the system to take into account the need for harmony among the various needs.

The role of individuals is important. Success creates problems in the African environment: how has ICIPE surmounted its own success problem—envy by colleagues? And, what happens after Prof. Odhiambo relinquishes its direction? To this, Prof. Odhiambo responded that the key was an absolute commitment to be apolitical, to be open to criticism and quality control, to be open to new ideas, and transparent to the outside world. Many African institutions, including universities, are opaque to criticism and government institutes are worst of all. This is a key weakness of African institutions. Hence the need for a charter for S & T in Africa, that would spell out the rights and responsibilities of scientists and governments.

Dr. Sutton pointed out that the phrase "no excellence in democracy" was aposite: distinction leads to problems; this is an issue to which the meeting would return.

THE AFRICAN UNIVERSITIES: SUCCESSFUL INSTITUTION BUILDING

Prof. A.A. Kwapong's paper provided both a retrospective and prospective view of institution building and international co-operation. He pointed out that efforts in institution building in Africa are bedevilled by the basic conditions. Drought, collapse of infrastructure, the focus on relief efforts—the whole macropolitical socioeconomic context has had a profound effect on African institutions. The Silver Jubilee of the Organisation of African Unity (OAU) was May 25th, 1988 at which, among other things, the status of achievement was assessed. The October 1987 World Bank study (Education Policies for Sub-Saharan Africa: Adjustment, Revitalisation, and Expansion, P.R. Moock and R.W. Harbison) recognised the importance of the education sector not only as a basic right, but as both an important determinant in labor productivity and in non-market factors such as human fertility, and is therefore a means of breaking out of the cycle of hopelessness. The report also describes the crisis in African education, and highlights the key role of the universities in education. The problem is that without good universities, there cannot be good quality 1st and 2nd cycle education. The base is important. The political context is also important: Nairobi was critical to ICIPE; ICIPE might have been established in Kampala and would have been wrecked there. So the macropolitical context must be addressed. There is a need to protect good institutions, perhaps by regionalising or internationalising them.

The importance of staff development programmes

There must be top quality trained people, who must measure up to the highest standards—this is the key issues in institution building. Staff

development, and appropriate mechanisms and policies for producing human resources, through well-trained undergraduates and graduate students, is essential. In the industrial countries this is taken for granted. In Africa in the 1960s and 1970s the policy adopted was to take high level students and postgraduates from abroad and develop local graduate programmes. At Legon, specific links were created with other universities for this purpose, through a twinning relationship with the University of Guelph, Ontario, in agriculture and home science; Charles University, Prague in plant breeding; the University of North Carolina, Chapel Hill, in demography; UCLA in community medicine; Oxford in law; LSE, School of Administration in management; the universities of Paris, Bordeaux, Dakar and Abidjan in languages.

The key elements of this successful development were:

1. careful strategy, and a clear programme, not dictated by donors;
2. entrepreneurial leadership by the President/Vice-Chancellor, with government approval; and
3. US private foundation assistance—a flexible grant from the Ford Foundation provided support for infrastructure; the Rockefeller Foundation provided support in agriculture, medicine and economics research; the Carnegie Corporation gave support in education (including $250,000 for establishing a department of communications and journalism); USAID supported exchanges with institutions in the US; the U.K. Ministry of Overseas Development supported faculty exchange through the British Education Support System (BESS) programme; the two Canadian agencies (Canadian International Development Administration and the International Development Research Centre) provided assistance from Canada.

The basic economy of the country was healthy during this period and supported the training and expansion of graduate studies this training permitted. However, when the economic and political situation suffered, in its train came *coups d'etat*, and the destruction of political stability. This period was characterised by the brain drain causing seepage of talent. The Medical School was denuded by a haemorrhage of staff to other countries; conditions were intolerable for the faculty, with both push and pull factors operating to drive and attract them from Ghana.

Prof. Kwapong argued for a programme to support the return to their countries of expatriate African scholars: perhaps a consortium of donors on an international scale could help to arrest the decline of institutions on the continent? Among examples of successful international co-operation are the UNU research and training centres programme: this includes the WIDER Centre for Economic Research in Helsinki, a successful operating institution; the Institute for Natural Resources in Africa (INRA) in Yammassoukro, Cote d'Ivoire, and Lusaka, Zambia, for natural resources research and training, which still lacks the necessary endowment. The rationale for these centres is creating a programme in areas of priority need, working through existing institutions (where the research and training is largely carried out), directed and co-ordinated by the centre. The various sub-centre research and training facilities are networked, which draws on the strengths of the institutions. The institutions are also linked through a college of research associates—visiting associates either at the centre or at the sub-centres—so that the internal brain

drain is combatted and they do not leave their own national centre. Institutes like INRA are needed as a framework to support well-focused and high quality research. It presupposes sound national educational systems. The political dimension must be in place if it is to be successful.

Prof. Ajayi posed the question: what is responsible for the rapid decline of a successful institutions, such as the University of Ibadan? Universities have a role which others will not replace. ICIPE cannot be a model, since all African institutes cannot emulate ICIPE. Universities are not producing isolated individuals but creative people who must work together, and there is the need to create and sustain the academic community and the capacity for self-sustaining growth. Universities with enough people should be self-sustaining; they themselves hold the initiative, since good universities do not grow from only elementary and secondary education. Universities come first, and yet have declined rapidly in the present economic recession.

There is now a new policy on S & T in Nigeria—a mass campaign for a new S & T programme for the nation. The government is making all the right noises—including stressing the need to link home and school. A new national policy for education has been developed; the old system was colonial, the new one is "6–3–3–4" (years of primary, middle, junior and senior secondary schools, respectively) with both junior and senior secondary schools as terminal institutions. Everybody will have at least a junior secondary education including S & T, as a crucial part of development. The necessary equipment, laboratories etc. are very costly, and their acquisition was postponed. However, the Bulgarians have offered a country-financed project to provide unit facilities at 20,000 Naira/unit cost (4.5 Naira = $1.00; official rate in March 1988) or approximately 100,000 Naira to equip each secondary school. (The Nigerian government subsequently turned down this arrangement).

Historically, farmers taught their children the basic S & T they required for their survival. Today, it is different, and institutions like ICIPE and the universities are needed for teaching and research on modern S & T, and thus must become self-sustaining. Ibadan University was a success, but we need to focus on basic ideas, and tackle problems at different levels. What is the purpose of the university? The linkage between S & T and the social sciences needs to be rethought.

The subsequent discussion underlined the need to understand the linkages of traditional African thinking, S & T and modern culture; traditional African S & T did succeed, it sustained people, but for the most part at a low level. There is a sentimental perception of a former "golden age" of Africa, prior to colonialism. And while it is true that great African achievements were made in the kingdoms of Mali, Ghana, Songhai, and Zimbabwe, for the most part life was short, violent and probably quite unpleasant for many people. The colonial period brought solutions to some problems, and brought others in its train: health was improved, but the population growth this permitted, and the political fragmentation of Africa, are among the most serious of modern African problems.

It was also pointed out that given time, money can be found to create institutions. But to maintain them with local resources is difficult; the problem is how do you sustain growth?

Prof. Kwapong again stressed the historical dimension. The subject "African Studies" was treated by the colonialists, and by Africans after independence, as a separate curriculum subject. The language and culture of

S & T is very exciting—there is no dichotomy between the language of the African environment and high levels of high technology development. The role of the mission schools was important. The problem of a lingua franca should be taken up by African studies departments. Is there a basic language and cultural policy on which high technology can be based through a broad base of education?

Prof. Sutton felt the resistance of elitism was the distinctive role of Ibadan University. There was no tradition of institutes. Dr. Wai pointed out that the African anti-elitism led to a proliferation of institutions, because the standards in the early institutions were very high. This was particularly true in Uganda. The issues are:

1. Quantity vs. quality—how do you control these, and what is the balance?
2. How to persuade powerful illiterate politicians what is important about S & T?

Prof. Ajayi felt that expansion in higher education and training does not necessarily have to mean dilution of excellence. Excellence is not an external commodity; what we mean by excellence is creativity. After the Nigerian civil war, the dispersed Nigerians were regrouped in many different institutions. If there had been creativity, this scientific capital would not have been squandered. The ability to cope with the macropolitical situation is in itself a measure of S & T thinking—the whole of the University of Ibadan should be an Institute of African studies, rather than putting it in a separate department. But we have not developed beyond the inherited structure. The graduates cannot speak the local languages; scientists have not pondered on their African heritage.

The contrast between the industrial and developing world is salutary. African leaders for the most part relied on natural resources—gold, diamonds, copper, coffee, cocoa—and did not develop human resources. Japan does not have natural resources, and developed human resources, with enormous success. Africa has been bypassed by technology—fructose sugar has replaced cane sugar, carbon fibre has replaced copper, and the need for human resource development is thus even greater. Advances are taking place so quickly that Africa is being left behind, and there needs to be some method of promoting technological literacy: leaders do not know how to deal with high technology choices.

Dr. Aklilu Lemma referred to the Advanced Technology Alert System (ATAS) of the United Nations that was designed to warn African people about the pros and cons of new technology. It is an attempt to look at technology developments in a multisectoral way, in order to inform decisionmakers of the implications. However this effort has not yet found the Odhiambo style of leadership.

UNICEF has taken a different approach—to make available S & T to communities for self-help, interdisciplinary efforts, not co-ordinated centrally. Medics go to villages, particularly focusing on child survival and development, in multidisciplinary teams that help the villages to solve problems. The universities are very anxious to participate and respond: the community is aware and awake. Each district has its own priorities, and if water is No. 1, then that is tackled first.

Lemma asked whether the ICIPE Foundation could continue to exist in the context of international co-operation, supporting the ACAST project to

endow African Chairs of Technology? The selection of awards could be made by the African Academy of Sciences, who would select the recipients by a peer review process on the basis of outstanding achievement, rather than by politically-motivated deans or by the donors. In this way, the chairs would not be filled by mediocrities.

The Japanese analogy stimulated discussion. Prof. Kwapong pointed out that the Japanese were a highly-motivated, well-disciplined homogeneous group that emerged from isolation in the 19th century. At that time, they went out to contact the external world and its technology and trade and, more importantly, came back to Japan. This process was highly successful then, and also after World War II. Maybe it would not be so successful today, with today's macropolitical context of institution building. The Japanese and Koreans come from old institutions, and we can learn a lot from them, but if they had had the same colonial experience as Africa they would have had a different set of problems. Colonial S & T was not a great legacy and we must work hard to counteract its effects. People do not have confidence in Africans who still prefer to go to the metropole for training and yet are still not used as consultants by donors.

HEALTH AND MEDICAL RESEARCH

Prof. Ngu focused his remarks on CUSS (University Centre for Health Science), which is the University of Yaoundé's equivalent of the faculty of medicine. In the medical field, he pointed out, progress has been made in S & T in Africa, however we tend to confuse the evaluation of progress with the state of progress: we have made progress, but have we made sufficient progress? There is a big gap, and Africans are still on the losing end. The time factor must be reasserted. Europe took hundreds of years to develop technology, Africa is supposed to do a quantum leap. But how is this to be done? CUSS is an example. It was created in 1968, as part of 10 innovative medical schools, community-oriented, where research was essential, undertaken by undergraduates and the results incorporated into the programme. Clearly at the early stages, research was focused on the collection of basic information. There was a gradual evolution of the type of research. The Ministry of Higher Education and Scientific Research (MESRES) has followed the same pattern, and has now arrived at the stage of laboratory-based research as well as the earlier field data-collection research. The perception of disease is overlooked by the typical medical doctor conservative approach. There is need to look at psychosocial aspects of disease. Lots of data are generated and compiled, but health policies of the Ministry of Health do not reflect the data. How do you transmit lots of information to government so that they can adequately exploit the information for improving policies?

Promotion is based on research and teaching. We do not know if this is enough motivation. There is the problem of evaluation—the objective is concerted effort to look at a project (in the planning phase) to identify what to get out of it (objective, outputs) and to identify how to assess success or failure. There are imponderables—the unpredictability of electricity failure, the bridge swept away by the flood, but if you are to do high technology, lab-based research, in high risk areas, you must be able to predict the outcome, evaluate the cost-effectiveness of approaches. You can never prescribe the factors, this can only be done on a case-by-case basis.

In the ensuing discussion, Dr. Malu stressed the crucial point of complexity (which he observed is different from complication) and the ability to develop a working model, to identify the most important factors. He would request donor agencies to fund research on the development of working models. Donors are not only interested in output, but effectiveness.

Dr. Prewitt was pleased with the description—the connective apparatus of bringing S & T and government policymakers together, through an evaluation mechanism. The question was flagged. Models are available. In the US, the government subcontracted the civil service to the private sector (unlike the UK model, where the civil service doesn't turn over, and is the professional group to do the evaluation). There is need to repackage data for decision-makers. Africa is data-deficient, and this hurts planning and evaluation, as well as democratic accountability (which is used in the West to hold politicians accountable for government actions). James Grant (UNICEF's Executive Director) can take 6 numbers and weave a sermon around them to raise money for UNICEF. Donors have pernicious properties—they are more concerned with audit than with substance, and these are expensive datasets. What is the minimum dataset required for good decision-making? Scholars have an unending appetite. From the policy viewpoint, data needs to be summarised, focused. What are the technologies to improve the database, that must be ruthlessly cost effective? We need the institutional apparatus to develop policy-oriented research on how to be more effective, not only governments, but the donor community as well?

Dr. Haven North pointed out that the evaluation process cannot wait for perfection—the decision is going to be taken, ready or not. The manager must take charge. The problem is that institutions have lost their dynamic character, their ability to evolve and respond. Information may often be around, but must be packaged anew for each visiting donor group. Dr. Wai pointed out that there are reliable data only in a few places, and much of it has to be "cooked". Is there need for a Brookings or RAND Corporation for Africa? Dr. Prewitt suggested a policy research board of the Ministry of Health, with independent resources to put out Requests For Proposals—an apparatus to connect people together, rather than a new institution. (c.f. the Planning and Analysis Group of the CSIR in Ghana whose purpose was to link S & T to national development planning).

Martin Bell pointed out there are different levels of policy-making: here we mean policy in the sense of resource allocation within the existing structure. Expertise in this is a bit thin in some countries and institutions. W. Douglas Daniels of IDRC has been providing countries with support to build up expertise in these areas, and we should look at this policy expertise and find where the IDRC effort led.

Dr. Kwapong underlined the problem of effective interfaces, but asked who evaluates the evaluators? The question of skilled human resources is often political dynamite, involving questions about the population. In Ghana the Central Statistics Office in Accra collapsed due to lack of support and resources.

The experience of UK ODA

Mr. Mathieson observed that the current British government does not care about development. The former structures, developed by the farsighted and able Barbara Castle and Sir Andrew Cohen, have been gutted. Originally, ODA helped African universities through the Inter-Universities Council for Higher Education Overseas (IUC). The African and UK universities interacted directly: the bureaucrats were not involved in this "colonial relationship" until later, when the British Council took over IUC funding and paying Unesco dues. The current picture is bleak for future support to Africa. The 1986–1987 ODA report on R & D is written in opaque prose. The Tropical Products Institute, a world centre for research into tropical technology, has been dispersed, and the headquarters moved from Victoria to Chatham, "because it was too accessible." The Desert Locust Organisation information service, which provided information on locust movement from Morocco to Pakistan, has been handed over to FAO. When the UK withdraws from Unesco, Mathieson asked his UK Government colleagues whether the funds that had been going for Unesco dues might be tapped for ICIPE, but it was too late—they had already been given away.

Prof. Kwapong wondered if anything could be done to revive the status of ODA. The past activities and policies had been models. Judith Hart had made a $10 million contribution to the UNU endowment. The IUC model of inter-university collaboration was excellent, stabilised the staffing situation through the BESS scheme for staffing African universities. ODA was manned by dedicated professionals and operated good mechanisms. The UK universities should come together to exert pressure on the government to try and revive substantive inputs for S & T in the UK aid system.

Dr. Prewitt pointed out that earlier discussion had focused on instability among African governments and the strategy needed to internationalise and protect institutes from government intervention. However, it is clear there is also instability among donor agencies. The strategy must not ignore the instability of donors—"donor fatigue"—and must find ways to respond to new challenges created by the availability of the means to produce new vaccines, and such things as microelectronics applications. There must be ways to foster donor innovation.

Dr. Wai observed that the British philosophical emphasis in technical assistance, inherited from the colonial days, was on the generalist and administrator, rather than the specialist and the manager that were required now.

Prof. Odhiambo pointed out the success of marrying carefully articulated mission and donor funding—e.g. the Tropical Disease Research Programme (TDR) and training operated through the World Health Organization; the CGIAR system's package—institutional development, green revolution architecture—and successful programming. The donors must gain obvious benefits and must be the architects to have something from the TDR and CGIAR.

The experience of the US Agency for International Development

Dr. W.H. North described the evolution of US assistance over the past 25 years, and the diversity of experience that emerges from AID's evaluation of its projects. The focus has been on the impact of the projects on development. In the 1950s and 1960s higher education in agriculture and health had enormous impact. There was tremendous institution building—a clear task in agriculture—and lesser impact in health institutions. What is not working? Worldwide (i.e. including Malaysia, India, Indonesia, Thailand) resources for teaching and research are declining. Student opportunities for future employment are declining. Isolation has affected the quality of teaching and research. The professional community is cut off from its need to interact. Many of the old generation trained in the initial period are retiring, and the new generation is in-bred because of this lack of interaction. In agriculture, there is a weak link to the farming community, and a lack of interaction with farmers. There is a lack of multidisciplinary approaches to solve problems. National research systems receive inadequate attention, have a weak systems perspective, and the individual institutes within countries are unlinked. There is the difficult problem of maintaining excellence and relevance. The first generation was enormously successful; for the second generation, issues are not given the same attention by their governments.

There are 4 areas of concern:

1. The problem of commitment and continuity of support

The stability of the political and economic context generates an inhospitable attitude to universities and research. The problem of crisis in resource management and redirection. The loss of recognition of the importance of S & T for the development process (distraction of economic and political concerns) and short term vs long term focus. The donors, including AID, have a shift of emphasis and priorities. The early attention to "Basic Human Needs" went too far, by requiring a direct and immediate impact on development, bypassing institutional development (the question always asked by Congressional committees was, "Why send Africans abroad? What has that to do with basic human needs?" Following basic human needs, the focus shifted to macroeconomic policy reform and restructuring the economy, again diverting interest from institutional development. Certainly in AID evaluation looks for a nice report of a task completed, and moves on to the next project. Current policy is that AID should not be in institutional development; what is needed is to get prices right and market forcess will take care of the problems. However, there is already a shift in attention from policy reform to other emphasis, including the need to rebuild linkages to institutions supported by AID in the past. This thinking has led to an interest in the advanced developing countries (those which AID formerly supported, such as Nigeria) and looks for new ways to relate to past institution building. However, this evolution of policy takes place in a context of the fragmentation of the development task by Congress—the Foreign Assistance Act is earmarked for countries, for dairy interests, for Vitamin A, AIDS, North American waterfowl, etc., and becomes a mixture of unlinked activities (not unlike Mathieson's British ODA portfolio).

However, the African Development Fund which has been recently created from the non-earmarked assistance to Africa tries to focus on development issues.

2. The problems of time dimension and institutional growth

We underestimated the time required to build institutions. Donors had a 5-year perspective, but the task is much longer. It took time to recognise that development was accomplished in incremental stages: planning and learning, financing, providing a steady reliable source of funds (not too much too soon or too little too late).

3. The problem of conflict between short and long term objectives

Donors come in and deal with crises (e.g. to eradicate smallpox). This type of donor role is resented by the recipients, and is therefore transformed into pressure for building up local capacity. There is a need to find a balance between short and long term—short for donor support, long for institutional development. There is a need to go beyond the short term objectives, pressures to terminate donor contracts—rigidity of structure, and organisational compartmentalisation. Agriculture in the universities is under the ministry of education, while its mission is under the ministry of agriculture, and barriers are created between ministries and efforts. There is a proliferation of R & D institutions which are also compartmentalised. But the boxes are not co-ordinated. There is need for managerial leadership—not just individuals (entrepreneurs), but a team or group both in LDCs and among donors. There is a need for building constituencies (c.f. the AID report of an evaluation of the Nigerian universities project). In Africa, there is an absence of strong external pressure groups on public and private institutions for the kinds of things S & T institutions should do.

4. The problem of selecting the best students, faculty etc

The report of the evaluation of AID's support for Hassan II University in Morocco describes aspects of this problem, and the importance of entrepreneurs as managers among the faculty (for research, and interacting with other institutions) and leadership in the planning process. He referred to the October 1988 conference on Agricultural Higher Education for the 21st Century—which will focus on how to help universities and planning agencies undertake a broad-based approach to strengthen institutions and provide the environment to think through their mission. There is need for a critical redefinition of the university role, without which they may wither, and this conference will involve 10 LDC universities, 20–30 universities round the world, to focus on the redefinition of the 2nd generation of issues: university isolation, lack of resources, lack of priority in development; lack of interaction with their environment; lack of impact on society. How is the university therefore to establish a new relationship with the community, and to define new sets of issues and new "models"?

In the ensuing discussion, Dr. Rabinowitch pin-pointed the problem of the evident inability todate of being able to use good conclusions about S & T institutions and society to change policy, philosophy and operations by African

governments and donors—how can this be done? Donors' use of expressions such as "revolution in thinking" recalls the Institute for S & T co-operation debacle (in which a quasi-governmental institute was created by Congress to support US technical co-operation with developing countries, including AID "graduates", along the lines of the Canadian IDRC, but Congress in the waning months of the Carter Administration also failed to fund it.) The revolution did not happen. How can policy be transformed?

Dr. North suggested economic growth is the way—and what does that entail for S & T? The S & T community must communicate how it relates to economic growth, how S & T promotes economic growth. AID's S & T Bureau has a hard time justifying its existence. Hard science is easier to justify than the social sciences, for which there is already not much enthusiasm (there are no "breakthroughs" evident in the social sciences). The message that will catch the ear of the politician needs to convey the "ozone effect" of the relevance and influence of the S & T process. This needs a strong push from without the organisation.

Martin Bell asked: Are the kinds of institutions produced in LDCs products of constituency groups? In the US, for example, the constituencies for agricultural research are farming groups; in LDCs they are not. A university agricultural education is for the purpose of obtaining a qualification for employment, not for Africans to become farmers.

Dr. North stressed that education was the way to success; farming was not business, but business was farming. There is the need to revive the connection between farming and the university R & D. John Voss pointed out however, that agricultural R & D rarely shows an early payback, and maybe this is expecting too much. Nevertheless, it was agreed, politicians need results.

Experience of the US foundations in Africa

Like basic science, Dr. Sutton observed, history has you hope as you look at it that you will find something useful. Development is a very complicated business. In the beginning, the question of African self-determination and human values engaged the interest of the Ford Foundation. This led to the recognition that there must be a connection between problem-solving and institutional development, and the formation of national capacity, government capabilities, and a predominantly statist viewpoint which neglected the private sector. There was special emphasis on S & T competance. The Unesco CASTAFRICA conferences (Conference on the Applications of Science and Technology in Africa) were emphatic about how much GNP (at least 1 percent) should be spent on S & T and why 60 percent of students should go into the sciences. There were aspirations towards industrialisation, particularly in Latin America. The focus in Africa was on maintaining the inherited colonial facilities and Africanising them.

There were differences between anglophone and francophone countries because of the different colonial philosophies and policies. (French support for creation of the African universities came much later than in anglophone countries, because there was less Africanisation of the bureaucracy. The specialised agencies responsible for exploitation of commodities were compartmentalised, and there was little contact between their research personnel and the universities. Most training of Africans was accomplished

through the metropolitan universities, and by in-service training in the technical agencies.) There was a factor proportion problem after independence—salaries took more of the budget, and there was less money available for research and maintenance. Manpower planning dominated university admissions policies for years, before it was consigned to disgrace. This was acceptable in a period of expansion, but not when there was saturation, which occurred by the 1960s with an excess of graduates even in the sciences. Most institutions were producing more graduates than could be absorbed into the system. Manpower planning was then abandoned and became the subject of derision. The importance of research in the universities was a widely shared perspective. The Ford Foundation went happily to that undertaking, believing it was possible to have successful programmes in the natural and social sciences, building institutions and also achieving short-term results. The focus on basic human needs affected the perspective of institution building well into the 1970s. The main competitor to institution building was R & D, especially agricultural R & D. In a simple-minded attention to the support of the best institutions, F.F. Hill of the Ford Foundation pushed for the creation of IRRI. CIMMYT followed. There was little clarity of purpose when it came to IITA—the concept was broad, and was based on faith in the model of the IRRI-type institution, that fundamental problems were amenable to this type of international research institution approach.

The centres did not focus on national capacity building in the early stages; they instead were directed at finding solutions through external means, not through building local capacity. There was a fuzziness about their functions in training and extension. The "happy enclave" that they were supposed to provide was simply not true. They were too eager to contribute to extension and training before research produced the results.

The purposes of the centres were mixed from the first: soil management was the original focus. Commodities research was added later. The problem of finding adequate funding came much later; the money problem was the subject of a previous Bellagio meeting called by Robert McNamara in 1969.

In the subsequent discussion Mr. Mathieson recalled that when F.F. "Frosty" Hill first visited Nigeria to look at farming systems, he was disinclined to put money into Nigeria, and insisted that the centre should be associated with a university. Mathieson also pointed out that there had been proposals for establishing international centres in population, health, economics, etc. on the same basis, but that funding support had not been forthcoming.

Dr. Prewitt observed there were few independent voices in development, only the US foundations. Unlike universities and governments, foundations have the means to move quickly, and play a special role. Basically there is no difference between the Ford Foundation and the Rockefeller Foundation regarding the big strategy of support for international development. Therefore, there are actually no different or dissenting voices—was this a mistake? Agreement may turn out to be a cause for dismay at the second generation problem, the "downside of collaboration". Dr. Sutton observed there was always a tendency to exaggerate differences between the foundations; both were driven by contemporary enthusiasms, and readily agreed to a division of labour.

Prof. Odhiambo pointed out the importance of the conjunction of foundation funding with that of other agencies. The CGIAR was led by the

foundations, then the World Bank, AID and other government agencies came in. There was a debate within the CGIAR about consensus—donors are floundering, and the lesson is that foundations have an important role in fostering stability, and do not veer with fashion like governments. Dr. Sutton compared their role to that of pilot fish with the leviathan, leading, looking to direct the big fish.

Historically, Dr. V. Rabinowitch indicated, foundations have the image of risk takers; they also recognise that if the job is worth doing, they are in it for the long haul. Nowadays foundations are taking less risks, have the notion that they are planting the seed, not necessarily ensuring survival. Institutions in Africa have been dumped, instead of being sustained to maturity. There is need to ensure that seeds are nurtured to the stage of plant survival. The CGIAR experience is an example; the centres were not dumped in countries for the LDCs to support, but are recognised to be an international responsibility.

FOUNDATION SUPPORT FOR UNIVERSITIES

Dr. D. Court's paper described the historical lessons from the University Development Program (UDP) of the Foundation, designed to help African universities become strong, healthy and independent, through scholarships, visiting faculty arrangements, and grants for research. The UDP concentrated on health, agriculture and the social sciences. The Foundation was not alone in this programme, was always a partner—often only a minor partner as governments put in the major funds. How has the model held up?

1. The programme had a simple, powerful idea: that progress in Africa would rest on people producing knowledge and ideas, and that universities were the places to do it. (This was quoted by George Harrar in 1959, and Haven North also quoted it in his paper for this meeting.)
2. The programme worked with existing institutions, to expand and internationalise them, increase their capacities, and also enhance regionalisation. New centres for social sciences research were supported at existing universities.
3. Because external agencies have to focus their efforts, the UDP concentrated on particular universities, and particular departments in these universities. They also concentrated around issues (such as the support for ICIPE) and this may be a better way for the future than choosing a specific physical or geographic location.
4. The UDP was conceived as a long term commitment—20–25 years, which turned out in fact to be the length of the programme.
5. It benefited from continuity of leadership—rapid turnover of staff can be as debilitating as "donor fatigue".

The UDP ended abruptly for severel reasons. Where the activity was successful, there were no good ideas about what to do next. The programme should have planned for success—and should have had a plan ready in anticipation that it would be successful. The core activity was support for Ph. D. staff development, through fellowship programmes. It was based on:

- close attention paid to identifying and selecting outstanding university graduates to be aided to go to good US institutions;

- social sciences opportunities for support of field research towards dissertations; and
- the recipients retaining their identification with their home institution.

The Foundation underestimated the importance of incentives and maintenance structures for the returned graduates, and did not put enough into this essential aspect. There is also need to look at the types of training the fellows received, and whether they should also receive auxiliary training in such aspects as research grant application writing.

The programme provided expatriate staff—sometimes too many. The Visiting Scholars programme, on the other hand, probably stopped too soon. This was an important strengthening mechanism for departments, often at crucial times (c.f. Prof. Kwapong's observation about the value of the twinning mechanism at Legon.)

The multidisciplinary and regional activities were not very successful. Academic disciplines were what universities had. The social sciences research units were created, but found it difficult to co-operate with the biological and agricultural scientists. It would probably have been better to put social sciences into medical or agricultural faculties than into seperate social sciences departments. The problem of integration of research among departments and how to promote it is interesting. ICIPE has relevant experience in this regard.

The concept of the "development university" of the 1960s and 1970s, both with and without the philosophy of basic human needs, was unsuccessful. Universities are good at teaching and research—they are not so good at development. The Foundation tried to respond to this urge or need, but was not very successful.

Lessons learned: it is possible for an external agency to help institutions develop, and to work with local and external supporters. In a complex situation (such as countries are now facing), the need for international co-operation is more necessary than ever. The Ford and Rockefeller Foundations are thought to have "worked hand-in-glove" regarding the creation of IITA, but this is an oversimplification, and was more a mixture of agreement with following the fashion and faddism.

In 1983 the UDP was phased out, and the Foundation is now trying to think about lessons and decide what to do next. The next phase may only partly involve universities, and is likely to call on historical experience.
Dr. Haven North observed that this was a clear description of the problems and achievements. There is a 2nd generation issue for donors:

1. Future programmes involve linkages rather than new institutions.
2. What is the relevance of the university as a development institution? Chapingo Agricultural School created a series of centres where rural research in agriculture and rural sociology is carried out. This mechanism provides the catalyst for credit, understanding of issues, and provides a bridge between the university and the community; it is an interesting example.
3. What of centres of excellence—how can these be built for small countries? They must be regional, since they cannot be everywhere, but they seem inevitably to slip back into a national focus when support dwindles.

Dr. Court agreed that the big question is can the university be a development institution in its own right? In East Africa academic standards have been downgraded, along with staff conditions and incentives, and the vocational emphasis weakened academic quality. There is a need for more differentiated types of mechanism. Universities are less adequate than they were at providing high level training—so there is need of alternative institutions of excellence. Regional or national institutions of excellence were diluted in the past, and were not successful.

Prof. Wai paid tribute to the Foundation and felt that others could benefit from their experience. Various experiments were carried out by donors, and the efforts particularly of the Rockefeller and Ford Foundations were exemplary. The vision and quality of Foundation leadership, missionary zeal, and convergence of interests all helped. Visiting foreign scholars from the US and Europe were an important helpful short-term technical assistance mechanism, making sabbatical arrangements, etc. Concentration on a few countries was good for results. Commitment to the institution as opposed to the individual was also important. Some questions should be asked:

1. Why could the Foundation not incorporate rejuvenation in the programme? Why could it not reproduce itself?
2. Institutions vs. individuals—now networking is the answer: IDRC, the Bank, the Foundations are all supporting networking, but will it be successful? Institutions are atrophying: can we both support them and network them? Networking is better than nothing, but not as good as institution building.
3. In supporting Ph. D. students to write theses, the new programme is not doing what it used to do, identify US institutions and good universities, etc. Students are writing on obscure topics at obscure universities. The UDP was the best thing the Foundation did. It helped in elite formation; you find former Foundation students everywhere in top positions. Why did it have to end?

Dr. Court noted that the internal reason for ending the UDP was the absence of new ideas, other than just continuing as before; the job had been done; departments were in good shape, staff had been trained. The Foundation needed a new set of ideas.

Prof. Kwapong pointed out that there was also some disillusionment that some institutions did not turn out as had been hoped. Dr. Sutton observed also that cost became a factor. Training of staff began to get very expensive, but funds had not increased in constant dollars, so the budget had declined. There was ambivalence about supplying staff for the overseas offices of the Foundation, and disillusionment with higher education. Concerning the support of institution vs. individuals, the cost factor operated, and networks were constructive and productive, even though individuals came from weak institutions. It was a choice of where to put resources—into Ph. D. fieldwork, into a reflection programme with time to read and write.

Dr. Prewitt observed that the entry point for the Foundation was through disciplines at universities. The current focus is on the problem areas, rather than on institutions: agriculture, health, population, and industrial sectors. This focus has 5 properties:

1. It forces you to use knowledge, actions solve problems and evaluate the programmes.
2. Multidisciplinarity—anthropology, economics, sociology and technology are forced to work together by looking at disease, pest management, etc.
3. It provides for a standard of measurement and evaluation; problems mutate, but there is a focus to evaluate, otherwise project evaluation becomes just numbers of people involved or trained.
4. A problem preoccupation engages donor attention—there is a need to keep handing them problems and attracting attention.
5. Networking—there are two ways: A. within layer, economists-to-economists (which is easy) and B. across layers (policy, decision-making, problem solving, end user) which is much more difficult. Type A is always narrow, specialised. A problem focus forces broadening across the network.

For these reasons the Foundation is in the process of launching a programme at a different entry point.

Prof. Ajayi observed that, on the question of evaluation, because there is no way to be pessimistic about the achievement does not diminish the quality of the approach. It was building capacity of both institutions and individuals—because there was need of individual creativity before the problems could be tackled.

Prof. Kwapong wished to enter a dissenting note into the "glorious celebration" of the Foundation. The UDP was based on the reaction of the chosen few in the US looking at Ibadan. But why choose Ibadan? Why had the early courtship in Ghana not been consummated? The problem of strategy worked excellently, but its weakness was the arbitrariness of the choice—the choice was made from outside by donors. The strategy of networking of institutions could have been more effective. In the case of the UNU, networking of institutions is more effective than of individuals. There is need to strike the balance between individuals, institutions and problems. We should applaud the quality of the programme and its impact on scholarship; the lesson is to move to the next stage, where individuals, institutions and problems can be supported. Problem areas are selected, identify co-ordinators of networks, work out programming details, and make sure collaboration is effective.

Dr. Rabinowitch expressed concern that the graveyard of development is full of abrupt shifts—today, education; tomorrow, maternal and child health and so on. Dr. Court's point in his paper was that there remains a real need for emphasis and activity; people and education are basic to the solution of problems, and you can't stop strengthening institutions broadly and helping the educational system to be better able to solve problems. ICIPE is a problem-solving institution—yet we had to fight all the way to keep it supported; only a few key donors were willing to consider the need for ICIPE and were committed to solving problems.

Dr. Prewitt agreed that the problem-solving strategy is necessary; pests eating food is strong motivation. But there is a difference of view about problem orientation as opposed to basic science.

Institutional infrastructure—relationships between S & T institutions and their sociopolitical context

Dr. R.M. Bell observed that there are two types of institutional problem:

1. the development of particular institutions or types of institution—universities, research institutes, etc.; and
2. the development of articulated structures in S & T, interactions among complementary institutions, and their complementary roles.

The second type are more difficult, but he attempts in his paper to focus on them. He focused on the coherence in agricultural S & T, and industry, broadly defined, including mining, natural resources, energy, manufacturing, especially industrially-oriented S & T institutions.

There is no shortage of evidence of disarticulation. Industrial R & D institutions have had almost no impact. Their achievements have been very small (e.g. the unique achievements of the Technology Consultancy Centre in Kumasi, Ghana).

There is no shortage of ideas about the nature of the problem—the irrelevance of R & D, or a perception that the sector is dominated by the multinationals. An alternate diagnosis leads to other perceptions: the absence of functional coherence, the coherence between the different strata of S & T in society. Many "engineering activities" generate change without a link to R & D, but are not independent of R & D—they are necessary complements to R & D. They articulate demands and needs for new knowledge; they "pull downwards" into their stratum. The strata are much larger than R & D—80 percent of scientists and engineers are not in R & D as it is strictly defined, but are engaged in this middle stratum of adaptive development, neither in universities or institutes.

The institutionalisation of the 2 strata, their differences and common patterns, shows that the 3 bottom strata are organised within independent enterprises which use technology in production; so is R & D. S & T infrastructure is complementary to S & T infrastructure. In industrial countries infrastructure is responsible for the majority of the inventiveness in industry in their different ways. Infrastructure is not strictly R; it is problem-solving about production, and is responsible for many innovations.

In Africa in the last 2–3 decades, this infrastructure is almost entirely absent, and its absence builds functional incoherence into the system. The S & T systsm floats in thin air. The gap reflects the gap in policy concerns by governments. Economic policy is focused on the bottom stratum, and nothing contributes to the intrastructure. S & T policy bodies on the other hand focus on the top 2 strata. This analysis does not lead easily to prescriptions, but poses challenges for donor agencies and foundations.

Prof. Ngu observed that this institutional definition can be extended to other things in the industrial private sector. The exploitation of relevant information by government or the private sector. The development of infrastructure is not within the control of government, and this is responsible for 90 percent of the bankruptcy of Cameroonian parastatals.

Prof. Bell agreed that the infrastructure must be developed to make it effective. It involves economic policy and the ideas underlying policy.

Prof. Ajayi pointed out that government is not under the control of institutions—disarticulation is what we are describing. There were cleavages in colonial times dividing the masses from colonial development, creating a social dichotomy, so that development became exotic, and composed of imported turnkey operations which led to more disruption. Governments now must find ways to reduce this disarticulation.

Prof. Kwapong pointed out that effective R & D is in the infrastructure; innovation is not in the universities or the research institutes, but in industry. In Japan, the Industrial Institute (MITI) and the banks are the influential agencies, and are fully supported by the Japanese government. African governments must promote development through their own policies. So how do illiterate governments make the difference in articulating public policies and plans to develop the missing infrastructure? What is the international element that should be injected to encourage tractable governments to move in the right direction?

Prof. Bell observed that it is not only illiterate politicians; the problem is rooted in the ways economists think about technology and economic change. The Governor of the Bank of Japan in the 1950's could find no reason for Japan to build automobiles; he thought that Japan had no comparative advantage in adopting this technology. The process of acquiring awareness works by education, by insinuating understanding into planning (c.f. the impact of the Dahlian Institute of Management in China in orienting middle-level bureaucrats to private enterprise).

Dr. K. Prewitt asked what is to be done about industrialisation? What about existing structures—which are white elephants, which are healthy, among both traditional and modern industries? Is capital going into Africa for the low-wage labour pool?

Prof. Bell said capital is not invested in Africa because it is chasing low wages—it would be a waste of time, because skilled labor is not available at low wages. However if the quality and quantity of skills are raised, the situation could change. Mrs. Adams observed that it is also a function of investment payback—the US investors demand a 2-year payback; the Japanese are prepared to wait for 20 years. Dr. Prewitt indicated that there was deep frustration with the false optimism generated about industrialisation.

Prof. Johanssen drew attention to the Kilimanjaro declaration from the recent CASTAFRICA II conference that, among other things:

> "strongly appeal(s) to the governments of African Member States of Unesco firmly to resolve to:
>
> (i) define and implement clear national S & T policies and allocate the resources necessary in order to upgrade the work of Africans and strengthen their S & T capabilities with a view to the judicious exploitation of the natural resources of the continent, this being the only way to improve the standard of living of the peoples of Africa;
>
> (ii) prepare and implement plans and programmes for indigenuos S & T development, in keeping with the aims and priorities of their national development plans, while ensuring that imported technologies are appropriate, fully mastered, and conducive to the enhanced use of indigenous technologies;
>
> (iii) devise programmes for the development of technologies suitable for rural areas, including the use of new and renewable sources of energy,

with a view to ensuring among other things the promotion of small-scale local and cottage industries;

(iv) mobilise sufficient financial resources for the promotion of S & T for development;

(v) promote the training of researchers, engineers and technicians and other specialists, paying special attention to the training of women and encouraging the use of African expertise;

(vi) promote better use of their S & T personnel, in particular by providing them with good career prospects and by ensuring that scientific workers enjoy appropriate status in order to reduce "brain drain";

(vii) encourage the establishment and strengthening of African S & T communities oriented to solving major developmental problems;

(viii) make the necessary arrangements to set up or strengthen machinery for the storage, dissemination, popularisation and utilisation of research findings, particularly in rural areas, by drawing on the facilities of the mass media and audiovisual methods, by using national languages and by strengthening literacy programmes, particularly within the framework of Unesco's Regional Programme for the Eradication of Illiteracy in Africa;

(ix) work for the pooling of their S & T potential and for the creation of centres of excellence for technological development by strengthening their cooperation at regional and subregional levels, and in particular by harmonizing their national development plans and projects with the objective of the Special Programme of Assistance to Africa in the fields of S & T research and of R & D (SPAA);

(x) organise exchanges of experience and information on S & T for development, on the one hand among African countries, and on the other between these countries and other developing countries as well as between African and industrialised countries;

(xi) support African regional organisations working in the field of S & T;

(xii) enhance S & T culture by paying more attention to the popularization of S & T, and by improving the teaching of S & T at all levels of the educational system and particularly during early childhood;

(xiii) heed the fact that the strengthening of S & T culture depends also on women's growing awareness of its importance since women are the key agents of socialisation; and to that end promote programmes to familiarise women with the use and application of S & T;

(xiv) make deliberate efforts to accord to women their rightful status and appoint a suitable proportion of women to key positions in the S & T field, especially in decision-making and the implementation of development programmes."

Prof. Hassan observed that a fundamental point is whether donors should join forces and ideas, or foster a multiplicity of ideas and approaches. He also referred to the success of the Indian institutes of technology, drawing on the best experience from the US, Soviet Union and German universities.

Current programmes of the international organisations and foundations

The Third World Academy of Sciences

Prof. Mohamed Hassan described how the Third World Academy, headquartered in Trieste at the International Centre for Theoretical Physics under the presidency of Prof. Abdus Salam, has been operating networks of scientists in Africa to help them in various ways. To date they have involved over 2,000 African scientists in their programmes.

The needs have been already identified:

1. international journals and textbooks;
2. equipment and spare parts;
3. scientists collaborating in Africa to enhance communication, rather than only meeting in Trieste;
4. African collaboration with the rest of the international community;
5. African centres of excellence in areas of critical importance—basic knowledge for training and training of trainers;
6. International Centres for Science—ICTP analogs:
   (a) International Biotechnology Centre in Trieste and
   (b) 3 additional centres, in materials sciences, geosciences, and chemistry, also in Trieste and
7. organisation of scientific meetings in Africa.

To date, activities have been undertaken in physical sciences, through ICTP, and in biotechnology, through the sister centre in New Delhi in India, relating to the use of biotechnology in agriculture.

In the physical sciences, there is a budget of $10 million, 90 percent provided by the Italian government, and $2 million from the IAEA and UNESCO. With these funds courses have been taught in high-energy physics, optics, and medical physics, involving 664 man-months of 500 scientists from 40 African countries. It has also supported long term visits in physics and mathematics, and supporting activities at African universities. These have amounted to over $2 million in 1986, or about 20 percent of the budget. New initiatives include:

1. Establishing a centre for low-cost laboratory equipment manufacture using local materials, in Dar-es-Salaam, in physics now, and other disciplines later.
2. Establishment of 4 centres of excellence in Africa, in Côte d'Ivoire, Benin, Nigeria and Senegal, and to strengthen mathematics training and research in Africa.

The Third World Academy has a number of programmes analogous to ICTP, in biology, chemistry and geology:

1. Providing research grants for projects in Africa and the Third World generally, funding individuals for equipment, material, library, etc., through refereed proposals up to a limit of $5,000. In 1986/1987 27 grants were awarded.

2. Visiting "South-South Fellowship Program" for research collaboration; 16 African scientists were supported in 1986/87. These are for long term collaboration in Italian laboratories—75 Italian laboratories have agreed to support Third World scientists for up to 1–2 years. The labs provide all local costs, TWAS provides the fellowships at $50,000 and the institutional linkage.

TWAS has appealed to Japan to provide $10 million for Third World scientists to go to Japan for collaboration, among whom would be numerous African scientists. To date TWAS has sponsored 71 scientific meetings in Africa.

The textbooks project: TWAS is making an effort to help libraries at 8 African institutions, by subscribing to journals for them—e.g. *Science, New Scientist, Scientific American,* and supplying textbooks on request.

These efforts are attempting to help Africans strengthen their S & T problem-solving capacity. The capability exists, but needs funds. A constant preoccupation of Prof. Salam's is the amount of resources going into defence, as opposed to that going into S & T. African countries and industrial countries are spending about the same amount of heir GNP on defence (4.1 percent and 5.1 percent respectively) but only 0.2 percent on S & T in Africa compared with 2 percent in industrial countries.

United Nations

Dr. Aklilu Lemma referred to the Advanced Technology Alert System (ATAS) of the United Nations that was designed to warn African people about the pros and cons of new technology. It is an attempt to look at technology developments in a multisectoral way, in order to inform decision-makers of the implications. However this effort has not yet found the Odhiambo style of leadership.

UNICEF has taken a different approach—to make available S & T to communities for self-help, interdisciplinary efforts, not co-ordinated centrally. Medics go to villages, particularly focusing on child survival and development, in multidisciplinary teams that help the villages to solve problems. The universities are very anxious to participate and respond: the community is aware and awake. Each district has its own priorities, and if water is No. 1. then that is tackled first.

UNICEF, Prof. Lemma continued, is taking a model approach to technology for child survival. Based on a Firenze hospice for abandoned children, a UNICEF staff college has been developed working in 4 areas:

1. national capacity building;
2. child rights;
3. economic resources mobilisation—sustainable community participation; and
4. urban children's problems.

The MacArthur Foundation

Mrs. R. Adams observed that the Foundation has no special S & T programme, nor a special African programme. With assets of $2.5 billion,

projected to increase to $3 billion, it is the leading actor in philanthropy. It has a small staff, a very active board, and is looking for a president to guide its future. Its programme consists of:

1. Health Programme Network
2. 5 Institutes for research on parasitology
3. Fellows programmme—the so-called "genius awards"
4. Environment and world resources—including buying land to preserve habitat and biodiversity
5. Education
6. Peace and International Co-operation (the programme Mrs. Adams administers).

The budget is $60 million for 3 years, mostly spread over many institutions, particularly in higher education. There are few activities in S & T in Latin America and Africa. There is enormous potential, and the programme needs advice and counsel.

The Rockefeller Foundation

Dr. Prewitt observed that the science-based development programme of the Foundation is about two thirds of the international programme, and about a third of the money going into domestic programmes. The total budget is about $50 million.

The international programme is based on the following rationale:

1. S & T is the driving force in history. The arms race and the East-West race for consumer products have almost nothing to do with the Third World. It is important to try to subvert talent and redirect it to Third World problems, e.g. in biotechnology and agriculture applied to rice and cassava as opposed to tobacco or tomatoes. There is a special problem of tropical disease and vaccines. Unesco, the Ford Foundation, Rockefeller Foundation, and WHO are putting in small pieces of this, but so far only small amounts of dollars.
2. The subversion process needs to give the Third World a voice in the world of science, in such things as rice biology in China and India, and reproductive biology in Africa.
3. Pop culture for science-based development—primary and secondary schooling for science-based development—school, media, radio, fairs, prizes etc.

The African component is a third of the programme. Its features are that it is put together with vigor. The major component is what type of leadership is needed for the 1990s? What type of fellowship program, etc. is required to build S & T for the 1990s in Africa (not in Asia or Latin America). This will build up a leadership cadre, communities of scholars and scientists around problem areas (not problem-solving, but maybe including problem-solving) as opposed to disciplines. We are not uninterested in human resources development, basic research, etc. The Foundation feels it is particularly important to improve the connection of S & T to the policy process. What is the

role of the African Academy in getting S & T on the agenda of political leadership in Africa?

In sum, the programme seeks to provide leadership for the 1990s connecting S & T to economic development pacemakers, and action in creating a cultural/popular response for S & T.

The Foundation is diminishing its field presence, the last office is in Nairobi; it is now strengthening the field service in Africa. It is not too much of a formal strategy, somewhat opportunistic—and ranges from cassava to mid-career linkages. In 4–5 years the lead ideas will be fixed.

Dr. J. Moock pointed out the power of donor convening and co-operation. There are extremely few opportunities for co-operation because of the centrifugal force of programmes. She identified two types of co-operation:

1. co-operation based on consultation forums—the Bellagio education group; exchange of ideas and information; the tropical forestry programme of donor co-operation; the IBRD policy paper on education proposing a gathering of donors; and
2. a common pot of money for specific projects, because:

    - the idea is so big (e.g. the CGIAR system, which has both large needs and is premised on the opportunity for foundations to buy in),
    - there is "safety in supporting motherhood", and
    - shared responsibility for the mundane—macroeconomics in Africa.

Ideas sustained are tested ideas, born of experience and accomplishment, such as the CGIAR experience, which has become crystallised and well-articulated. Where can African institutions lever donors? Three ideas so far suggest themselves:

1. Better definition of issues and problems. There are only a few ways to spend money—universities, population growth, etc.—which does not offer much choice, and few new ideas.
2. Justification—demonstration of demand; we have to show how state policy, technology and practice can be linked.
3. Greater exposure of S & T institutions to their communities.

The World Bank—Africa Regional Office

Dr. Dunstan Wai indicated that the Africa Regional Office thought it was critical to be represented at the Bellagio meeting. The Bank is an international multinational lending instituttion, which experienced an internal "structural adjustment" last year, and Mr. Edward Jaycox, formerly Eastern and Southern Africa director, became Vice-President for the Africa Regional Office.

The Africa regional portfolio is about $3.4 billion, plus half of the $12 billion IDA funds—$6.3 billion raised for core funding. There are dangers of shifting interest and emphasis among infrastucture, rural development etc. The "three sisters" organisation of World Bank (IBRD), International Development Associate (IDA) and International Finance Corporation (IFC) are the agencies through which the funding is organised.

The traditional procedure in funding African development has been to identify the problem, prescribe solutions, invite Africans to apply, and negotiate investment conditions, requiring a reasonable IRR (typically 11 percent). Regarding instituion building, the Bank is distrustful of institutions, and has established parallel units in ministries, with solutions than in imparting technical assistance). This has undermined institution building in Africa. The emphasis has been on appraisal, structural reform, creating the right economic framework etc. All these efforts may not yield tangible results, because of management difficulties—there are few trained and skilled people in Africa, few receiving local training, and unnecessary disagreements. Most African projects were failures, yielded low IRRs because of institutional capacity weakness. Now the Bank is developing new policy for the Africa region, needs to revise its approach and refocus, needs to involve locals in what is feasible, and recognise that implementation is as important as policy. There is therefore a need to shift to manpower and capacity building. In this light, the Bank has already given a grant of $1 million to ICIPE for its new building. A Bank report dealing with African higher education (the Moock report) calls for looking at country experiences. What needs to be done? We don't know. We need to learn, to promote professional and managerial training, and support regional centres of excellence. The Bank needs feasible co-ordination strategies, and to exchange views with the foundations, hence the importance of the Bellagio meeting.

The Ford Foundation

Dr. Sutton observed that the Foundation at one time was investing $250 million/year in its programmes; now it is down to $10–15 millions/year. This is certainly not trivial, but it is not now big in terms of US foundations. It has always focused on problems, not disciplines, and this persists and is being accentuated. Most of his paper deals with the past, support in the 1960s for universities, which then passed in the 1970s in favour of the CGIAR Centres and assistance to governments to improve management. The Foundation is now moving away from support of governments towards PVO's and problems of the poor. In 1981, its president, Frank Thomas, changed the structure of the Foundation towards topics such as:

- rural poverty and resources, water management in Sri Lanka;
- women and an action-oriented, urban poverty programme, which is the largest programme, both domestic and overseas;
- education and culture; education was the casualty, has not revived; and
- international affairs, concerned with economics, peace, security, refugees, migration.

The US Agency for International Development

Dr. North indicated that the AID budget for 1987 was $800 million, excluding food commodity assistance. There is a distortion, with the new provision for the African Development Fund. Earmarked budgets grew as Congress directed AID to fund specific line items, but the loss of flexibility created problems and now there is a return to consolidate aid for Africa in one fund with greater flexibility—$500 million is in the development account for

Africa. More emphasis is given to the flow of resources to encourage and assist the policy reform process—in macroeconomic terms to supply "reward for development" sector resources for policy changes.

Attention is also given to research in agriculture. In the 1985 strategy statement there was an 8 country national development focus, towards assisting those countries of particular concern to the US, Cameroon, Kenya, Liberia, Senegal, Somalia, Sudan, Zaïre and Zimbabwe were the original 8 countries, but these change as political problems arise, or as countries fall behind in debt interest repayment. Agricultural research support in these countries is focused especially on the major food commodities and livestock in generating new technical information and approaches. In 15 neighboring countries, support is provided for applied, adaptive research. Institutional development assistance including support to national systems of research and extension in some areas is provided in most countries on an ad hoc basis.

The main areas of emphasis in AID's overall programme are:

- natural resource management;
- child survival, sustaining programmes, including institutional development;
- basic education; and
- training.

The main thrust is towards macropolicy economic reform, economic growth, export development and trade, to get countries to generate income and support their own development. How this is to be done is not clear.

From the chair, Prof. Ngu summarised the points raised:

- donors are open to new ideas, especially the MacArthur Foundation and the World Bank which recognises that in the past its African programme has had limited success, and it is therefore looking for new ideas; and
- there is a multiplicity of ideas of approach by the donors, and among the issues are:

(a) problem-solving focus vs individual training support;
(b) definition of problems by donors vs by locals;
(c) a shift in policy of donors to suit agencies' interests.

Prof. Kwapong observed that the summary of the experience of the meeting suggested the importance of partnership among colleagues, and of looking for openings for prospective collaboration through sober reflection on the distillation of the interaction among the various groups represented, based on an understanding of what is driving the donors.

SYNTHESIS

Prof. Kwapong explained that the task of the final session was to bring together the issues and generate a synthesis. This is a challenging and valuable period in Africa, and of international reaction to African needs. The donors are in a very positive frame of mind, and the meeting should come up with a succinct, powerful statement of what had been discussed. This would deal with the importance of S & T in contributing to African development, the role of

education and particularly the universities, the future role of regional institutions, and sustained support, and the need to improve the perception of S & T by government and the African public.

Prof. Odhiambo observed that the Bellagio meeting felt it was important to look at the past, and identify the factors responsible for success, as well as at future opportunities. Analysis of the past experience is the appropriate activity for an institution such as the ICIPE Foundation to wind up its career. But the real issue is the future; we have the promise of S & T providing a motor for a modern African technology-based society. Society must become science-led, and this will require a longer time horizon than we are accustomed to, hence the urgency of taking action now, to promote steps towards solving the serious economic and political problems in Africa. We cannot hanker for stability, it is not there. Donors may not be empathetic for Africa for all time—they are in ferment to know what to do. Africa is a difficult case, and has not lived up to hopes, or produced the successes of Asia or Latin America. There are a few key elements:

1. We cannot democratise excellence, it has to be paramount. Linked is S & T leadership, to ensure there is creation of excellence to contribute to development. This is taking place in an atmosphere of instability. We should establish a resource base to give protection to the new leadership we are trying to form, to create institutions, and to develop a charter for African S & T to foster science culture for the continent.
2. How to establish that trust, to link African S & T leadership to the resource base, and to assist the thinking that should go into that the scientific resource base—with the need to internationalise it from the beginning to protect it from capricious interference—and to be persuasive that it is not a new neocolonial establishment? How to persuade scholars and intellectuals that the new elitism is important for Africa, and that they should be part of creating it?
3. Private foundations should be an important player—they are shy of being leaders—and their activities can help to bring in the World Bank, the African Development Bank, UN organisations and other forward-looking agencies. We have a resource in the S & T institutional infrastructure and there is now perhaps a new chance to demonstrate faith in the resource base. We hope resources will emerge from Africa itself. Private people can look for immortality by endowing institutions. We can bring them onboard and create a patronage for S & T support, to contribute to it. (He observed that Gen. Obasanjo is open to this idea, and would be willing to lead this type of activity.)

Prof. Malu observed that it would be worthwhile to take advantage of other reviews at the Arusha CASTAFRICA II meeting, and the CASTAFRICA declaration, to strengthen the case. Institutional development has really only benefited the agricultural and health research fields so far—other areas lag far behind. There are very few qualified technicians; a poor state of scientific services, and engineering and technical services; research is poorly linked to practical application of its results. If we want to become credible, we have to show results not just for show, but linked to development. We must work seriously; there is a need to increase the productivity of the S & T community—to publish papers, and translate them into benefits for the economy. The issue

is not only agriculture and basic human needs, but also engineering and technical services.

Prof. Ngu thought that in the interchange of ideas, everybody gained something. There is a diversity of views on the analysis of experiences and perception, successes, failures and conceptual approach. The heterogeneity of Africa makes it impossible to have a formula. It is reassuring that the donors have expressed the need to obtain new ideas—this sets the tone for the future. The prerequisite for future actions is dialog with donors and countries, when strategy formulation will take place. The multiplicity of approaches requires flexibility. Taking stock of experience is a natural and sensible approach—we need periodic stock-taking, and to interpret what has been achieved in light of what has been provided. That this is complex is only to be expected of human experience.

Dr. Prewitt asked Prof. Odhiambo about the disarticulation problem between S & T and popular culture: S & T is tinkering at the top; appropriate technology, and "the development university" look at the end-user perspective (e.g. low cost immunisations, low-input agriculture). Maybe it would be useful to tinker at the low end: the labour force is becoming literate (c.f. the Japanese experience). Might a new idea be that we should not be so arrogant in always trying to fix the top levels? What strategies are there to do some linkage at the top, with the policy level, to gain serious understanding through schools, incentives, museums, prizes, etc., of the potential importance of local S & T? What is a vigorous strategy at both top and bottom levels? Should a parallel strategy worry at both levels?

Prof. Odhiambo agreed with this point—we cannot only have colonels at the top, and need to link to the bottom by developing S & T literacy. Traditional knowledge is transmitted at age 4–8 from parents; education in these ideas is in the mother tongue. Children should be absorbing S & T analytical knowledge through storytelling and games along with the traditional knowledge base. In Scandinavia children know and appreciate their history. Africa has history but does not articulate what the pharaohs did, musicology, folklore, and other aspects of the traditional knowledge base in the same way. We need to discover knowledge about ourselves, geography from Ptolemy, bring the history and the latest astronomy into elementary and secondary schools. Professors can come to their level to write books or TV programmes, design exhibits in science museums, etc. S & T should not only be in the laboratory and field, but in the home. Social science, the relations of human beings, should be in the new curricula. Material sciences should be applied to improving village pottery. We are not using mothers to teach pottery in schools.

The Kenya Coffee Research Institute is supported by farmers, for farmers; private support for research is possible. But so far there is no user community for industrial research. Profs. Kwapong and Bell have pointed out the 2 disarticulated strata without "connecting tissue". People who rise up make a difference—you cannot extract S & T and look at it separately from the social-cultural context. There must be a strategy, selective because of limited resources, to bring both strata together.

Prof. Ajayi observed that the development of S & T must pay attention to philosophy of science and curriculum development. How do you introduce S & T to the African child? It is similar to the Christain problem of tainted animist traditions; we have now tainted colonial traditions. African studies

programmes look at other people, not at us; we need to look at our own roots. This is an essential part of the development process, and S & T needs to look at this. Law, history, and medicine have relevance the scientific ethnography of Africa must be developed. Ethnobotany should provide a classification based on uses; we must have confidence in African resources.

Dr. Sutton pointed out that primary and secondary school curricula were not included in the review. There was an era of science orientation of African curricula in the 1960s, to try to make them more related to their African setting—e.g. math in Swahili. The problems encountered have been omitted from the agenda. The US and UK gave much attention to this area; it was part of the impetus provided by Sputnik. NSF devoted much to curriculum development all round the world—e.g. the new math. The balance of value of this is difficult to judge; it was not cultural problems that were responsible for the rise and fall of the new math. At that time scholars were connected to school teachers; people from MIT and Harvard taught in African classrooms. The enthusiasm and capability of the teachers is the limiting factor. Nowadays we are losing our best teachers to other opportunities. We have heard about the problems of rapid expansion of the schools in providing adequate materials. But the problem is basically not a funding problem; it is a teacher problem. The system is only as good as the teacher. Excess people graduating end up in teaching.

Dr. Rabinowitch observed that the question of the science culture is a most promising issue. He is convinced that Prof. Odhiambo's emphasis is well placed. Earlier efforts at curriculum development were not based on science culture. They assumed that there was a science-based culture on which analytical new math could be based.

Dr. North referred to the science education for Africa programme based in Accra, and suggested the experience needs to be reviewed. It is not only the conceptual problem; the principles and concepts need to be resurfaced. Congress is interested in basic education; a better understanding of the past is required.

The question was asked—what is it in African culture that inhibits science culture? Prof. Hassan said that without scientific awareness and understanding on the part of the community, S & T is only "playing symphonies to the cows". He suggested that African scientists should be supported to write vernacular pamphlets, magazines, TV films and other modalities.

Dr. Court pointed out that in Kenya the primary school curriculum is full of conclusions of science, but it is presented in a way and with a factual content that is not related to the larger culture of the community.

Dr. Prewitt made the analogy to sandlot baseball in the US; this is a system designed to foster a deep appreciation for the sport and develop the cream of the youthful talent for the profession. S & T leadership cannot free itself from the recruiting problem, to get the very best minds into S & T, and a feeder process for S & T creativity. We need to be careful that it is consumer awareness and appreciation for using scientific knowledge effectively in society that drives the system, not the scientific career professionals.

Prof. Ajayi observed that there is nothing in African culture that inhibits production of 1st class scientists—Odhiambo, Lemma, Hassan, Ngu and Wai are examples. But this is not creating a culture. The masses are not aware of great individual scientists; science is exotic, brought in from abroad. The

Nigerian example of having to import Bulgarian technology is apposite; how can Nigerian children be aware of what is in the country already unless their mothers teach it along with language?

Prof. Bell noted that in many countries there are farmer's organisations, not science organisations. Diffusion of farmers' experience is best done by farmers. African experience of the past 20 years shows that the whole structure was designed to develop technology for farmers, and force it down the pipeline to farmers as "passive recipients". The new development is breaking this model, and incorporating farmers into technical change. There are experiments in innovation, and we need to learn from them, multiplying them, discarding where necessary. Paul Richards of King's College, London has written on indigenous African agricultural modernisation. Parenthetically he observed it is sad that reorganisation of African experience is not being made by Africans. There is need for more people to analyse and work on African S & T. IDRC has contributed its efforts, supporting people to observe and hold workshops on the bottom-up approach, of which the palm oil industry in Ghana is an example. It is difficult to be prescriptive, and future action should be based on capturing past experience.

Prof. Ngu observed that what is missing is teaching sciences relevant to our area. Cameroon was both new math and old, and it is impossible to reconcile them. We have missed out in Africa. Science must identify understanding and explanation of physical phenomena, because it is in everything. It is in river blindness, in the nodules and worms, but the villagers have never seen the worms, know nothing of their life cycle.

Mr. Mathieson observed about the promotion of elitism that 30 years ago he had been abused for it. He proposed resources should be concentrated on 6th Form "A"-level teaching to get elite up to the standards required by the universities in 10 African secondary schools, because of competition from elementary education. But this was politically impossible to do when the government was pressed to support literacy and universal primary education. There are too many fragmented, dispersed scientific institutions in Africa. Sir Charles Pereira pointed out that 96 percent of the budget of national agricultural services is spent on salaries. The Gamble report on AID's experience in 3 Nigerian universities describes quality overwhelmed by floods of admissions demanded by the public. There is no money or facilities for research, equipment but no maintenance. There is a need to concentrate on quality, otherwise objectives are diffused, and a need for dynamic capacity-building.

Dr. Prewitt added that there was also the need to erase some institutions in order to focus priorities, and concentrate on a few for their excellence, but not exclusiveness, to raise standards for the whole system.

Prof. Kwapong in looking at future mechanisms and direction, raised the issue of the need for organising a trust or other mechanism that protects the S & T leadership to assist promoting the objectives desired. What kinds of mechanisms can be available to assist protection of institutions and individuals of high quality science?

Dr. Prewitt thought it should not be protection—encouragement and recognition, facilitation—but why protection? Why an S & T charter? Governments are not denying passports—there is an international commitment to encourage S & T at the highest levels. Excellence is measured in terms of quality and effectiveness in creating knowledge and solving problems.

Dr. Kwapong referred to mechanisms required to guarantee growth and stability of institutions, giving as an example the survival of ICIPE through a period of turmoil through positive support to enable good science to persevere. This needs a partnership between international institutions and African institutions.

Dr. North suggested this was a function of programmatic content, to pursue excellence and relevance to assure support from outside. The onchocerciasis programme in West Africa has not encountered any impediment—in spite of severe political problems among the countries involved—because of its excellence and relevance. This also applies to the Desert Locust Control Organisation (DELCO).

Prof. Ngu thought a trust should focus on the promotion of S & T for the masses in villages, towns and schools. A good programme would produce S & T films and radio programmes relevant to development in Africa aimed at the primary school in a non-elitist way with inputs from the right people from a varied background and emphasis on reinforcing S & T notions which already exist.

Prof. Malu emphasised the importance of quality of leadership in successful S & T institution building rather than on infrastructure and bureaucratic models.

Dr. Moock summarised short and long term points from the discussion:

Short term:

1. The need to internationalise staff and advisory committees on national institutions to help protect and stabilise them.
2. To help similar institutions around Africa focus on similar objectives—network on focused problem.
3. Setting up of a communal fund for specific problems—providing for fellowships, sabbaticals, etc.

Long term:

The S & T institutional apparatus is surrounded by mass culture, and the political and military leaders come out of the mass culture. There must be a more direct means for the S & T community to talk to and become identified by decision-making counterparts, through internships, prizes, etc. because in the long run the S & T resources base must be locally funded.

Dr. Wai observed that macropolitical problems have mesmerised donors. It is difficult to focus on what can have an impact. In evaluating impact, 65 percent of the lack of positive impact results from donor problems. Human resource development in the Bank needs people in education, nutrition, family planning etc. that must be developed with Bank assistance. This needs regional institutions. There is need for technical assistance to catalyse contact among S & T people and planners, rather than fund negotiations. There are advantages and disadvantages of the role of foreign agencies.

Dr. Prewitt was sympathetic with this problem of unresolved intellectual questions. The Bank has design engineering problems which it is very difficult to combine in one meeting with S & T culture in Africa; people who design response to situations and have control of the money have to do their own design.

Prof. Kwapong observed that we cannot work out a detailed blueprint for the next steps round the table. He had the impression that the group has

flagged certain important areas for a distillation and synthesis of thinking and reflections that will produce a statement for pacesetters, for users, and for the intellectual community that will help. The consensus reached at Bellagio signals an opening of an important new window of opportunity in African development, in which it is important to re-emphasise the importance of African scientific institutions to the future of economic and social development, and in particular, to reorient all levels of education towards creating a science-based African culture.

It was agreed that the meeting could most usefully contribute to promoting and reshaping support for new approaches to African S & T institutional capacity building by circulating a concise statement of these shared perceptions to African governments and the donor agencies that are assisting them. It should focus on the following issues:

- the success of past efforts in building scientific and technological institutions, and their achievements;
- excellence and relevance;
- short term and long-term issues that should lead to decisions on S & T by the donor community;
- the importance of the macropolitical and sociocultural context;
- the vulnerable economic position many African countries have been placed in since 1974, and the need for research by Africans to "break out of the cycle of hopelessness";
- lack of political commitment to S & T at top government levels, low public awareness of the importance of strong S & T capacity, and weakness of commercial technical infrastructure;
- the central role for science in education;
- the key role of the universities;
- the need for stability and continuity in support of research; and
- future directions in international co-operation, and the special roles of the international scientific community and donor organisations.

Prof. Kwapong concluded that this is the opportunity to come out with a clear statement reflecting the diversity of views and the consensus on their importance, particularly the willingness of donors to look for new relationships.

Mrs. Adams raised two issues not hitherto discussed: internationalising foundation support, and communication. She pointed out that the donor agency community of the 1950s and 1960s is not the same community operating in the 1980s and 1990s. The new players are from other countries (such as Japan) and new foundations such as MacArthur, Pergammon (in UK), and Pew, that will not have operating staff. How are they going to deal with grant-making under changing circumstances? They may contract out to local management, which will create the need for a new mode of donor relations. The African Academy has a grant to look at donor relations because we are all worried about its being entirely dependent on external support.

One hopeful development is the possibility of using new computer links for Africa in S & T to bring people and institutions together. There is need of a strategy to fund a network for S & T in this area.

Dr. Dow mentioned the experience of the BOSTID computer-linked asynchronous conference on cellulose biodegradation, and the urgency—

confirmed by the recommendations of the BOSTID microcomputer applications study, and by the TWAS working group on an International Centre for Computers and Informatics—of making computer-modem data access and transfer available to scientists and technologists throughout the developing world, since over time resources available to acquire hard copy of books and periodicals will inevitably decline.

Prof. Ngu suggested donor agencies should consider providing assistance to link universities with commercial activity and industry. WHO is funding research by contract on vaccine development by industry in the US. This may be relevant in Africa. African R & D also needs to be developed through the private sector. Dr. Wai stressed that key centres in the US and Europe should join with Africa—this interface is very important.

Prof. Ajayi underlined the importance of books, journals, and other publications, as is the focus of the TWAS project, and stressed that more needs to be done.

Dr. Hassan pointed out that TWAS subscribes to journals subscriptions to the amount of $160,000/year. 50,000 books and journals are circulated; a meeting of people involved is scheduled for 1988 to look at the achievements and discuss future developments.

Prof. Odhiambo indicated that AAS/TWAS had established a new science publishing house for books and scientific publications—the *Journal of Discovery and Innovation* was the suggested title—which will be the subject of a meeting later in 1988; it will be both for anglophone and francophone Africa, computer-linked to editors.

Dr. Voss in his closing remarks, thanked the sponsors, hosts and participants for assisting in a stimulating and productive meeting.

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INDIVIDUAL PAPERS

THE DEVELOPMENT OF SCIENTIFIC AND TECHNOLOGICAL INSTITUTIONS IN AFRICA: SOME PAST PATTERNS AND FUTURE NEEDS

*R. Martin Bell**

Introduction

It is my understanding that this symposium has two main purposes. One is concerned with success. It is about drawing lessons from the experience of considerable achievement by one African scientific institution—the International Centre of Insect Physiology and Ecology (ICIPE). The other seems to stem from perceptions of more general problems and difficulties: despite efforts to develop modern scientific and technological institutions in Africa over recent decades, the realised achievements in terms of contributions to the welfare of African people are perceived as falling far below expectations.

Others are much better qualified than I to comment on, and draw conclusions from, ICIPE's success. I hope, therefore, that I may be excused for concentrating my comments on the apparent limitations of scientific and technological institution building in Africa over the last few decades, and on the needs for new kinds of action. But one must start such comments by taking some care over how one characterises "the problem."

Two issues are particularly important. First, one must obviously try to generalise, but that runs the danger of suggesting a homogeneous, Africa-wide picture. That is not my intention. I shall use a very broad brush to suggest a general picture of "limited success" in the development of African scientific and technological institutions. But that does not mean, for example, that one should regard ICIPE as unique and forget that other African scientific institutions also have records of considerable achievement.

Second, one must bear in mind that any general perception about success and failure is the product of two things: (1) a set of observations about what has actually happened, and (2) a set of expectations about what "should have" happened. While it is obviously important that the observations are reasonably accurate, it is just as important to set those against an appropriate set of expectations.

I shall return later to the issue of expectations, and will start with what I hope are some reasonably accurate observations. These will necessarily be very general, although I should emphasise that they draw on experience of issues about science and technology concerned only with agriculture and industry.

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However, I define the latter quite broadly to include the energy and mineral industries as well as manufacturing, together with the "manufacturing" component of other important industries such as the railways.

Broad patterns of institutional development

If one cuts across the detailed evidence about scientific and technological institutions in Africa, including the summary of key issues presented by Professor Odhiambo at the previous meeting in Nairobi, two kinds of problems seem to be evident. One is concerned with the individual components of the overall structure of scientific and technological institutions, the other with the articulation and functional coherence of that overall structure.

The individual components

There is no need to rehearse here all the detailed evidence about problems and weaknesses at the level of particular organisational components within the overall structure of scientific and technological institutions. There is ample evidence to indicate various limitations in the "quantity" or "quality" of output from organisations that are concerned, for example, with scientific research, scientific or technological education and training, applied research and development, or the provision of extension or other technical services.

I have the impression that other contributors to this symposium will concentrate on the experience of these and other components of the structure. I shall, therefore, concentrate on the second institutional issue about functional coherence—although that will lead me back to issues about particular institutions.

The functional coherence of the overall structure

Alongside the problems faced by particular organisations, it is clear that the overall structure of institutions for exploiting the potential of science and technology in Africa is usually disarticulated and functionally incoherent. For example, even where excellence is achieved, scientific research too often seems weakly linked to technological development. In turn, technological research and development, whether in universities or specialised research organisations, has generally remained functionally disconnected from the use and application of technology in agricultural and industrial production. In the case of industrial production, that disconnection seems to be almost total in most countries. But even in agriculture, research has had a very limited impact on the technology used by farmers—except in the case of a few crops in limited geographical areas. Agricultural research is more often separated from farmers than connected to them by extension organisations; and institutions concerned with education in agricultural technology have little to do with the education of farmers who use that technology.

The implications of those patterns are well known. The "modern", large-scale sector of industry draws almost all the technology it uses from foreign, not African, sources, while small-scale, "traditional" industry has usually not been able to draw on any sources of improved technology. As reflected in the growth of production efficiency, the rate of technical change even in the large-scale sector is in any case usually very low. The "direction" of change is often

ill-suited to African conditions—making limited and/or inefficient use of African natural and human resources.

In agriculture also, part of the problem is that technology has been drawn from foreign rather than African sources. This has often been accompanied by enormously expensive (and usually inefficient) projects to bulldoze the natural and social environments of African agriculture into forms that are compatible with using that technology. But a far more important part of the problem has been that the vast majority of African farmers have not been able to draw from any sources the technology needed to reduce their risks and raise their efficiency in production. Often with enormous ingenuity, they have remolded, adapted and "fine-tuned" the existing technologies to meet new conditions, opportunities, and threats. However, with rising populations pressing on increasingly scarce land, that has not enabled them to raise per capita food production or income. As those existing technologies have been pushed into ever more marginal environments, the technological ingenuity of farmers has been unable to sustain even minimal standards of living or the natural environments on which they depend.

Comparative perspectives

Africa's problems in developing coherent institutional structures for exploiting science and technology in production are not, of course, unprecedented. Very similar problems have been experienced by other societies. Those include not only other Third World societies in the twentieth century, but also previous latecomers to accelerated industrialisation and agricultural change—for example, Japan and countries in continental Europe in the nineteenth century, and the former British colonies in North America as they moved through the early decades of independence in the late eighteenth century.

So, for instance, a symposium like this—reviewing the experience of two or three decades of American independence in the late eighteenth century—would have emphasised similar problems to those outlined above. Industrial development involved heavy dependence on imported technology, except in "traditional" industries that were already established to meet the basic needs of the predominantly rural population. This was combined with the marginalisation of domestic innovation.(1) Supposedly "applied" agricultural research was disconnected from the mass of farmers and contributed little or nothing to improve their farming.(2) Even after nearly 70 years of American independence, a national congress reviewing the condition of indigenous science highlighted the fact that it was largely molded by foreign ideas and influences, and showed only rare cases of excellence and originality.(3)

The late twentieth century is obviously enormously different from the late eighteenth, and the current context for scientific and technological development in Africa bears little resemblance to that faced, for instance, by Japan in the late nineteenth and early twentieth centuries. Nevertheless, the earlier experiences of those other societies had several features in common with the current experience of Africa. As they sought to accelerate industrial and agricultural growth, all of them had weak scientific and technological capacities. All of them had to create new institutional structures and new human resources in order to exploit the potential of science and technology. They all had to overcome their scientific and technological weakness in an

international context in which other societies had already established dominant economic, technological and scientific strength. Broad comparisons across those different experiences may throw useful light on some of the issues addressed at this symposium.

Institutional development: innovation and imitation

In the earlier experience of the currently industrialised countries, the evolution of organisations for harnessing science and technology to economic and social change was not based on copying "ready-made" models that already existed in other countries. Selective and adaptive imitation was combined with a continuing stream of home-grown organizational innovations. These paths of innovative institutional evolution were rooted in those societies' own experience, with individual steps designed to meet particular needs which emerged at particular times.

Innovation was very evident, for instance, in the development of institutions for generating technical change in agriculture. In the United States in the first half of the nineteenth century, for example, a stream of new kinds of organisations supplanted the agricultural societies which had been modeled on the "learned societies" of British gentleman farmers, and which had contributed very little to technical change in farming in America. The later development of the land grant colleges continued that pattern of innovative institutional development for the particular needs of American agriculture,(4) but that did not merely involve the invention of the land grant colleges in the 1860s—just as significant was the continuing evolution of the system, to answer the needs of colleges of the 1950s that differed from those of the 1860s as much as the latter differed from the agricultural societies of the early nineteenth century.

A similar pattern was evident in Japan. In the 1870s, improvement of productivity in agriculture involved institutional imitation rather than indigenous design and innovation. There was wholesale copying of the experiment stations, agricultural colleges and teaching curricula that had been observed in Britain and the United States. Well within a decade, it was recognised that this was a mistake, and that quite different kinds of institutions would be needed to generate technical progress in the particular conditions of Japanese agriculture. The imitated institutions were redesigned or abandoned. A totally novel system was developed for generating widespread technical change—the rono system of experimentation-cum-extension, which was staffed largely by farmers themselves and concerned primarily with the diffusion of technological improvements generated by farmers.(5)

Innovation also characterised the evolution of institutions concerned with industrially-oriented science and technology. For example, in the middle decades of the nineteenth century, the industrial followers of Britain's technological leadership (especially the German states) developed new kinds of educational institution in order to strengthen the technical and scientific skills required to absorb, improve and then replace imported British technology.

As industrial technology entered a phase of more rapid change in the later years of the century, new needs arose and new kinds of institution were developed to meet them. In the United States, for instance, it became clear that the existing universities were not providing people with the kinds of skill and knowledge that were increasingly needed. But the response to that situation

involved much more than change in the content of curricula. New ways of organising education in engineering and technology had to be developed—for example the Co-operative Course System "invented" at the University of Cincinnati, or the variations on that approach which were developed in electrical and chemical engineering at MIT. Meanwhile, new kinds of organisatiosn were developed to undertake increasingly formalised research and development—initially within firms, but later the specialised contract research institute was invented. Then in the first decade of the twentieth century, organisations like the Mellon Institute emerged as novel institutional hybrids that incorporated several of these ways of creating and using technological human resources.(6)

When it came to the second and third quarters of the present century, those prior paths of institutional development in the more advanced countries provided a wealth of experience that could be drawn upon in designing scientific and technological institutions in Africa. But that experience could have been drawn on in three very different ways:

1. One could have drawn on the contemporary experience of those countries—using as "models" for African development the wide range of specialised scientific and technological institutions which had evolved to play particular roles in the contexts of the more industrialised countries in the mid-twentieth century.
2. One could have drawn on the historical experience of those countries—using as "models" the even greater diversity of institutions which the more developed countries had found useful in a much wider range of different contexts.
3. One could have been less concerned to draw on any of those particular forms of organisation, and more concerned with the underlying principles and processes which had generated the diversity of past and present institutions. In particular, emphasis might have been placed on the evolutionary process of innovative design and development which had fitted institutions to differing and changing contexts, while usually embedding individual components within functionally coherent structures.

Arguably the last of those approaches would have been the most appropriate. Africa faced an unprecedented task. None of the more developed countries had sought to overcome their technological backwardness in the context of mid-twentieth century science and technology. Nor had any of them sought to develop their scientific and technological capacities in economic, social and political contexts which were remotely similar to those of mid-twentieth century Africa. Consequently none of them had evolved types of institution to deal with those challenges, and hence none of them could offer institutional models that were "ready-made" for the task on hand. Everything seemed to cry out for innovative institutional design.

That, of course, was not what happened. With few exceptions, institutional development rested on the first of the three approaches outlined above: on a more or less wholesale imitation of scientific and technological institutions that were used in the developed countries at that time. There were, of course, variations across Africa in the detailed features of those institutions, but those variations rarely reflected the heterogeneity of African contexts, or

the adaptation of institutional design to differences in those contexts. Rather, they simply reflected differences in the source models drawn upon.

However, that pattern of institutional imitation involved a process of only partial imitation—one which transferred only the more centralised and easily transported components of the institutional structures used in the developed countries. Almost inevitably, therefore, problems of functional incoherence were designed into the structure from the beginning—an issue that merits further comparative elaboration.

Institutional development: centralisation and decentralisation

A striking feature of the past and contemporary experience of the more industrialised countries is the decentralisation of the organisational structure used to exploit science and technology. Technologically creative human resources have been widely dispersed throughout organisations within the production sectors. Those resources have been developed and accumulated, as well as used, on farms and in firms. More centralised institutions like universities, technical colleges, research institutes, and extension/advisory services have only been complements to those components of the overall structure.

Agricultural science and technology. In the early nineteenth century, for example, the stream of new kinds of organisations for generating technical change in American agriculture were primarily farmers' organisations, not scientists organisations. They were developed primarily to enhance and draw upon the technological creativity of farmers. That emphasis was reinforced by the invention of the land grant college system towards the end of the century—a system which was designed primarily to enhance the knowledge and skills of farmers and other rural people, and only secondarily (and much later) with generating technical change for them and delivering it to them.

Similarly, over the 40 years from 1880, the main agents of technical change underlying the continuous growth of output and productivity in Japanese agriculture were not agricultural scientists and formally trained agriculturalists operating within a centralised research and extension system. They were farmers themselves.(7) More centralised and specialised expertise reinforced this widely dispersed stock of technologically creative human resources, but the system for generating technical change in agriculture involved two components: one: institutional arrangements to facilitate the development and diffusion of improved technology by farmers, and two: more centralised research and experiment institutions to support those activities.

Over time, the balance between those components shifted. An increasingly complex structure of specialised and centralised research institutions was developed to sustain continuing technical change; and a new type of institution—various forms of extension system—had to be developed in order to maintain the connection between the two components.(8) Thus, the balance of the structure shifted towards the more centralised generation of new technology for farmers, and its delivery to them. But farmers continued to play a technically informed and active role in the process; and the coherent functioning of the system continued to depend heavily on both components and on their interaction. Indeed, one can estimate that in the United States in the 1980s, the resources allocated to the on-farm/by-farmer role in the innovation process amounted to a significant multiple of the total public and

private expenditure on agricultural research and development.

Only the more centralised parts of this structure were transferred to Africa—only the parts designed to generate technology for farmers and to deliver it to them. However, those agricultural universities, research institutes and extension systems had evolved to play effective roles in the context of quite different types of agricultural production, and in the context of important complementary roles being played by quite different kinds of farmer. Looking at Africa's experience from that perspective, it would perhaps be surprising if, within a decade or two, those kinds of institutional "transplants" had met the expectations placed upon them. (Table 1)

Table 1. Comparison of number of farm units per Land Grant College (LGC) in the US and Uttar Pradesh.

US LGC System
1880s 1 LGC per 100,000 farm units 1950s 1 LGC per 70,000 farm units
University of Pantnagar: LGC System in Uttar Pradesh, India
1960s 1 LGC per 16,000,000 farm units
Possible Courses of Action: A. Set up 230 LGCs in Uttar Pradesh? B. Increase the size of the University of Pantnagar to 230 X the typical size of US LGCs? C. Organise activities to serve 0.4% of farm units in Uttar Prudesh? (Guess which 0.4%!) D. Invent a different way of doing things that is designed for the context involved.

Industrial science and technology. In the experience of industrialisation during the nineteenth and early twentieth centuries, technical change was generated primarily by industrial firms themselves, drawing on their own stocks of skill and knowledge. Correspondingly, industrial firms undertook a very large part of the process of developing those technologically creative human resources. In the nineteenth century, those efforts were often particularly intense when firms entered into new areas of production based on imported technology. By the twentieth century, the complexity of technology often required firms to make even more intensive and explicit efforts to ensure that, in importing technology, they also built up their capacity to generate technical change. But, since it is rarely possible to acquire that knowledge and expertise in adequate depth solely through international transfer, firms had to make substantial additional investments in developing those kinds of knowledge and expertise.(9)

Those technological activities undertaken by firms themselves played several roles:

1. They complemented the education and training undertaken in more centralised institutions. They developed the detailed firm-specific and industry-specific types of engineering and related expertise which can

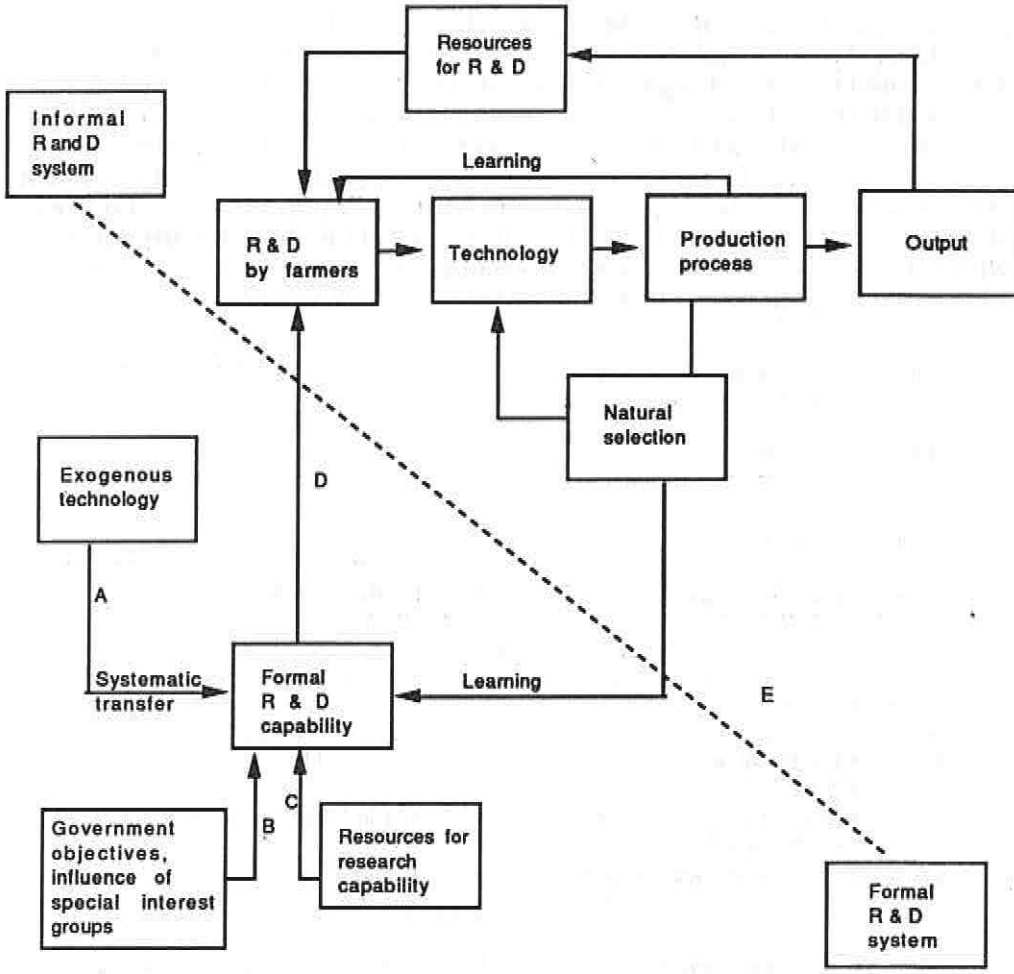

Figure 1. A combined formal and informal agricultural R & D system

seldom be provided by training and education in institutions outside industry itself.

2. Those types of human resource development were usually concentrated in relatively large firms, but those activities acted as important sources of technological expertise that diffused to smaller scale firms.
3. They developed the internal technological capacities required to generate the kinds of incremental technical change to existing production systems which can rarely be acquired "ready-made" from outside the firm, but which contribute substantially to the overall economic impact of technological change.
4. They enabled firms to build on that basis more substantial capacities to develop their own technology and to manage the acquisition of technology from other firms and economies.

But in two ways the intra-firm organisation of those technological activities also provided the basis for effective interaction between firms and more specialised and centralised institutions. On the one hand, they provided within industry the base of capacity that is almost always required to absorb and assimilate the results of innovative activity undertaken by universities, research institutes and so forth. On the other hand, the internal technological capacities and innovative activities of firms generated effective demand for the inputs of those other institutions—generating the "pull" on research which is usually a necessary condition for effective innovation. That "demand pull" from industry also played an important longer-run role in the continuing evolution of the overall structure of indigenous scientific and technological institutions: it often contributed to the development of new institutional initiatives designed to meet new opportunities and challenges.

Those technological activities organised within industrial firms remain a dominant characteristic of the contemporary industrialised countries.

1. Within the total of all industrially oriented research and development in the more developed countries, industry itself carries out around 60–80 percent—and at the higher end of that range in more dynamic economies. Industrial firms carry out a very much larger proportion of the engineering activities which are required to complement research and development in generating technical change; and they carry out virtually all of the myriad forms of technical change that do not draw on research and development at all.
2. Industry itself undertakes a vary large part of the development of its own technological and related human resources. Its intake of trained scientists and engineers from universities and colleges is only "raw material" that enters its own systems of training and skill development.(10)

Africa's experience over the last two or three decades stands in marked contrast to those historical and contemporary patterns in the industrialised countries.(11) For example, various kinds of industrial research and development institute have been established outside the structure of industry, and substantial efforts have been made to create various types of centralised institution for education and training in industrially oriented science and technology.

Although detailed evidence on the issue is scarce, the complementary development of those kinds of expertise in industry seems to have been very limited.(12) In some cases, growing investment in the fixed (physical) capital of important industrial sectors has been accompanied by the development of technologically creative human resources neither in industry itself nor in specialised institutions outside it.(13)

One aspect of that limited development of industry-specific and firm-specific technological capacities in larger scale industry is well recognised: few firms have undertaken their own research and development activities. But far more important is the fact that few firms have even developed significant capacities to undertake the various kinds of technologically creative engineering activity that are usually required to complement the execution of research and development by institutions outside industry.(14) In the absence of those intra-firm resources, functional incoherence of the overall structure is

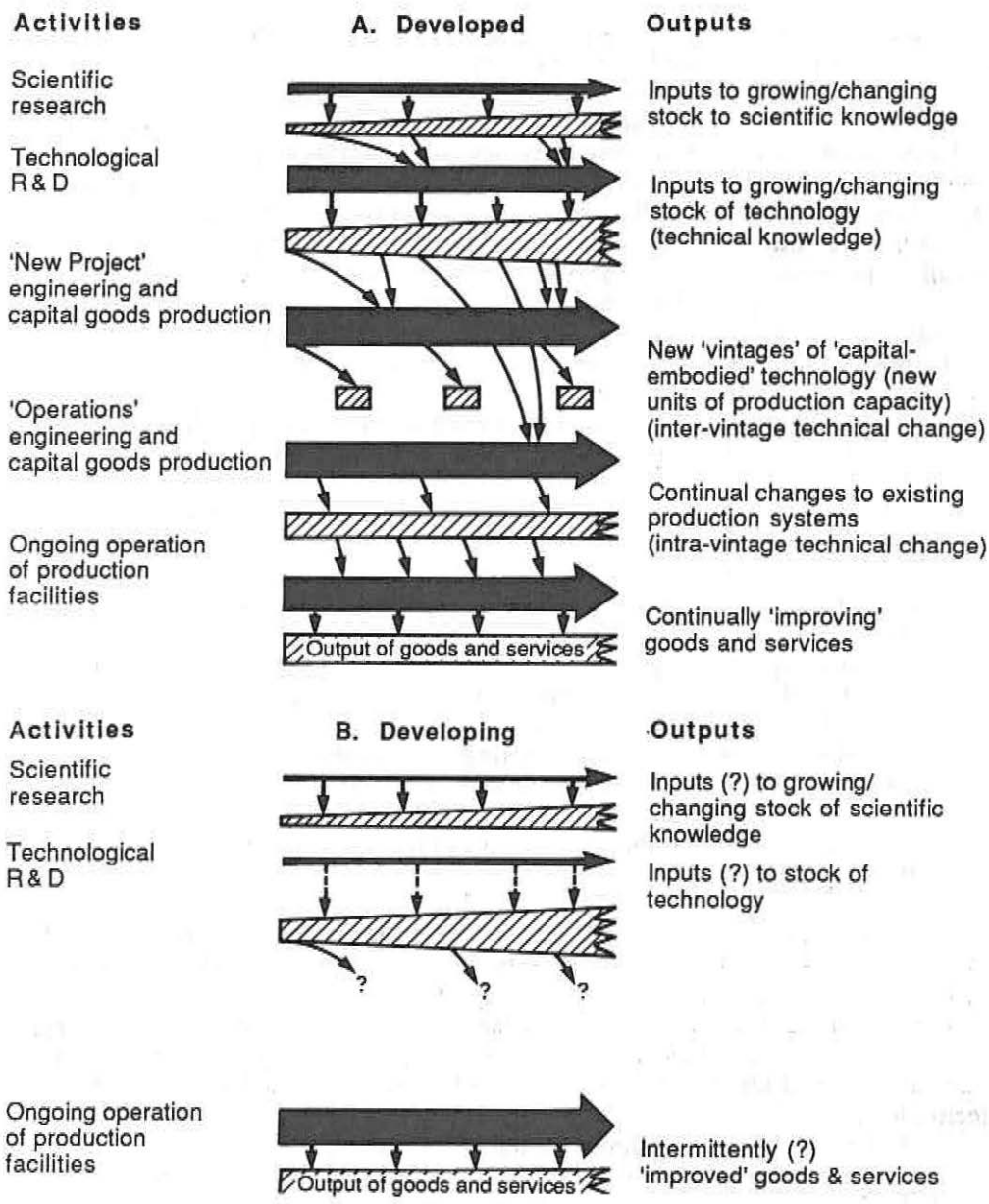

Figure 2. Diagrams of linkages of research to outputs in developed and developing countries

virtually inevitable regardless of the competence, efficiency and funding of the research and development institutional infrastructure. However, those intra-industry resources are also the kinds of technological capacity that are required to adapt and improve existing production systems, to manage and control the technological aspects of investment projects, to provide smaller scale local firms with the specifications and know-how needed to supply equipment and intermediate goods, and to build on those bases the indigenous capacities to provide a growing proportion of the technology needed by industry.

Recent Trends. With respect to agricultural science and technology, one of the more exciting features of recent African experience has been the emergence of experiments which are trying to break away from past patterns. This is not just a matter of shifts in the orientation of agricultural research—for example, (1) giving greater emphasis to the food crops which play a particularly important role in African agriculture and in the livelihoods of rural people; or (2) giving greater attention to the intricacy of African agricultural systems involving complex patterns of intercropping, or elaborate forest/livestock/food crop interactions. It is also a matter of experimenting with new kinds of institutional arrangement for generating technical change in agriculture. These involve not only a search for greater functional coherence in the system, but also (as a necessary part of that search) efforts to incorporate farmers and their expertise in the process of generating and implementing technical change.(15)

In areas concerned with industry, however, there seem to be few signs of significant change from past patterns. For instance, despite frequent "reorganisation", centralised research and development institutes remain centralised and disconnected from industry. At the same time industry continues to allocate very limited resources to developing its own capacities for generating, implementing and managing change in the technology it uses.

There are, of course, exceptions to that continuity of experience. For example, the Technology Development Centre at Kumasi in Ghana has evolved in ways that seem to have resulted in greatly increased success in contributing to the development of small-scale firms.(16) This highlights the more general failure of institutions that have been set up to support the technological development of small-scale industry.(17) Also, there is evidence from a few situations that some larger-scale enterprises have begun to accumulate intra-firm capacities for generating and managing technical change with significant private and social economic benefits.(18) However, apart from the fact that these examples appear to be rare exceptions to more general patterns, the development of these capacities seems to have resulted almost exclusively from the slow, gradual process of experience accumulation—from relatively passive processes of "learning-by-doing". That serves to highlight what might have been achieved by more pervasive, deliberate and active investment in developing the technologically creative human resources of African firms.

The context of government policy

The patterns of institutional development outlined above have obviously occurred within, and been molded by, broad frameworks of government policy. Those have involved two areas of policy:

1. "Science and technology policy"—the strategies, plans and measures concerned explicitly with science and technology, and often the responsibility of particular councils or ministries.
2. Other areas of government policy, especially areas of economic policy, which appear to have little to do with science or technology, but which implicitly have a major impact on the paths of scientific and technological development.

That dual structure of public policy has influenced the development of science and technology concerned with both agriculture and industry. But here I will focus my comments only on the first.

Science and technology policy

By the 1970s many African countries had established organisations which, at least formally, had comprehensive responsibilities for science and technology policy. Those responsibilities were often described as spanning the whole set of government measures for augmenting the nation's scientific and technological capacities, and for harnessing them to the process of economic and social development. Again, however, imitation was the dominant approach used in designing those organisations, and the apparently relevant models were bodies in the developed countries which also had responsibility for "science policy" or "science and technology policy"—national research councils, national science foundations and so forth. However, in at least two ways, those developed country institutions usually had quite narrow responsibilities.

1. They had seldom been concerned with the problems of designing and creating *de novo* the overall structures of scientific and technological institutions in their societies. Since they had usually been established after most of the basic components of those overall structures had been developed, their responsibilities were concerned primarily with "policy" in the sense of resource allocation to different activities within those existing institutional arrangements. To the extent that they played a policy role in relation to institutional development, that was usually concerned with what were essentially marginal additions and modifications to the existing structures.
2. The scope of policy responsibility usually covered only those parts of the overall system that were concerned with research and development. It was concerned with such things as the allocation of resources to various kinds of research and development, the development of additional or modified research and development institutions, and (sometimes) the development of human resources for research or development. Often those roles were played only in relation to selected areas of research or development, and sometimes only to scientific research. In effect, "science policy" or "science and technology policy" usually amounted in practice only to "research and development policy".

Not surprisingly, the institutional "clones" set up in Africa had very similar characteristics. The scope of "science and technology policy" was in practice usually limited to policy for research and development (and related support

services) and the main policy issues addressed were essentially about resource allocation to different areas of research development. (See references to notes (19) and (20) for more details.)

Economic policy

Issues about developing the "human capital" needed for industrial development have not, of course, been ignored by policy makers and their advisors. But policy concern about those issues has been narrowly circumscribed in at least two ways. First, it has focused almost exclusively on allocating resources to the education and training infrastructure—on the development of institutions that will generate human resources for industry. Second, policy concern has centred primarily on the development of human resources for using and operating given technologies, not the resources required to generate and manage change in those technologies. Consequently, very little attention has been given to the infrastructure for education and training, and it is hard to identify policy measures that have been designed to enhance the development of human resources in industry, especially industry's technologically creative human resources.

The absence of policy intervention in this area is curious. Even in the heartlands of market economics, it is well recognised that the market usually works very inefficiently in allocating resources to investment in knowledge. Consequently it is widely accepted that those market imperfections call for government intervention. However, in Africa as in many other developing countries, governments have not accepted the idea that support, incentives or subsidies may be needed to offset the inefficiency of the market and ensure that firms allocate resources "optimally" (or at all!) to the development and accumulation of technological capacities which are needed to complement the heavily subsidised education, training and research and development which is undertaken outside industry.

It is not possible in this paper to explore why economic policy, and the economic theory and analysis on which policy has drawn, have had that myopic focus. However, the consequence is clear enough: there has existed a huge gap between (1) "science and technology policy" (and other areas of policy) which have focused almost exclusively on the scientific and technological infrastructure, and (2) economic policy which has been primarily concerned with the allocation of resources to investment in industry's fixed (physical, not human) capital.

Policy about the development and accumulation of industry's human resources for generating, absorbing and managing technical change has disappeared through that yawning gap. While that gap remains, functional incoherence in the overall structure for harnessing indigenous science and technology to production is also likely to remain—frustrating the hopes and efforts of the research and development policy makers. At the same time, while that gap remains, industry will continue to use and choose the technology embodied in its physical capital far less efficiently than is possible—frustrating the hopes and efforts of the economic policy makers.

But the sins of economic policy in this area have not only been sins of omission. In a variety of ways, implemented economic policy has frequently operated to reduce the likelihood that industrial firms will invest in developing and accumulating their own technologically creative human resources. These

aspects of economic policy include, for example, patterns of trade protection (not the existence of protection per se, but its structure, non-selectivity, and timing); associated measures for promoting industrial development which fragment industrial investment across a diversity of "disconnected" industries, and across a diversity of firms within them; and measures which act in effect as incentives to use capital inefficiently, rather than as pressures to engineer capital saving choices into investment projects and capital-saving changes into the subsequent operation of plants.

In the context of those sins of policy omission and commission, it has increasingly become only a secondary issue that government policy has commonly favoured the importation of technology, often by means of "turnkey projects" which only transfer technology already embodied in capital goods and in engineering and management services. Much more important is the combination of policy and non-policy which minimises the extent to which those imports of technology are complemented by active investment in the underlying "disembodied" technology and associated engineering and managerial expertise needed to absorb, assimilate and develop what is imported. But those capacities are also the resources needed to reproduce, improve upon and replace elements of previously imported technology. Hence, by the late 1980s, the limited accumulation of those indigenous technological capacities in industry has increasingly become the cause, rather than the effect, of continuing "technological dependence".

Conclusions

Timescales and expectations

I have suggested, at least implicitly, that the inherent timescales involved in building coherent structures of scientific and technological institutions in Africa are probably much longer than those which seem to have been incorporated in common expectations.

1. The experience of other societies suggests that creating effective new institutions may take decades, not years. That is particularly so when the focus is shifted from the building of individual institutions to the complex evolution of complementary components of the system which is required to achieve functional coherence, and hence effectiveness, in new and changing environments.
2. One also has to add the time required to "unbuild" and redesign imitative institutions which are ill-suited to the African context. And, in this respect, Africa has perhaps faced a greater problem than some other societies in the past. For example, Japan was able to abandon and redesign its initially imported agricultural research, education and extension institutions within a decade, without having to face the same complex of imitation-inducing pressures that have impinged on decision-making about the development of African institutions.

The problem of unrealistic timescales arises partly in an *ex post* sense—in relation to the expectations that are inevitably built into assessments of African experience over recent decades. The consequence, on the one hand, is to exaggerate disillusionment and frustration. On the other, it is to reinforce a

search for "instant" remedies for institutional problems, while diverting attention from the key issues involved in the complex process of evolving coherent institutional structures for African contexts.

But the problem about unrealistic timescales also arises in an *ex ante* sense. At the level of individual projects and programmes, and at the level of investment in scientific and technological activities in general, claims for resources have been accompanied by "promises" about future impact which have probably too often incorporated timescales that were unrealistically optimistic. They have therefore encouraged *ex post* assessments based on unrealistic expectations.

That problem is perhaps particularly acute with respect to more "basic" types of scientific research. In a host of areas, this type of research is needed to accumulate broad bases of knowledge and understanding before more "applied" research and development can contribute effectively to the solution of African problems. The temptation to offer over-optimistic promises in these areas is obvious and understandable. But the longer-term consequence may have been to reinforce misconceptions about the nature and role of these types of research, and perhaps to reduce future resource allocation to them.

Functional coherence

I have focused my comments heavily on this issue—suggesting that, after several decades during which institution building has concentrated primarily on individual components of the overall system, the problem of functional incoherence needs to be addressed more directly and head-on.

Action to address that issue needs to take a place on the agenda for action which has at least the same priority as issues about strengthening individual components of the system. But it is not simply an additional item on the agenda which can be treated as a separate problem alongside those concerned with strengthening individual components of the system. In a very practical way concerned with finance and resource allocation, the two sets of issues are inextricably interconnected. Officials responsible for resource allocation in national treasuries, budget bureaus, planning ministries (and donor agencies?) have become increasingly sceptical about the promises of "future impact" on economic development which have accompanied claims for resources for scientific research, applied research and development, and so forth. Rightly or wrongly, before increasing (or even maintaining) past levels of resource allocation, they want to see much more of the impact of past investment. Strengthening the functional coherence of the system, and hence increasing its demonstrable "impact", is therefore becoming a prerequisite for obtaining the resources needed to strengthen the component parts.

But that emphasis on functional coherence is not the same thing as another suggestion which one sometimes hears with particular reference to Africa: rather than increasing efforts to generate new knowledge and new technology, priority should now be given to strengthening institutions for diffusing and applying the ample stock of technology which is already available to make an "impact" on African development. On the contrary, my emphasis on the issue of functional coherence stems in large part from two views:

1. Technologies which are "ready made" for immediate and profitable application to improve on existing methods are not available for very many situations in Africa; and a more functionally coherent structure of institutions is required to generate the new knowledge and create the new systems that are needed.
2. Large parts of that creative activity can only take place effectively in the immediate contexts where technology is applied and used on farms and in firms. Consequently, even the concept of "diffusion" itself is unhelpful. It reinforces perceptions which separate the institutions and activities concerned with generating improved technology from those concerned with using it—perceptions which reflect very little of the reality of technical change in both agriculture and industry.

The second of those points helps to explain the orientation of my comments on the need for institutional innovation.

Institutional innovation

In emphasising the importance of innovative approaches to institutional development, I have focused on parts of the institutional structure which are close to the application and use of technology in production.

1. With respect to agriculture, new kinds of organisational arrangement, and new ways of managing those which exist, are needed in order to draw the technological capacities of farmers into the process of generating technical change.
2. With respect to industry, institution building should focus urgently on developing within industrial enterprises the technological capacities needed to generate and manage technical change—on building the technological intrastructure which seems to be almost totally absent in much of African industry. But that in turn will depend heavily on the development of imaginative new institutional arrangements for acquiring and accumulating the necessary knowledge and expertise.

These seem to be priority areas for action—although institutional innovation and redesign are necessary in other parts of the overall structure. This is partly because the effectiveness of other parts of the structure depends heavily on institutional development in these areas. It is also because of the huge costs of inaction and of continuing reliance on conventional arrangements.

In agriculture, for instance, the pressing needs to accelerate technical change, and the enormous costs of failing to meet them, require no elaboration. But the costs of trying to meet those needs through conventional types of institution are also enormous. For example:

1. It is almost inconceivable that resources can be found over the next decade and beyond to scale up conventional types of extension system to the extent that would be needed to "deliver" improved technology to more than a tiny fraction of Africa's farmers.
2. In any case, the necessary diversity of improved technology is not there to be delivered, and it is inconceivable that the formal agricultural

research system can be scaled up over the next decade to provide what is needed in the enormous heterogeneity and complexity of African agriculture.

In that context, it seems a matter of priority that national governments, international agencies, and bilateral donors should support, reinforce, and multiply the kinds of experiment that are already trying to break away from conventional organisational arrangements and to find ways of drawing African farmers much more effectively into the process of generating technical change in agriculture. After all, those farmers constitute by far the greatest part of Africa's agricultural technological capacity.

The experience of recent decades also indicates that the development of mineral, energy and manufacturing industries has typically imposed huge costs on Africa, while failing to generate the benefits that had been expected. Some observers have concluded that these high costs and limited benefits are inevitable—that they are inherent in industrialisation at this "stage" of overall development in Africa. It has therefore become fashionable to suggest that African countries should concentrate development efforts on their pressing rural, agricultural, and environmental problems, turning attention away from misguided concerns about developing industrial sectors.

I have suggested, however, that there is another interpretation of Africa's experience of industrialisation. The evident costs and unrealised expectations are not inherent in industrial expansion *per se*. Rather, they stem in large part from the very peculiar way in which industrial development has been undertaken—from the combination of myopic concentration on accumulating fixed (physical) capital, and the almost total failure to ensure that industries also accumulated their own stocks of technologically creative human capital. No "strategy" could have been better designed to ensure that, in the second half of the twentieth century, Africa's mining, energy, and manufacturing sectors would constitute an enormous burden on society. No combination of policies could have better ensured that capital would be allocated and used inefficiently, and that industrial "development" would be a graveyard for hopes about the income and employment to be generated both directly and indirectly.

That burden will not go away just because policy attention is turned to other things. Nor will those hopes be realised simply by foisting "structural adjustment" programmes on African industry. Those programmes may expose industry to the bracing forces of "rational" price structures and international competition, but they do less than nothing to strengthen the technological capacities of African industry. Yet it is those capacities that are required to respond effectively to changing markets and competitive pressures, and it is also those capacities that are required to enable industry to play its potential role as a positive complement to Africa's rural development efforts over the next decade and beyond.

In that context, lower priority than in the past should be given to investment in industry's physical capital, and that investment should be much more selective. Within the allocation of resources to research and development, it is probably also appropriate to give a lower priority to industrial research and development—especially to industrial research and development that is organised in institutions outside industry itself. But, as a matter of urgency, economic policy and technology policy for industry should give a very much

higher priority to the development of industry's engineering and related managerial resources for generating and managing technical change.

There are, however, few "ready-made" institutional and organisational models that Africa can copy in pursuing that reorientation of past policy. Although the experience of other societies can illuminate possible approaches and principles, organisational inventiveness and policy experimentation will almost certainly be needed to devise the particular arrangements that will "work" in African contexts.

Notes

(1) York (1985), for example reviews this period of American experience:

> Americans [had] depended on the mother country for technological information of all sorts. . . information on methods of business organisation and conduct as well as production techniques. . .they [had] wanted to make a basic technological transformation. . .[but] the great visions of manufacturing enthusiasts before the War of Independence. . .remained visions technological expressions of wishful thinking. . . .Although manufacturing enthusiasts avidly sought the latest technological data from abroad. . .they did not do everything in their power to stimulate invention and innovation at home. . .[and domestic] inventors experienced nothing but one disappointment after another regardless of the "utility" of their inventions. . . American manufacturing enthusiasts left the 1780s without havin g realized their ambitions. . ..Moreover, eagerness to adopt inventions that had proven themselves in Britain did not simultaneously bring an eagerness to adopt new unproven inventions made at home.
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> See also Jeremy (1981) for descriptions of the inability of Americans to assimilate imported technology effectively during the 1780s. In one case, for instance, a group of Philadelphians acquired in 1784 the components of an innovation (the spinning mule) which, along with others, had revolutionised the production of textiles in the more advanced British economy. Over four years the complexity of this technology defeated the capacity of locally available expertise even to assemble the components, let alone to operate the equipment efficiently or reproduce it locally. The components were shipped back to Britain, leaving the Philadelphians little wiser about this important step in technological development.

(2) Flint (1861, cited in Bates, 1965), for instance, assessed in the following terms the impact of the research carried out by the Agricultural Societies over the 2 or 3 decades following independence:

> . . .the prime movers in the formation of these societies were not men actually engaged in farming. . . and all the agricultural teachings of educated and scientific men prove[d] unavailing. . . Many years elapsed after these efforts were made, before the habit of reading became sufficiently common among the masses of

practical farmers to justify the expectations that any general benefit would arise from the annual publication of the transactions of these societies. . .they failed to excite any spirit of emulation in the public mind. The improvements proposed fell almost dead upon the people who rejected "book farming" as impertinent and useless. . .

(3) Miller (1970) summarises the address to the meeting made by Alexander Bache—later to be one of the first Regents of the Smithsonian Institution:

"What are the wants of science in the United States?", he began, "What conditions have produced the present situation?" Moulded of foreign ideas and domestic circumstances, American science had passed through several phases. Before the Industrial Revolution, science had shared a colonial status with other institutions. With few exceptions it had been derivative and utilitarian, subservient to the European Scientific Establishment. The American Revolution had ushered in a second period . . .[of growth in independent research]. . . Yet, Bache reminded the delegates, Americans had advan ed few original ideas in spite of their frantic activity. "Experiments made abroad were repeated here, and men acquired a reputation for mere repetition."

Bache attributed the meagre output of original scientific work to a want of solid institutional support, and to a widespread misconception of what the pursuit of science actually entailed. Because Americans tended to confuse research with teaching, discovery with dissemination, few colleges or universities made provision for faculty research. Because legislators lacked scientific understanding, they often bungled public appropriations which might otherwise have been turned to good account...To secure financial support for research, either within or outside the existing framework of higher education; to provide more and better scientific journals; to improve the general reputation of science and its practitioners: these were the needs of science in the United States. If they hoped to meet such needs, Bache declared, Americans must cease their fawning dependence on Europe and strike out on their own.

(4) One should bear in mind, however, that most examples of this institutional innovation were a dismal failure for a considerable time. If the fate of the early land grant colleges had depended on 3-year grants and evaluations by international aid donors, they might well have been wound up well within a decade. In the early years they attracted hardly any students. Faculty were few and often of poor quality. In any case, they had little to teach since a base of formalised knowledge about local farming was usually absent, and they had little advice to offer farmers that marked any significant improvement on what farmers had already worked out for themselves. But research to create that base of knowledge for teaching or diffusion to farmers was frequently fragmentary and of poor quality and, where funds for research were available, they were often siphoned off to support the general teaching budget. These conditions

persisted for many years—for instance, for more than 20 years after the establishment of the agricultural college of the University of Illinois (Fitzgerald, 1985).

(5) See, for example, Hayami (1975).

(6) Aspects of this phase of US experience are outlined, for example, in Noble (1979). See also Mowery (1982).

(7) Hayami (1975).

(8) However, it is important to stress that in the United States and Japan, for instance, formally organised institutions specialising in the provision of extension services were not developed in order to connect agricultural research and farmers. Except perhaps in the southern states of America, they emerged after other arrangements had already resulted in close interaction between the two.

This experience may have relevance for some discussions about the development of agricultural institutions in contemporary African countries. For example, it has sometimes been argued that the land grant college "trinity" of activities (interrelated but organisationally specialised teaching, research, and extension) is an inherent characteristic of any effective institutional system for supporting technical change in agriculture—in effect, an institutional analogue of the second law of thermodynamics. However, two points might be born in mind. First, the teaching (and later research) activities of the land grant colleges had been proceeding for about 50 years, and reasonably effectively for perhaps 30, before the Smith-Lever Act formalised and funded the extension component of the land grant college trinity. Second, a large part of the argument for that step in institutional evolution was about separating agricultural research and farmers, not about connecting them! Farmers were already so well connected with the colleges that their demands for advice and technical services had become a disruptive burden on the teaching and research activities. It was necessary to set up a specialised institutional arrangement to act as a barrier, not a link, between research and farming. Many African countries which have built that barrier between farmers and agricultural research into their institutional structures might envy the "problem" faced by the land grant colleges before they invented the extension system!

(9) It is well known, for example, that during the post war period Japanese industry complemented its enormous imports of technology with even larger investments in developing within enterprises the indigenous engineering and related capacities needed to assimilate what was imported. But this complementarity was a striking feature of Japanese experience at much earlier stages in the process of industrialisation. For example, Yukiko's ongoing D. Phil. research at SPRU illustrates that pattern in the early development of the Mitsubishi shipbuilding company between 1885 and 1930. The company developed its

technological capacity by drawing heavily on technology imports and by investment in indigenous knowledge and expertise. It organised its own technical training school, and built up its own problem-solving engineering capacity that evolved into an research and development capacity to improve upon and replace initially imported technology. All foreign engineers were replaced by about 1900, and by the 1920s its own research laboratory was generating about 100 technical reports per year on detailed aspects of the company's product and process technology. See Yukiko (1986) for preliminary results.

(10) For a review of current US experience, see Eurich, 1987.

(11) One can also draw contrasts with other contemporary developing countries. In some cases these comparisons involve atypical examples in other countries. For example, the experience of the Ajaouka steel plant in Nigeria differs sharply from the experience of the USIMINAS steel plant in Brazil where the company made substantial investments in developing its own engineering capacities to generate and manage technical change (Dahlman and Fonseca 1987). But the USIMINAS experience is not typical of Brazilian or other Latin American experience. In other cases, the comparisons involve more general experience in other developing countries. For example, a striking feature of postwar Korean experience has been the intensive investment in technological capacities within industrial enterprises (Enos and Park 1988).

(12) Mudenda's (1984) study of the copper mining industry in Zambia, for instance, indicates that, 15 years after nationalisation, virtually no progress had been made in developing a Zambian replacement for the former expatriate capacity for dealing with the creative engineering aspects of the industry's operations. Nor were the industry's programmes of human resource development oriented to achieve that objective as a matter of priority. But the study also highlights the strategic importance of those engineering and related capacities. When the industry was nationalised, the multinational corporations which had previously developed both research and development and project engineering activities within their Zambian enterprises did not withdraw the research and development from Zambia. They seem to have been more concerned with the strategic significance of their engineering design and project management capacities, and withdrew those to incorporate them under their direct control in the United Kingdom.

Nyangasi (1985) also provides rare evidence about the intracompany training of African engineers—in this case in a range of industries in Kenya (sugar, railways, cement, and metalworking). With a few exceptions, even the training provided for operating, maintaining and managing existing production systems was fragmentary and unrelated to specific tasks or skill-development programmes. Training that might have contributed to the development of capacities for improving and changing existing technologies, or for managing the selection and acquisition of technologies, was almost totally absent.

In the case of the railway industry, for example:

> [i]n respect of engineering skills. . .[concerned with]. . .equipment design and construction. . .we found little evidence to indicate that any assistance is given to the apprentice to learn this aspect of engineering skill. . .[and]. . .In respect of the engineering skills associated with the development of existing work methods we also found no evidence of any provision for such learning to occur. . .[consequently]. . .The apprentice is unlikely to develop and internalise the engineering method and approach to problems; namely, the perpetual search for improvement and innovation in products and processes. . .His exposure is only to the exploitation of known and tested techniques, and not to their review and development. . .This is in spite of rapid changes in technology that would demand innovative approaches to changing technical tasks.
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> In the cement industry, "The existing technical capacity is able only to operate and maintain existing plant. The capability to devise improvements through modification of deficient plant items is still not in place." A similar absence of capacities for "evaluating and redesigning processes" was evident in the metal working industry, where most of the enterprises studied "were found to have no training arrangements for graduate mechanical engineers."

(13) For example, in many African countries the growth of relatively large-scale textile manufacturing has been a significant component of industrial expansion. But a number of studies have indicated that, over two or three decades, the growth of the industry's production capacity has been accompanied by little or no growth in its technological capacity. In Tanzania, for instance, cotton textile production was identified as a "leading sector" for industrial development after independence. Investment in the industry was initiated in the mid-1960s and between 1968 and 1980 another eight investment projects were undertaken to set up new (larger) mills and to expand the capacity of existing ones. But, as Mlawa (1983) has indicated, investment in the industry's development over that whole period was limited to investment in fixed capital and in the types of human capital required only to carry out the most basic tasks of ongoing operation and lower-level supervision and management. There was no acquisition of higher-level expertise in management, let alone in areas like textile engineering, fibre technology, or textile chemistry. Action to set up a centre for developing and applying at least some of those kinds of expertise was not even started until 1982, almost 20 years after the initial investment in the industry's fixed capital. By the end of that 20-year period there still existed virtually no capacity to exercise any significant control over the technological evolution of such a central component of the country's economy.

Mytelka (1985) indicates the existence of a similar pattern in the case of the textile industry in the Cote d'Ivoire and (in less detail) in Nigeria. The consequences in both cases included (i) inefficient production, becoming increasingly inefficient in the case of Nigeria; (ii) the avoidable use of scarce resources of capital and

foreign exchange; and (iii) the industries' inability to respond to new market pressures and opportunities with alterations, improvements and adaptations in the technology used.

(14) What seems to be a common pattern is illustrated by the Kenyan experience examined by Juma (1986) in his comparison of projects to develop alcohol production in Southern Rhodesia/Zimbabwe and Kenya. In the case of the former, project planning and implementation was undertaken in ways that involved not only (i) selecting technology in the light of locally available plant fabrication and construction expertise, but also (ii) systematic training programmes to enhance those capacities, and (iii) the accumulation of increased engineering knowledge through intensive studies and evaluations. Subsequent operation of the plant involved a continuing stream of experiments and analyses to augment yet further the available knowledge about the technology, and to lay the basis for improvements, adaptations, and the absorption of knowledge about developments made elsewhere. In Kenya, on the other hand, there was no attempt to link project planning and implementation to the utilisation or development of local technological capacities. Training activities were limited to the development of skills for operating the production systems, with no strategy to enhance "deeper" levels of knowledge and engineering expertise relating to the technology: ". . .the management argue that they could not invest in longer-term training and accumulation of technological knowledge because their employees could easily leave them for other jobs. As a result, the training programme was designed to cater for medium-term operating requirements and not long-term plant level capability accumulation". (p. 268).

The study of Kenyan engineers by Bennell (1984) provides what are probably broader reflections of that pattern. In 1980, graduate engineers from the University of Nairobi who were employed in industry seem to have been engaged primarily as "managers-cum-technicians" in routine administrative, supervision, maintenance, repair and production activities which provide no opportunities to develop technologically creative engineering expertise. In-firm training has typically involved little or nothing to develop that type of knowledge and expertise (See also Nyangasi 1985, and note (12) above).

It was perhaps not surprising that, although several consultancy and engineering enterprises had developed in Kenya by 1980, these were almost all engaged in civil/structural engineering mainly for infrastructural projects. Engineering consultancy specialising in the design and implementation of industrial projects was virtually absent. That kind of engineering requires types of knowledge and expertise that are highly industry-specific. It involves product-specific and process-specific knowledge and expertise which can only be mastered by training and experience in particular industries—precisely the types of training and experience which seem to have been unavailable for Kenyan engineers. With the absence of efforts to develop those kinds of technologically creative capacities in industry, it is also not surprising that there were few links between industry and the University of Nairobi's faculty of engineering.

(15) Richards (1985) indicates the significant innovative capacity of African farmers. Drawing on a wider range of African experience and research, he also outlines some of the interesting experiments being undertaken to draw upon, and reinforce, that capacity (Richards 1986; Bell and Richards 1986).

(16) See Smillie (1986).

(17) De Bruijn and de Boer (1986) for example, examined the experience of 20 small-scale industry service centres in 10 developing countries, including Liberia, Cameroon, Nigeria, Togo, Ghana, and the Sudan. Their rather dismal "most important finding" was that "as far as it was possible to judge, there was almost everywhere the feeling that the results achieved by the centres were far below even the modest expectations".

(18) With reference to the textile industry in Kenya see Mytelka (1985) and Langdon (1984).

(19) For example, an authoritative recent review of national science and technology policy bodies in West African countries (UNESCO 1986) notes the inadequacy of financial resources allocated to "national science and technology", but then defines that as a problem about "expenditure on research and development".

(20) A diagram pertinent to this discussion can be found in UNESCO (1974)—the report on the 1974 Conference of Ministers of African Member States Responsible for the Application of Science and Technology to Development (CASTAFRICA).

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INSTITUTION BUILDING IN AFRICA: REFLECTIONS ON THE UNIVERSITY DEVELOPMENT PROGRAM OF THE ROCKEFELLER FOUNDATION

*David A. Court**

Rationale and principles

The University Development Program (UDP) of the Rockefeller Foundation was a twenty-year effort to support the evolution of one kind of institution—the modern university—in 12 different countries of the southern hemisphere. It involved the application of selected measures to support indigenisation, adaptation, and ultimately, internationalisation of this institution. It rested on a powerful premise—that knowledge is good for its own sake and that it is also the best means by which the well-being of mankind can be improved. It had the clear goal of assisting a small number of universities to become significant, valued and effective institutions in their own societies, performing the mission of all such institutions, i.e. producing scientific and technical talent, carrying out good quality research and training high level manpower.

Thirty years after this program was launched, and 5 years after it was concluded, it is appropriate to ask whether anything was learned from the experience that might guide us as we address ourselves to the challenges of institution building in the distinctive circumstances of the last decade of the twentieth century. A major study attempting to respond to this question was curtailed when its author, James Coleman, died. Those who knew Jim will not be surprised to learn that there was to be little place in his interpretation for the kind of prodigious personal effort that he or other individuals made assisting African universities. Instead, the single most important conclusion from what he had written is the paramount influence of context and timing. He emphasised the uniqueness of situations, historical epochs, cultural domains and political conditions, and the ultimate futility of seeking a recipe for creating institutions. Yet, the study is an account of institution building. Furthermore, there is a discernible historical accomplishment which is the product of a variety of factors—some arbitrary, unanticipated, and locale-specific, but others planned, intentional and, perhaps, generalisable.

The Rockefeller Foundation UDP was infused throughout by some powerful principles which were part of the long term philosophy of the Foundation. Fundamental was the view that advances in human welfare require the leadership and insight of highly trained minds. Coupled with this was a belief in the importance of institutions, and of university institutions in particular, as the necessary nurturing place for intellectual leaders. The Foundation perceived complementarity, rather than antagonism, between the furthering of individual excellence and the building of institutions and, where no institution existed, placed great faith in the ability of talented people to create them. This basic philosophy translated into a number of distinctive operating principles that guided the development of the UDP:

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1. Concentration upon a small number of universities—one or two in an entire continent—and, within universities, upon several areas of primary focus and a reluctance to allocate resources more widely.
2. Commitment to long term association with these universities in which the Foundation was often a partner in planning institutional innovation.
3. Central emphasis upon the identification and training of gifted individuals through the provision of scholarships and staff development grants for graduate study.
4. Provision of long term expatriate staff serving in professional roles prior to indigenisation.
5. Promoting a multi-disciplinary approach within selected areas of attention (health, agriculture, the social sciences).
6. Support for research as an integral part of teaching and for topics which focused on development concerns.

This paper draws upon a small segment of the Rockefeller Foundation experience to review the long term "robustness" of these core elements of the Rockefeller Foundation model. It offers some general comments about institution building within universities in Africa, from the standpoint of one external agency that was involved in the task. The Foundation was never alone in this enterprise and was frequently not even the main external contributor, but it can claim a close association with particular achievements and distinctive approaches in the universities where its efforts were concentrated. The reference points are the universities of Dar-es-Salaam and Nairobi, the National University of Zaïre, Ibadan University in Nigeria, and Makerere in Uganda. The point here will be to add some propositions to the stock which will be discussed and sifted at this meeting, and to identify some of the approaches, practices and emphases that seem to have been important in contributing to institutional development.

The final third of the paper moves beyond the historical experience of the Rockefeller Foundation to consider significant changes in the context of university development and pinpoint some of the issues which seem likely to dominate the agenda of institution building in the 1990s. This section focuses on the new challenges and on the opportunities for the kind of renewed collaborative effort which now seems urgently called for.

Concentration

Concentration upon particular universities, rather than a broader more diffuse programme in a variety of institutions, was a cardinal feature of the Rockefeller Foundation approach. It is instructive to look at some of the criteria used and their relative significance in the operation of the programme.

The role of leadership

The Rockefeller Foundation placed great importance upon the prospect of strong institutional leadership, believing it to be a prerequisite for academic excellence. The historical record shows that the Foundation sometimes placed too much reliance on particular university leaders, falling captive on several occasions to particular individuals and suffering the consequences, at other times, of neglecting the situational, culture-specific and country-specific factors

which condition and constrain the effectiveness of leadership anywhere. However, given the centrality of leadership in university development, its particular prominence in the social structures of the African continent and its congruence with the Foundation's mode of operation, reliance on individual leadership was a critically significant aspect of institution building.

Potential for innovation

The perceived potential of an institution for change was another criteria in the selection of co-operating institutions. The Foundation assumed that universities which had been recently created, such as the University of East Africa and the National University of Zaïre, would be predisposed towards new and imaginative structures and directions. In other places, such as Dar es Salaam, the absence of entrenched tradition was thought to be conducive to innovation. In practice, in many of the universities which were assisted by the Foundation, the presumed potential for innovation was never realised in face of such change-retarding factors as the power and resilience of dominant pre-existing academic traditions, entrenched vested interests, including some within the Foundation, and lack of resources amidst the pressure of expansion.

In the early days of the UDP local absorption of recurrent costs was seen as an important guarantee of local interest, and in many instances it occurred. However, as national economies came under pressure it became increasingly unrealistic and indeed harmful for every donor agency to have high expectations about the ability of an institution to absorb the recurrent costs implicit in its acceptance of external contributions.

Concentration within selected institutions

Not only did the Foundation concentrate upon selected universities but also upon particular disciplines and units within those universities—most notably agriculture, health and the social sciences. This kind of concentration had at least two advantages. First, because of the limitations of Foundation resources in relation to the enormity of the need, concentration made possible a definable impact. Secondly it reduced the risk of creating exaggerated expectations and resulting resentment over non-fufillment in areas where only modest resources could be placed. A further advantage was that it made possible close professional collaboration between Rockefeller Foundation staff and university faculty and officials in the development of programmes. The main disadvantage was that concentration involved exclusion, on the one hand, and preferential treatment on the other, and generated feelings of deprivation among those not favoured. There were also situations where the areas of external concentration were not congruent with the priority needs of the university itself or the prevailing power structure.

The potential for complementary external and local funding

The task of assisting universities and the scale of the UDP made it essential that there be multiple sources of support. Because in Africa working with universities was for the Foundation an exclusive, as well as long term, commitment it was able to play a catalytic and entrepreneurial role in raising

funds, as well as providing intellectual leadership in the university support programmes of other donors.

Potential for regional concentration

Part of the rationale for selectivity and concentration was the expectation that the universities would each develop centres of excellence serving a regional clientele, thereby avoiding expensive duplication of facilities. However, regional programmes did not develop to the extent, or at the pace, originally anticipated due to the desire of individual countries and universities to possess their own programmes. Although there are now some significant examples of university-based programmes serving a regional clientele, nationalism was, and still is, a crucial determinant of university development, overriding what might have appeared to be more "rational" economies of scale.

It was also expected that the network of Rockefeller Foundation-supported universities around the world would place the Foundation in a particularly favourable position to sponsor inter-university exchange programmes, enabling universities to share experience and benefit from one another's comparative advantage. In particular it was hoped that, to the extent that university development is a linear process, universities at an early stage of growth could take advantage of graduate programmes at more advanced Third World institutions which might offer more relevant training than equivalent programmes in the United States or Europe. However the stated desire by the universities for professional and training exchange programmes within the African continent and the Third World, has been little followed in practice. There were some exchanges between the East African universities and Ibadan, and the National University of Zaïre but these were modest and spasmodic. Overall, universities have tended first to follow the established paths leading to American and European institutions. Nevertheless, although these paths are still well trodden, other paths are developing under the aegis for example of the Inter-University Council of Eastern and Southern Africa and the African Academy of Sciences. The Foundation itself is supporting a variety of professional exchanges under a "south-to-south" rubric. These regional programmes now have the challenge of developing an excellence which will become their own self advertisement.

Long term commitment

The long term commitment of funds has always been one of the distinctive features of the technical assistance programme of the Rockefeller Foundation. In this case, the original expectation was a programme of between 15–20 years. The ability to declare a long term commitment made it possible for the timetable of the UDP to relate to the rhythms of university development and, hence, helped to reduce the likelihood of premature or inappropriate action. The staffing model was that of a small core staff providing administrative continuity over time to the visiting faculty. This type of presence and long term commitment furnished a means for responding sensitivity to the different levels and types of need associated with different stages of institution building, and increased the likelihood of contributions that corresponded to the state of absorptive capacity of the institution.

Timing and absorptive capacity

Between 1963 and 1983, the universities grew in stages—a founding, an expanding, and a consolidating phase—with different kinds of support required at different times. The phases were not exclusively defined by the numerical process of Africanisation although this was a basic objective. For example some innovations which were rejected at one time—elective deanships, rotating department chairmen and cross-disciplinary registration—were adopted later on. In the first years of the universities, expatriate administrative leadership was sought by university authorities. This role was neither possible nor desirable for later generations of visiting faculty. On the other hand certain kinds of external contribution were not possible until several generations of African staff had established themselves. An example here was the establishment of postgraduate programmes. At the same time, levels of depth in local staffing were necessary before visiting professors could be viewed less as threatening intruders and more as peers in new and equitable kinds of working association.

Flexible forms of support

Flexibility is a by-product of a long term commitment. A project with a short and bounded period for the achievement of its purpose cannot afford the luxury of experimentation. The quality most welcomed by university partners in the UDP was the Foundation's capacity to provide support quickly, where, when and in the form required, and to adapt to changing conditions and priorities. Many of the innovations depended on the Foundation's ability to learn from experience. Because the Foundation had a wide range of available means of providing funds—different kinds of fellowships, research grants and professional provision—it was possible to offer varied, but mutually reinforcing, types of support at a single time or to emphasise one approach at a particular state of institutional development. For example the Rockefeller Foundation supported graduate programs depended upon the complementarities of basic grant support, the presence of key visiting faculty members and the incentive of Ph. D. Fellowships for those who performed well.

Concluding the commitment

A long term commitment is not synonymous with an unbounded association. University development, by definition, involves the growth of institutional autonomy and the reduction of external influence. The issue is one of timing in deciding the point at which the activity and financial responsibility for it should be devolved to the institution.

The UDP did not end with the elegant panache of the ICIPE Foundation's seminar but rather abruptly and unexpectedly. It had much to do with internal considerations in the New York office and little to do with the state of African universities. Indeed closure came in the face of a Board recommendation to continue and preceded any formative evaluation. However, the reasons for its closure had to do with the fact that it had run out of steam. The long term commitment and original vision could not reproduce itself. Twenty years after its inauguration, officers seemed surprised by its success and undecided on

new directions. The point is simply that long term commitment is a *sine qua non* of institution building but it needs to incorporate mechanisms of rejuvenation and criteria for deciding when original purposes have been reached and, ultimately, the point at which a programme should be concluded or revised.

Mechanisms of institutional staff development

Given the long standing Foundation commitment to training and its abiding conviction that it is individuals with capacity for leadership who build institutions, it was natural that the education and training of African scholars for professional positions was the paramount device of institution building. The objective was to assist the universities towards a state of self-reliance, by providing resources which enabled them to increase the number of local scholars on their permanent staff and upgrade the professional qualifications of those already on the staff. This was done principally through the provision of Ph. D. fellowships and staff development grants. The key elements in this aspect of institution building were: the availability of different modes of furthering staff development; the careful identification and selection of outstanding students from undergraduate and Master's programmes; the allocation of these students to first class universities overseas and the practice of monitoring to keep in close touch with students' academic progress and of serving as an intermediary between the home institution and overseas university. Particular care was taken to minimise the de-racinating effect of protracted study overseas by selecting institutions which had at least some faculty who were familiar with Africa, and by encouraging field work in the home, or another, country at the dissertation stage of the degree. The point of this was to promote research on a topic of national relevance and to facilitate re-integration with the home institution once the degree course was complete.

The extent of achievement in this part of the programme can be gauged from the uniformly high initial return rate for fellows and the distinguished contributions which they have made since their return. Detailed analyses of the career paths of former Rockefeller Foundation Fellows are available. Suffice it to say here that they continue to dominate the academic leadership of the departments with which the Foundation was associated and, on a wider stage, have provided the intellectual capital upon which a rich variety of other programmes, activities and organisations have been built in the public, non-government and private sectors.

Internationalism

As a private organisation, the Foundation could avoid the kind of bureaucratic inertia which often besets programmes dependent upon government-to-government relationships and could exemplify an internationalism which was important for the effectiveness of its programmes and the stability of the institutions being supported. In contrast to many other agencies the Foundation was able to send Fellows for training to institutions in a range of different countries as well as recruit academic staff from many different nations. This gave a variety and depth to what the Foundation was able to offer in training and reduced the risk for the recipient institutions of any semblance of dependence upon a single external source of support or tradition of training.

Attrition and the provision of career incentives

Despite the preponderance of former Fellows who have returned and remained in academic positions, there has been an accelerated attrition from the universities towards positions in government, international agencies and business, especially for senior staff and those whose acquired skills are in high demand outside, as well as inside, the university. Questions about attrition concern the extent to which it has retarded institutional development and whether anything could have been done to reduce it. The Foundation's fellowship programme was geared to departmental and university programmes of staff development, and attrition—because it involved the loss of a senior cohort—made it difficult for some departments to reach a point of self-sustaining growth. It is doubtful that the Foundation could have independently done more than it did to encourage fellows back to their home institution in the first place, except, perhaps, by insisting that fellowship funds be treated as loan support, to be repaid if a prescribed minimum period of university service did not follow the completion of the degree.

However, once Fellows had returned, much more needed to be done, by the universities and the Foundation, to reduce attrition through the development of career structures and professional incentives for scholars and scientists. To the extent that attrition was a consequence of uncompetitive salary levels its reduction would have required flexibility on the part of the universities. Such changes as permitting differential salary structures between departments would have provided preferential inducements to understaffed areas, as would have contracts allowing part time teaching. An external agency can do little in this area. The Foundation's brief experimentation in providing salary supplementation produced consensus that it was an undesirable and unsustainable mechanism for an outside body.

However, more important than emoluments for the preservation of the scientific community would have been measures which solidified scientific and scholarly careers. A major reason for attrition was the poor state of university infrastructure compared to the place of original overseas study. In a survey of all former Rockefeller Foundation Fellows, 60 percent cited this as a major problem which had hindered their readjustment to professional work at home and reduced their motivation to remain. The specific things referred to included: the lack, or poor maintenance, of scientific equipment, the degradation of libraries and the absence of funds for basic research, post doctoral training and journal subscriptions. In the early part of the UDP the Rockefeller Foundation did provide support for these things but then concluded, erroneously, that they could be left to government provision. Thus, the Foundation did not make any special provision for its Fellows once they had returned to a university teaching position. Part of the reason was the desire to avoid exacerbating invidious distinctions between those who had received Rockefeller Foundation support and those who had not. With the benefit of hindsight, it is clear that the Foundation underestimated the magnitude of the effort required to sustain scholarly careers and the undermining effect of the absence of those incentives which, in other places, help to sustain scientific careers and a scholarly community.

The dilemma of institutional versus individual fellowships

A recurrent debate within the Foundation centred on whether the paramount criterion in the selection of Foundation fellows should be the needs of the institution or the incontestable quality and potential of the individual. Institution building has its own overpowering rationale: institutions require a concentration of trained staff; the best chance of getting individuals who will return to form such a concentration is to select trainees from the institution itself; to do this however is to reduce the pool of talent from which fellowship candidates can be recruited. There can be no question that the UDP focus upon institution building, rather than individual exceptionality and giftedness, affected the overall quality of fellows. There was also pressure to get candidates quickly into the pipeline in order to accelerate the process of indigenisation. The result was lower overall quality than in a programme of unbounded and unpressured recruitment of the most truly exceptional candidates wherever and whenever they could be found.

The arguments in favour of this latter approach are that no external agency can insist that an individual returns to his sponsoring institution and that the high cost of fellowships for overseas study requires that they be concentrated upon those best able to make use of them, whatever their institutional affiliation. There will inevitably be a free market in trained talent and outstanding individuals will move to where they can best exercise their talent, if need be by creating new institutions, and in the long run there is a non predictable aspect of institution building which has to be allowed to run its course. An example here is the highly successful macroeconomic research network, funded initially by the IDRC and now by a consortium. It rests upon the talents of former Rockefeller Foundation fellows, but was certainly not predictable at the time that the Fellowship Program of the Foundation was launched. It illustrates the point that institutions evolve and may serve originally-intended functions—in this case the acquisition and application of knowledge—in forms which were neither predictable nor even recognisable when the original institution building effort began.

Visiting staff as sources of innovation

A basic device in the institution building approach of the Rockefeller Foundation was the provision, at the request of the universities, of professional scholars and scientists to occupy line, and sometimes authority, positions. Their role was to provide interim leadership in teaching and research pending the return of the universities' own staff development candidates. Because they lived long enough in the region to gain some cultural understanding and were usually equipped with a professional competence that inspired collegial credibility, these visiting faculty were able to acquire a level of familiarity with the academic context which increased the likelihood of productive role. The most effective helped departments to re-organise curricula and degree structures and to incorporate research and field experience into undergraduate training. At a more general level, they posed alternative ideas and procedures to those which they found. They exemplified and encouraged basic international norms of scholarship, colleagueship and academic self governance and academic freedom during the formative stages of university development.

The two main issues surrounding the role of visiting faculty concern the relative effectiveness of different types of staffing arrangement and the question of the profile of qualities that made for effective performance. Both these factors were governed by the stage of growth of the institution.

The relative effectiveness of different staffing arrangements

The Foundation used three main methods in recruiting faculty on behalf of African universities: long term Foundation field staff, visiting faculty on two or one year secondment from their home university, and, grants to the universities for direct recruitment.

The most distinctive aspect of the Foundation's staffing contribution was the location in the universities of its own long term field staff. Field staff were critical to the effectiveness of the UDP in several distinct ways. In the early years they contributed vital academic and administrative leadership from their positions as Deans, Department Chairmen and Research Directors. Secondly, the long term nature of their appointment enabled them to embody continuity which was especially important in the early stages of university development when staff turnover was high. Thirdly, where they held representational responsibilities for the Foundation, they provided a link between the university and the New York office of the Foundation. Their familiarity with university needs and the day-to-day requirements and subtleties of the local context made it possible to base programmes on a degree of understanding of local conditions which could not have been attained from the distance of New York, or even from a Foundation office in a downtown high rise. From a historical perspective the opportunity for the Foundation Representative to "protect his hunches"—to sustain resources for temperamental individuals and volatile departments or research units—probably accounted for some of the most useful contributions that the Foundation made.

The main method of staff provision was the recruitment of individuals on secondment from selected universities in North America and Britain. This mechanism had several inherent advantages. Individuals recruited in this way came from some of the outstanding universities in the world and included men of great eminence in their professions. The best of them, helped departments develop a sense of participation in international scholarship and temporarily saved them from a degree of isolation and inbreeding. Some made a tangible contribution, through the production of teaching materials, and most exemplified standards of scholarship and commitment in their teaching and research roles which had important demonstration effects. Many developed relationships with departments and individual scholars and students which turned into important institutional links for later study programmes and research exchanges.

The Foundation also made provision for direct recruitment of expatriate staff by the universities themselves. This third type of arrangement also had several advantages. In the first place, because those recruited were individuals specifically sought by the universities they tended to feel a sense of responsibility for these individuals. Secondly, this method was relatively inexpensive, as it was frequently possible for the Foundation simply to contribute the salary supplementation necessary to facilitate recruitment. Thirdly, the mechanism resulted in recruitment of staff of diverse nationalities which was an important strength to the university through the infection of

different kinds of experience. Finally, because staff recruited through this method did not always have a home university base, they were able to work for longer than those seconded from elsewhere, and hence to build up local experience and expertise.

Effective styles of expatriate contribution

In the 1960s when universities were being built, the important objective of national governments was to create a core of African leadership to help establish the university and legitimise it. In this phase, the needs and conditions for expatriate academic and administrative leadership existed. Once university leadership had established itself, the administrative capacities of the visiting staff members became less important than their ability to teach and do research. Fundamental to their contribution was an ability to relate professional skills to the requirements of an unfamiliar environment and to develop personal research and training interests within the framework of locally perceived priorities.

The pattern of Rockefeller Foundation support for visiting faculty members during the UDP followed the two phases mentioned earlier, moving from small scale and highly selective leadership support, in the first institution-founding phase, to larger scale and quickly declining support in the second phase. Retrospectively, a more modest but more steady input over a more protracted period would have been more congruent with the requirements of the glacial process of institutionalisation. Having in one period saddled the University of Nairobi with six distinguished North American professors of Economics, including a future Nobel Prize winner and the author of the second most used text book in the USA, the Foundation had some painful experience on the issue of matching expatriate resources to the capacity of departments to absorb them. The lessons to be drawn are the need for a hypersensitivity to overpresence and to the fact that the high concentration of resources over a short period of time can result in a "too much, too soon" syndrome. The opposite situation—not enough when they are needed—was also part of the Rockefeller Foundation experience.

The two phases of institution building were followed by a third where the universities had become numerically self sufficient in their staffing. The characteristic of this phase was the emergence of a second generation of young scholars and scientists, often former Rockefeller Foundation Fellows, who had the self-confidence to recognise the limitations as well as the strengths of their own departments and were anxious to recruit a senior scholar into their midst. Unfortunately, this phase occurred at the very time that the Foundation and most other agencies were concluding that support for visiting faculty was no longer desirable. The general implication to be drawn from this is the fact that an evolutionary perspective is required, in which institutional staff development is not necessarily best conceived in the purely linear and numerical terms of localisation but needs to take account of qualitative factors.

Research and interdisciples

It seems likely that the Rockefeller Foundation's most important contribution to higher education on the continent will be seen to have been the encouragement of research and the dispersion of a research ethos. Certainly,

the twenty-year period since 1963 has witnessed the expansion of research in Africa, its emergence as a valued activity of government and the development of the institutional frameworks for fostering it, both in university faculties and in applied research institutes.

While the Foundation can claim some credit for contributing to the expansion and legitimisation of research, it was much less successful in translating its powerful rhetorical commitment to interdisciplinary approaches into practical expression. There was some success, most notably in the creation and development of several social science research institutes particularly in East Africa. In face of the inherited view that research should be either rooted in departmentally based disciplines or located in government planning units, these institutes embodied an alternative ideal. That ideal was the concept of a multidisciplinary social science research capability that would be applied to problems of national importance and would be separate from the day to day pressures of government decision-making, on the one hand, and those of university teaching and administration on the other. The road to institutionalisation of these university-based research units was a rocky one, with progress influenced by idiosyncratic factors of context and personnel—such as the attitude of a particular vice-chancellor or the qualities of a director—as well as by the systemic factors affecting any institution which attempts to straddle university and government functions. However, they have survived and been fully incorporated into university establishments, have attracted as much external funding as they could handle, have been emulated in the creation of analogous institutions, and above all, have demonstrated the possibility of a multi-disciplinary approach and the contribution which can be made by the application of intellectual resources from the university to problems of national importance. One reason for their survival was the devotion of professional commitment and personal energy to them, by the then Foundation representative Jim Coleman, along with substantial human and financial resources over a long period. Another critical factor was the support of the universities, derived from the inherent logic of national conditions in which multi-faceted social problems required multi-disciplinary attention.

The great weakness of these institutes was that they were never able to transcend their origins in the social sciences. Thus, while the Foundation can point to programmes of research and teaching that have linked different social science disciplines, corresponding links between different areas of Rockefeller Foundation activity in agriculture, health and the social sciences did not occur. By virtue of its multi-disciplinary organisational structure, the Rockefeller Foundation ought to have been well placed to encourage genuinely integrated activities.

There were several reasons for this lack of integration. In Africa the disciplines themselves had not developed at the same pace and it was difficult to have multi-disciplinary work without a level of parity among social science fields in their size and levels of research activity. In the second place, certainly in the Foundation and to some extent within the universities, agricultural and health scientists were not convinced that they had anything to learn from social science. Social scientists, on the other hand, had not worked out how they could make useful contributions to research and training in the applied sciences in ways that were plausible to their scientific colleagues. Within the Foundation itself there was a tradition of professionalism and specialisation

which reinforced disciplinary approaches and deterred much serious effort at joint activity.

Today there is a heightened recognition of the importance of the physical and social sciences combining their talents in the application of science and technology to the alleviation of human problems. Working this out and finding appropriate institutional forms are not easy tasks. To the extent that the problem centres on the application of a scientific package, the locus of collaboration is likely to be the scientific research institute rather than a social science department or research unit. The new Science Based Development programme of the Rockefeller Foundation, the Social Science Interface Programme of ICIPE and the interdisciplinary activities of the African Academy of Sciences are among the auguries for a new and productive era of collaboration.

The development university: pursuit of a chimera

The Rockefeller Foundation had always conceived of its support for universities as a two-part process. The process of university development—the achievement of institutional autonomy, capacity and maturity—was to lead into a phase where capacity was to be applied in the services of national development. The Foundation view of how this was to happen went little beyond broad notions of the importance of local relevance and the need to depart from the perceived impracticality of the inherited metropolitan models. The basic belief was that the critical task was delivery—increasing the arsenal of skills and knowledge—and that the task of application for developmental purposes would follow automatically.

In the early period replacing expatriates by African scientists was by definition "developmental". At a later stage helping to root teaching and research in local needs and problems became an important criterion of relevance. However, in the late 1970s a much more extensive concept of what universities should be doing gained credence among universities and donor agencies alike. This view stressed the need for universities to solve national problems and serve national policies in direct, immediate and practical ways. Universities now found themselves with responsibility for such things as increasing food production, addressing themselves to the poverty of rural populations, advising governments on house construction, as well as social engineering to improve ethnic balance and national integration. The new touchstones of university quality were its vocational and service contribution and its political commitment. The University of Dar-es-Salaam in Tanzania went further than most in trying to re-order itself to reflect the new mandate, through such things as emphasis on manpower planning, down-grading of examinations, new quota-based admission policies, vocationalisation of courses, the practice of national service, compulsory work experience and the introduction of non-academic criteria for staff promotion. There was a certain heady novelty and appeal in the boldness of these moves, but they certainly had serious implications for the academic quality of its research and instructional programmes.

The Rockefeller Foundation, keeping in tune with the spirit of the time, changed the title of its programme from University Development to Education For Development (EFD). This was intended to symbolise its concern with contribution to development as the measure of a university's maturity and

adaptation. However, the new kind of purpose proved less easy to apply than the first phase of institutional development, partly because the concept of a development university was itself a highly ambitious and underdeveloped one.

Universities have proved limited in their ability to devise new models of developmental institutions. Few of the programmes which were conceived with an exclusively "developmental" purpose in mind have yet unequivocally demonstrated their relevance to development, however, the latter is defined. This was partly due to their necessary preoccupation with the first phase of institution building, but also because some of the tasks which they were called upon to perform were more appropriate to other types of institution.

The emphasis upon service to the surrounding community, which was part of the new idea, created the impression that the most important activities of staff and students were what they did outside the institution. Clearly it is essential that what happens inside a university is infused by awareness of conditions and priorities outside, and preparation for life in society is not aided by distance from it during undergraduate years. However, at the same time the idea that the important contribution of the university occurs outside its walls had some damaging consequences. It led to a stress on consultancy activities—which, while useful as individual tasks tended to distract their practitioners from teaching and to dilute their contribution to the intellectual life of the universities. In a commercialised context such as Kenya, it required only a slight extension of this service concept for the economic activities of some staff to acquire more importance than their teaching contribution.

A fallacy of egalitarianism was also clearly associated with the developmental touchstone of university activity. Underlying the stress on vocationalism, national service, broader admission procedures, political education and so forth was the idea of reducing the privileged position of universities and treating them like other educational institutions. However, the effect may have been to reduce the universities' comparative advantage. Universities in most places—and certainly the kind that have developed in Africa—are able to provide some kinds of education but not others. They offer students access to facilities and experiences—books, libraries, stimulating staff and colleagues—which they will never have again. The uniqueness of the facilities is that they provide an opportunity for the development of knowledge and for analysis of the complexities of the development process on a national scale. Unlike most other training institutions, universities permit a large measure of reflection and exist for the production of knowledge, the encouragement of original thought and the exercise of imagination.

The developmental contribution of universities in Africa resides not in their precise impact upon particular material goals, but in the successful accomplishment of the things which universities alone are capable of offering including the creation of knowledge, understanding and intellectual integrity. In this sense the university is as much a measure of development as a vehicle for it. The things that the universities have shown that they can do well are teaching and research. The measure of their success lies less in a cost-benefit analysis of their effectiveness in extension projects than in an assessment of the quality of the intellectual life which they provide for their transient students. The important issues for the 1990s concern whether the balance of environmental factions will sustain and reinforce this quality or threaten and extinguish it.

For the Foundation this part of the history was very salutary. It is enormously difficult and frequently undesirable for an external agency to persuade other institutions to do something. In the case of the universities the significant contribution of the Rockefeller Foundation was its assistance to training and research. The contribution to policy came through its support for intellectual engagement and the quality of understanding, analysis and ideas which the universities were able to generate. The Foundation's switch to the title EFD was a symbolic proclamation of a desired direction but little more. It had little conceptual substance. It was not believed in by most Foundation officers and not understood by anyone else. It was dangerous because it implied a more far-reaching role for universities in economic and social transformation than was feasible or desirable and one that is not required of universities in the industrialised world. Titles and their images are important, for conveying comprehension of externally-assisted programmes of institution building to the relevant constituency. However, to be credible and comprehensible there has to be a philosophy and a programme behind the label. With its turn to the chimera of EFD and the "development university" the Rockefeller Foundation departed from the powerful premises which had inspired and sustained the UDP and in fact signalled its demise.

The new context of institution building

The immediate need to which the Rockefeller Foundation responded 25 years ago was a massive shortage of highly-trained individuals and the absence of institutions that could provide them. The achievement since then, through the assistance of the Foundation and numerous others, has been impressive. It is evident in expanded enrolments, the indigenisation of academic and administrative staff, the promotion of curriculum and organisational reforms, and the creation of new universities, to mention only part of the record. Yet, despite this achievement, it is unclear whether the capacity and conditions are sufficient for the task of accelerating the reproduction and sustenance of scientists and scholars to the extent required if they are to be major actors on the continent and have a significant voice in the international science community.

The basic approach of the Foundation was to support the training of scientific talent, to encourage it back into the universities and to assume that these exceptional individuals would have the means, the inclination and the environment to pursue their *métier* in a manner which was compounding in its scope and developmental in its impact. Some of the necessary structures and conditions have come into being. However, a second generation set of problems afflicts the ability of scholars and scientists to do what they want and were trained to do. The UDP was important in its era. It is now clear with the emergence of new circumstances that it was a necessary but not sufficient condition for the maintenance of high quality science and scholarship.

The erosion of quality

The basic problem facing university systems throughout the continent is that of maintaining quality in the face of expanding numbers and financial constraints. The widely-heard assertions about the decline of universities on the continent are difficult to substantiate empirically. They also tend to be

based on a nostalgia for some earlier golden era, whose standards and styles may no longer be relevant to present needs, or to refer to the extreme cases of decline such as the National University of Zaïre, Legon in Ghana or Makerere University, all of which have suffered substantially with the general disruption of their national economies. Actually, such pessimistic generalisations tend to ignore the immense variations between universities and, within universities, between departments, faculties and research units.

However, as a factor in the context of collaboration, the overall quality of higher education on the continent does not give grounds for complacency. The elements that threaten decline are already evident, in the shape of expanding numbers, unaccompanied by an increase in local and external resources and substantial cost-saving measures. The symptoms of a downward direction are evident staff attrition, reduced numbers and vitality of seminars, a lower volume of research, the inroads of consultancies on teaching, the number of parents of able students who choose to send them overseas, and so forth. At the same time, the state of buildings and equipment provide a symbolic, and sometimes a real, indicator of quality. We do not need to look beyond Makerere University to see a dramatic picture of how declining quality in materials, facilities, infrastructure and maintenance can affect institutional development.

Donor disenchantment

In the late 1970s, many agencies, including the Rockefeller Foundation, became disillusioned with universities. Disenchantment was associated with student turmoil and university closures, concerns about financial accountability, and a change in the conventional wisdom worldwide which began to emphasise the importance of primary and basic—as compared to university—education. This tendency was accentuated by the media presentations of an Africa in "crisis", which dramatised famine, debt and population pressures placing a premium on issues of basic survival and direct improvement in human welfare, rather than the apparent luxury of higher education. The result was an increasing tendency for agencies to move away from the institution building support of the earlier era—scholarships, curriculum development, equipment and teachers—and move towards university-based projects related to food, nutrition, energy, water and population—which seemed to promise direct practical impact on peoples' lives. Some of this change of style and direction was in tune with domestic sentiment, which wanted universities to be more involved in the task of development, and stressed their vocational and technical roles.

This shift has had two serious consequences for institution building. First, the decline in the numbers of staff development fellowships for Ph. D. study has made it difficult for the increased numbers of universities to replenish staff and maintain quality. Second, reliance on a project or fellowship mode for research emphasised the relationship between an agency and an individual and correspondingly tended to inhibit the ability of university departments to establish their own priorities and mount their own research programmes. As a result, the research programmes of university institutes and departments have often become little more than an amalgam of the individual projects being conducted by staff, most of which are based on contracts with government or

international agencies. The trend is disconcerting because the autonomous development of research capacity is a central element of institution building.

Technological change

In this context there has been limited progress towards self sufficient autonomous scientific capacity building within the continent. Yet at the same time the decade has witnessed the availability of new vaccines, genetically engineered crop varieties, new types of fertilisers and medical drugs and new forms of information processing all with vast implications for the quality of life in the continent. Yet, these technologies are being developed and applied with limited participation by, or reference to, the region's scientists and scholars, raising the spectre of a fundamental and enduring technological dependency of Africa upon the outside world. This dependency is inimical to sustained development and to the continent's ability to take charge of the process of its own destiny.

Challenges and opportunities in tertiary level institution building

The resulting need is clear. It is for renewed efforts to support the creation and sustenance of national and regional intellectual and scientific communities, that can play a central part in the application and development of types of science and technology, which are relevant to the continent's needs and draw on its resources and knowledge. It seems likely that this task will need to be addressed in three areas within universities in other tertiary level research and training institutions and in the education system that precedes university. The important conclusion from our historical analysis is that universities, as presently organised, are no longer the optimum institutions for providing the quality of education that is needed to produce this next generation of first class scientists and scholars. University-based scientists find themselves swamped with the teaching task, deprived of opportunities and resources for research, and lacking a clear incentive and career structure that can stimulate and sustain them as scientists and scholars. The productive life of a university-based scientist may be no more than five years. At present much of the best scientific research is being done outside the universities, in national and international research centres and commodity-based laboratories. This may well be the wave of the future as universities increasingly confine themselves to providing a consumer orientation to science and scholarship. This is not a trivial role, but if such a retreat occurs, and to some extent it already has, the task of providing specialised training for future working scientists will perforce have to rest upon other institutions and new types of arrangement.

In a context characterised by tight financial resources, expanding student enrollments, donor disenchantment and rapid technological change, universities are faced with a need to redefine what they see their unique role and contribution to be. Some aspects of this redefinition are suitable areas for collaboration. Others are best dealt with by the universities themselves. It is salutary to remind ourselves that the three features of the context which most influence university development—the state of national economies, the supportiveness of the political environment and the rate of increase of the secondary school population—are hardly amenable to measures involving

external collaboration. Nevertheless, where government economic and social policies are relatively supportive, there are a number of areas where external collaboration can strengthen the process of institution building within universities in the career structure beyond them, and in the preparation before them:

1. *Innovative forms of graduate training.* As long as universities and research institutes in Africa continue to require a Ph. D. as the main qualification for professional staff, external assistance to make this possible is a high priority. In recent years, donors have cut back on the provision of full scale support for overseas Ph. D. training on the grounds of expense—the full cost of a Ph. D. in the United States now exceeds $100,000—in so doing, have undoubtedly slowed institutional development on the continent. There is probably no more important subject for collaborative attention than the ways and means of providing high quality postgraduate training. The need is not necessarily best met by fullscale financial provision of overseas study. Various forms are possible including support for sandwich or split-site schemes, dissertation support and the development of degree-granting capability among institutions on the continent.
2. *Opportunities for women scholars.* Part of this effort should certainly focus upon expanding opportunities for women as students and teachers. As long as the proportion of women in African universities is less than 50 percent (as it is in all countries) the continent is under-utilising a corresponding proportion of its available human talent. Righting this imbalance, in the sex composition of tertiary institutions, is not principally a matter of positive discrimination through entry quotas, but is better done through the extension of facilities for girls' education at the secondary level. It has to be admitted that the issue of women in universities and research institutes is of more evident interest to external agencies than to the institutions themselves, for familiar political and social reasons. Yet there seems no intrinsic reason why the continent should continue to disadvantage itself through the exclusion of women. Certainly the building of high quality institutions will benefit from more deliberate and sustained attention to the promotion of women as scholars and scientists than has prevailed in the past.
3. *Strengthening infrastructure.* The earlier discussion of the Rockefeller Foundation experience made the point that a pre-requisite for the preservation of university quality is sustained support for basic necessities such as equipment, books, journal subscriptions, paper and laboratory chemicals. There has been talk for twenty years about the establishment of university presses in Africa, and some progress has been made at individual universities, but we have yet to see a university press which serves the continent in the way that it needs to be served. This is presumably because of the lack of the necessary sustained collaboration to ensure the right equipment, the in-depth training, the assurance of spare parts, the permanence of technical expertise and so forth. With the emergence of desktop publishing there may be a technical solution to this need and certainly there is scope of collaboration. However, the point here is not about publishing *per se* but rather is to emphasise the importance of support for the ordinary, the simple and the

glamourless in co-operative endeavours to enhance institutional development.

4. *Strengthening links between universities in Africa.* The UDP was not very successful in its efforts to encourage regional and continental linkages. But times and the spirit have changed to make a more propitious environment for continental co-operation in institution building among universities and between other types of research and training institution. As Africa becomes more integrated economically, and in its political spirit, the scope for strengthening existing links increases. At the moment among universities these links consist principally of exchanges of staff, students and external examiners. The report of a recent conference on *Inter-University Co-operation in Eastern and Southern Africa* points to many possible additional directions that would help to make more effective use of combined resources and, likewise, encourage donor agencies to think more in terms of regional programmes and projects. In face of the need to adopt economies of scale, it seems axiomatic that all possible forms of linkage in training and research should be sought. The record of the various United Nations or OAU initiatives, in this direction, is not a strong one, with the exception, perhaps, of the African Regional Technology Centre in Dakar, Senegal, and the Eastern and Southern Africa Management Institute in Arusha. Again more promising examples seem to be provided by programmes of private research centres, with the ARRPIS Ph. D. training programme at ICIPE as an outstanding case. A different type of successful continent-wide activity is exemplified in the division of labour between universities and locally based international agencies which has resulted in the promotion and maintenance of research networks. A good example from the social sciences is the small grants competition sponsored by Ford and the IDRC which has run for the last fifteen years. The allocation of research funds is made by a panel of African scholars, but two contributions of the sponsors—an aura of neutrality and an administrative base—have enabled the activity to avoid the types of political and ethnic fragmentation which have bedevilled, and often paralysed, other efforts at research organisation on a continent-wide scale.

5. *Career incentives and the maintenance of excellence.* Beyond changes within existing university systems, we need to think more intensively about the maintenance of quality of science and scholarship, and the retention of scientific staff once they have been trained. Improving quality in higher education tends to be thought of in the aggregate terms of improvement across the whole sector. The expansion of student numbers, the proliferation of universities and the decline in per capita funds available for students' raises the spectre of the dilution of university systems. The corollary question is whether, as the broad base of university education continues to expand, we ought to think in terms of a small number of highly specialised and selective institutions. These would concentrate the best teachers and facilities and the most able students, as a means of producing a cadre of intellectual and scientific leadership, and also some quality graduate training facilities particularly in science fields. There is an equity issue here but tertiary education is, by definition, elitist and not to develop some special differentiating provision is to risk general

mediocratisation, and the loss of the most able staff members to foreign institutions where the resources essential to their work can be found.

The issue of centres of excellence cannot be separated from that of private institutions. Private universities have come into existence in several African countries and more are on the horizon. The quality of these institutions often leaves something to be desired, and regulation and monitoring of them within national systems is essential, but they do represent a potential resource not just for coping with the demand for higher education but also for enriching and diversifying the quality of scientific training.

More important, the independent and international research centres represent major training resources that could be drawn upon more fully than they are at present for helping to meet training needs at the doctoral and post doctoral levels in Africa. Various scheme illustrating needs and styles are already in existence or are being planned. One at the planning state is a scheme to enable regular coharts of post graduate students from African universities to do part of their degree course at selected international centres. The already-mentioned ARRPIS programme at ICIPE is an example of a specific and formalised Ph. D. programme permitting students from different universities of the continent to make use of the scientific facilities at ICIPE. The recently initiated dissertation internship programme of the Rockefeller Foundation which offers students at the dissertation stage of their Ph. D. degrees the chance to do their field work at some of the best scientific research units in Africa is an example of another approach. Another Rockefeller Foundation initiative focuses on intellectual refurbishment at the post doctoral phase and provides an opportunity for scientists to spend a period each year at an advanced laboratory in Europe or the USA. These and other initiative illustrate different ways of providing a career structure for the scholars and scientists of the continent and hence an incentive to remain both in scholarship and on the continent. There is already a flow of good scientists from the universities to the International Agricultural Research Centres and part of the task for the future to expand the extent to which this flow is directed towards research rather than administrative positions. The general point is to underscore what others have said about the need to intensify all possible ways of strengthening the incentive system which can enable scientists and scholars to remain professionally active and productive.

6. *The role of the social sciences.* The UDP emphasised the development of disciplines in universities. The subsequent compartmentalisation of disciplines, combined with the new emphasis on science and the dominance of a vocational perspective within universities themselves, has drawn attention away from the significant role of the social sciences and humanities in the application of science and technology. Social scientists are often viewed by governments as little more than social critics and their contribution to the understanding of applied technology has been correspondingly devalued. This is partly because they have chosen to concentrate their attention on the exposure of social, economic and political problems and have concerned themselves less with the more immediately visible problems of food, health, shelter, and so forth. One of the challenges of the next era, will be that of integrating the work

of social scientists with that of their colleagues in the biological sciences. Without this integration, it will be difficult to find meaningful technologies that can lead to those improvements in agriculture, health and industrial productivity upon which the ultimate well being of the continent depends. The immediate challenge is to identify those particular problems where the social scientist can contribute to in the identification of an approach or the application of a technologies. The institution building task is to find the forms and environment which can enable the different types of scientist to work together on significant problems. Already there is a rapidly accumulating experience of this type of inter-disciplinary collaboration, most notably in the international agricultural research centres, and the time may be ripe for a systematic documentation and analysis of this experience.

7. *The foundations of scientific institution building at pre-university level.* During the period of the Rockefeller Foundation UDP neither the Foundation, the universities themselves nor other donor agencies had to worry about being able to find candidates for graduate study who had outstanding potential and solid preparation. This situation has changed in several countries of the continent. It is not that exceptional individuals no longer exist but rather that the education systems are losing their ability to find them, prepare them and select them. As many countries have come close to universal primary education, and face continuing pressure for access, the strain on resources has become acute. Vast classes, with virtually no facilities and poorly-trained teachers, have very little to offer in the way of preparation for a scientific career. The sheer press of numbers in mass primary school systems makes it impossible for all but the most brilliant teacher to offer even the rudiments of a foundation for scientific understanding. The situation is only slightly better at the secondary level. At the same time, insufficient concern about selection systems means that countries are losing their ability to identify and promote potentially talented individuals.

It is widely acknowledged that the continent's potential for development in agriculture, health and industry is going to depend upon the development of a cadre of scientists and technologists, who can be involved in the selection and adaptation of imported technologies and in the creation of local variants and alternatives. Yet Africa is not producing these people in sufficient numbers. There is need for effective thought about how science teaching can be improved at all levels of the education system, and on which, if any, technologies seem to be relevant to that purpose. One such technology, the microcomputer—does seem to be relevant to improvement in teaching, written productivity and administrative efficiency in universities and research institutes—and provides an illustration of the kind of improvement that is possible. Likewise, in situations of overcrowded classrooms and a shortage of teachers, more intensive use of video recorders would seem to be a relatively cheap and accessible, but so far underutilised, technology. Undoubtedly there are others.

Improving the quality of teaching and science education requires not only attention to content, process and technology in schools but also to ways of finding and encouraging future scientists and scholars. Unfortunately, in many African countries, the decline in the quality of primary education has been

accompanied by a deterioration in the ability of education systems to select people for further study according to relevant criteria. The production of scientists and scholars, to staff institutions across the continent, requires incentive systems and career structures at the higher level, but also needs to develop more refined systems for finding and encouraging the young scientists and scholars of the future.

Conclusion

External resources form a small, but important, part of the environment in which universities operate on the continent. University development has been significantly influenced by shifts in the magnitude, forms and sources of such financial co-operation. It is salutary to conclude this review with the acknowledgment that many of the early donor expectations about the course of development in higher education did not proceed as anticipated. The early donors to higher education on the continent did not expect to become permanent features of the university scene. What was expected to be an initial catalytic contribution to helping national universities become established has, instead, turned into the massive pervasive "industry" of collaboration that is today itself the subject of analysis and concern, as some forms of collaboration begin to look more like part of the problem than a contribution to its solution.

To take the particular case of staff development, it was thought that an initial batch of scholarships would be the basis for the development of strong undergraduate and graduate programmes that would create self perpetuating universities. Otherwise well-intentioned donor agencies did not anticipate the expansion of universities that we see today, the second generation problems of retention of staff, maintenance of the intellectual and physical infrastructure, the extent of political constriction, the collapse of national economies, crises of foreign exchange and so forth.

In a context defined by these economic and political pressures, assistance agencies more than ever before have a responsibility to co-operate and collaborate in the application of their efforts in support of institution building on the African continent. What has become clear is that the task of establishing a self-sustaining scientific capacities on the continent requires attention to the school system, to universities and to the incentive and career structure that encourages scientific excellence. As we sit at Bellagio, our ideas about how to meet the new challenge may be stirred, if not defined, by the experience of the Rockefeller Foundation's University Development Program. What follows by way of conclusions are selections, in propositional form, of some of the lessons which stand out for this writer:

1. University institution building is a long term process where the timing of external inputs is critical. Among the important features of the Rockefeller Foundation UDP was the extent to which a long term effort was accompanied by scale, purpose, a model to follow and, above all, a self-conscious commitment to understanding the process in which the foundation was engaged.
2. External agencies can make certain kinds of contribution to the institution building process-scholarship, ideas, links to international communities, etc.—but can have little influence on the larger economic and political context which ultimately determines the health and survival of the institution.

3. In the larger political context in which universities operate, the most inhospitable circumstances for institution building occur where highly personalistic authority systems prevail. Here the strategems for survival often include explicit efforts not to permit the institutionalisation of any structures or leadership groups, including particularly university professoriates, who are not directly supportive or manipulable.
4. In the varied political environments encountered by the Foundation, the advanced training of scholars and scientists remains the most single significant contribution that was made. The case for its continued priority status remains strong. Its utility in adverse circumstances is illustrated by the large numbers of young Ugandan Fellows who suffered the lost years of Idi Amin but who remained as a reservoir of human talent for the task of reconstruction when more rational circumstances return to their country.
5. The Rockefeller Foundation could not have made the contribution that it did without field representatives, a continuous presence in the region, and individuals serving the universities who had a knowledge of local conditions developed through many years of experience.
6. Central to the contribution of the Rockefeller Foundation UDP was the availability of a rich range of mechanisms which could be drawn upon, singly or in combination, for the tasks of university development.
7. A supportive and rewarding scholarly environment, and the incentive structure for scientific careers, are critical for the purpose of helping scientists and scholars continue to work at their profession. The Foundation during the period of its UDP along with most other agencies, paid insufficient attention to supporting the different elements that could have created a stronger intellectual environment.
8. Universities exist to provide teaching and research. To the extent that they depart from these fundamental purposes—into service tasks and vocational training, and introduce criteria of recruitment unrelated to these basic purposes—they lose their justification in the context of poverty which characterises the African continent.
9. In the early stages of the UDP an emphasis on research was closely linked to the quality of teaching. More recently, as agencies have placed relatively greater emphasis on research and the project mode of support, the quality of teaching in the universities has declined markedly. Improving teaching quality is now perhaps the most important challenge facing African universities.
10. As universities increasingly become mass training rather than educational institutions, the task of providing specialised preparation for scientific and scholarly careers will have to be done mainly outside the existing university network.
11. Future institution building in science and technology is unlikely to be successful unless it pays some attention to the quality of the primary and secondary school environment for the learning of science, and to methods for identifying and promoting individuals who demonstrate particular potential.

RESEARCH IN SMALL DEVELOPING COUNTRIES

*W. Doug Daniels**

This introductory essay focuses on the situation and particular problems faced by small developing countries (with a population of under 10 million) in research and development activities (R & D). Decisions on the level and direction of allocation of resources to research are, of course, those of the countries themselves. Nevertheless, an organisation funding research in these countries has an interest in understanding the countries' options so that its own decisions on the level and type of activity to support make the best possible contribution to strengthening national endeavours.

The contribution that R & D makes to the development process is widely accepted as vital. This process implies access to new knowledge and new ways of embodying and exploiting existing knowledge. The particular circumstances in which small countries gain access to existing knowledge, adapt it to their specific purposes or contribute to generating new knowledge are part of an extremely complex global system of relations. The extent to which research can contribute depends on the level of resources (funds and staff for research) and allocation of scarce resources to a multitude of needs; this goes hand in hand with the necessity to look at what mechanisms are most productive when the resources are as limited as they are in small country cases.

The research "system" (really a misnomer since activities lack the interconnectedness that this implies) thought appropriate for a particular country will depend on its resource endowment and the development objectives and strategy decided on. This gives rise to a vast range of different, individual situations and sets of choices for decision-makers. There are, however, some common considerations which deserve highlighting. One possible assumption is that small countries will have limitations in terms of potential economic size so severe that their development options will be significantly different from larger countries.

This essay begins to explore whether there are also significant limiting factors in the type and level of R & D that can be economically justified. In many areas of research, a certain minimum critical mass is required in terms of human and financial resources before R & D can be productive. The low level of resources that small countries can devote to R & D may mean that the input required to achieve even this minimum is beyond their means. There is an additional economic argument that suggests that production-related research in small countries is likely to be more expensive per unit of production than in larger countries—the research costs required on a crop which is grown on 50,000 ha in one country and 150,000 ha in another may not vary greatly; the research cost per hectare under production will be quite different.

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How many small countries?

Clearly, any definition of "small countries" is arbitrary and depends on the issue or problem being investigated. The imprecision of the term requires a definition each time "small" is the focus. The principal criterion used here for labeling small countries is that of population. This also serves as a reminder that the richer industrialised countries with relatively small populations face particular problems of R & D strategy as well.

Studies of "small countries" have proliferated since many countries that have gained independence in the last thirty or so years belong in this category. Various reports have shown a general congruence between population size and other measures of size although not a clear correlation. A more detailed assessment of criteria would be necessary to classify individual countries, but this is not necessary for this review. We will use only the criterion of population size, recognising that some countries with a small population may well have other elements which make some of the limiting factors less relevant. Depending on particular studies, the cut-off population size used varies between 5–10 million; here 10 million has been selected as the upper limit to the category.

What numbers are included in our category? Table 2 shows that in 1985 approximately 67 percent of all developing countries (used here interchangeably with "Third World countries") had a population of less than 10 million and 52 percent less than 5 million. The GNP of all but 5 of the 78 small countries for which there is data is under US $10 billion. Sixty-six of these countries have a GNP below the US $5 billion mark.

One consistent finding in studies is that there is no relation between country size and GNP per capita. Smaller countries do not necessarily have lower per capita incomes. A growing literature now studies the relationship between country size and economic performance—some figures suggest that

Table 2. Country size and gross national product (GNP) in developing countries, 1985 (US $ billion)

	GNP					
Population (million)	Less than 1	1–5	5–10	More than 10	No GNP data	Total
0–10						
0–1	21	10	1	–	4	36
1–5	5	17	2	4	3	31
5–10	–	13	3	1	1	18
Sub total	26	40	6	5	8	85
More than 10						
10–20	–	3	5	5	4	17
More than 20	–	1	5	16	3	25
Total	26	44	16	26	15	127

Note: Intervals are rounded. 1 United States dollar (US $) = 1.33 Canadian dollars CA $).
Source: World Bank Atlas, 1987.

small countries exhibit wider growth rate fluctuations and have tended to experience recession more severely, but the evidence is far from conclusive. Other studies relate size and the distribution of imports and exports as a percentage of GNP; these suggest that imports and exports account for a greater percentage in smaller countries, with a consequently greater degree of dependence on international markets. So there appear to be some distinguishing features in economic development characteristics, although the evidence is very preliminary. Are there distinguishing features in their research systems and potential?

Research in developing countries

The access of small developing countries to the outputs of R & D—their own and others'—is crucial to their development. Their level of activities in this area is low even as a percentage of their limited resources. There are two important observations. First, the level of R & D activity in the Third World is low in comparison to the industrialised countries. Second, much of this R & D is concentrated in the larger developing countries (e.g. Argentina, Brazil, China, India, Korea, Mexico).

Global and national figures of expenditures on R & D are still extremely unreliable. Best estimates available indicate that global R & D expenditures for 1984 was some US $240 billion with the Third World accounting for 6 percent of the total or US $14 billion (see Table 3). (These total figures include, of course, the considerable expenditure of a number of industrialised countries on defense research). The developing countries' share of world GNP is 21 percent with approximately 79 percent of the world population. As mentioned above, within the developing countries group, there are marked regional and country disparities. Using data for 1980 (see Table 4), there is a clear concentration of R & D effort in Asia with 56 percent of total LDC R & D expenditure followed by Latin America with 30 percent. Within regions, there is an even sharper contrast between countries. Nigeria accounts for 50 percent of Sub-Saharan Africa's research effort (excluding the Republic of South Africa). In Asia, China is responsible for an estimated 40 percent of the regional total. Similarly, Brazil alone was responsible for 50 percent of the R & D effort in Latin America while Argentina and Mexico raise the level of concentration to 77 percent of the regional total. What this means is that approximately $8–9 billion of LDC research and development expenditure is accounted for by 8 countries.

The OECD case

This is not so different from the industrialised countries. In the OECD group of 24 industrialised countries, the largest 5 countries account for 88 percent of total OECD R & D expenditure. The head of the science and technology indicators unit of OECD reported that the "second" five countries (which include Canada) spent a further 10 percent of all resources devoted to R & D in the OECD area, and added: "then there is a set of smaller countries spending 1–2 percent. This shows very clearly that research is an extremely concentrated activity and that for most countries the problem is not so much to undertake research, but to gain access to research from elsewhere" (emphasis

Table 3. Research and development (R & D) expenditures by developed and developing countries, 1980 and 1984

	R & D expenditure (US $ billion)	Percentage share		
		R & D	GNP	Population
Global 1980	207.8			
Developed	194.9	94	79	19
Developing	12.9	6	21	81
Global 1984	240.0			
Developed	226.0	94	79	21
Developing	14.0	6	21	79
OECD 1984	189.8			
USA	98.152	44	29	
Top 5	167.2	88	78	66
Bottom 5	0.5	<1	1	4
Countries less than 5 million population (6 total)	2.4	1	2	3
Countries less than 10 million population (12 total)	6.8	4	6	8
Third World (1980)	12.9			
Sub-Saharan Africa	0.8	6	8	11
Arab States	1.0	8	24	7
Latin America	3.9	30	31	11
Asia	7.2	56	37	71

Note: 1 United States dollar (US $) = 1.33 Canadian dollars (CA $). Percentages have been rounded.
Sources: UNESCO 1985 Statistical Yearbook; *OECD Observer*, 1986; and IDRC internal documents.

added). These 14 smaller OECD countries nevertheless account for a total research budget of $2–4 billion (an average of US $140–280 million per country).

The OECD has considered the problem of "smallness" (in this case defined by GNP) in relation to science and technology policy and economic growth in its small member countries. Different industrial strategies have been suggested (e.g. finding niches in the market; co-operation with other countries; specialisation) requiring different R & D strategies to support them. These countries face the problem of not having big enough domestic markets to generate competitive economies of scale or, in some cases, to pay back R & D costs. Academic studies have proposed general guidelines for the identification of areas where small industrialised countries might establish relatively large R & D programmes:

- areas where it is important for the small country to pursue an indigenous R & D effort to meet its social and economic objectives;
- areas where current R & D makes it natural to establish "axes of penetration";
- areas in keeping with the small country's R & D capability regarding cost, manpower, type of activity and field of science and technology;

Table 4. Financial and human resources in R & D — estimates for selected developing countries.

Country	Population mid-1985 (million)	R & D budget: Total R & D (US $ million)	R & D budget: Percentage of GNP	Number of researchers	Sectoral funding focus (%)
Botswana	1.1	4.3 (1984/85)	0.4	235	Agriculture 75 Technology and energy 23
Costa Rica	2.6	5.2 (1981)	0.2	850	Agricutlure 46 Social development 19 Health 15
Guatemala	8.0	14.8 (1983)	0.2	1094	Energy and industry 29 Agricutlure 22
Honduras	4.4	9.2 (1985)	0.1	612	Agriculture 76 Social development 11 Health 9
Jordan	3.5	4.2 (1984)	0.1	1472	Industry, natural resources and construction 42 Agriculture 21 Humanities 17
Malawi	7.0	4.5 (1984)	0.4	477	Agriculture 96
Mauritius	1.0	4.3 (1985/86)	0.4	263	Agriculture 94
Singapore	2.6	100.6 (1984/85)	0.6	2401	Engineering and technology 72 Medical sciences 13 Natural sciences 10
St. Lucia	0.1	1.2 (1985)	0.7	27	Agriculture and environment 75 Health 25
Trinidad & Tobago	1.2	19.0 (1985)	0.3	186	Agriculture 49 Energy and industry 38 Marine and environment 13

Note: 1 United States dollar (US $) = 1.33 Canadian dollars (CA $).
Source: Data obtained from national surveys and country studies undertaken for IDRC by local researchers.

- areas useful to a strategy for strengthening the small country's position relative to the international division of labour.

Size is mentioned as a specific factor limiting the scope of activities and requiring careful allocation of available resources in several OECD Reviews of National Science Policy: for Iceland ". . .given its smallness and given that its competitors base their economic perfor mance in large measure upon their ability to harness their own scientific and technological strengths, Iceland cannot afford not to have a clear science policy. . ." and Norway, ". . .when discussing the features specific to their [S & T] system, Norwegians usually begin by saying quietly, with a hint of reserve, 'Norway is a small country'. The examiners reporting on social sciences policy in Norway heard the same comment from nearly everyone they spoke to and added that the size of a country necessarily limits the range of research fields open to it and makes choices harder."

R & D in small developing countries

This reference to the OECD experience underlines that small developing countries are not alone in having to make tough R & D decisions and to limit the areas in which they can undertake to build R & D capacity. The resource constraint is always present (indeed even for the larger industrialized countries) but it does "bind" at different levels. The situation of the small developing countries is difficult to describe in detail given the absence of reliable country data. Notwithstanding the relative weakness of the R & D effort, it is important to enumerate reasonably accurately the level of resources devoted to R & D and their sectoral concentration. It seems likely that even the cost of collection of information of resources devoted to research is more expensive per researcher or research institution in smaller research "systems".

Table 5 shows information on the R & D resources of a number of small developing countries from different regions of the world. In most cases these come from studies of national research systems undertaken for IDRC by local researchers—but even these studies relied for the most part on existing (though sometimes difficult of access) information. In other cases where studies were started with no existing information, reports have still to be submitted.

Research institutions in developing countries are

1. relatively few in number;
2. primarily dedicated to agriculture;
3. seldom directed towards industry;
4. heavily dependent on researchers from universities. As university enrolment and teaching load have increased in the last 5–10 years, staff time devoted to research has decreased. In 1980, for example, staff time allocated to research in the Faculty of Agriculture of the University of Jordan was on average 50 percent of the total available, wherease in 1984 it had fallen to 25 percent. During 1980–84, the number of students enroled had doubled but the professional staff had increased by only 20 percent;
5. limited in how they can link to other countries, i.e. universities have talent, but not time and money. They are also limited in their linkages into the work of "full-time" research centres run by government; and
6. primarily dependent/reliant on foreign sources of support.

The science and technology issues facing small developing countries are complex: they are attempting to meet domestic economic and social needs, for which they require a contribution from domestic S & T, but are doing so in an international environment which is undergoing rapid technological change, and in which "conventional" wisdom is in question. One convention was that basic industrial activity (the "mature" industries) requiring low capital and high labour inputs would eventually shift to those countries which have a comparative advantage in those factors of production. Concomitantly, industrialised countries would shift into high technology, capital-intensive productive activities. There is some feeling that what is happening does not follow this convention. Basic industrial activities are becoming more technologically intensive. Consequently, some industries expected gradually to decline in the industrial countries are now experiencing a "renaissance" and are the subject of considerable R & D effort.

Table 5. Country-product combinations (%) generating enough economic value to support a minimum research module, the Carribean, Central America, and Africa.

Subregion/country	Maize				Rice				Cassava				Cotton				Beans				Potatoes/sorghum*			
	0.5	0.75	1	2	0.5	0.75	1	2	0.5	0.75	1	2	0.5	0.75	1	2	0.5	0.75	1	2	0.5	0.75	1	2
Carribean																								
Babardos																								
Cuba				●	●	●	●	●	●		●	●								●				●
Dominican Republic					●	●	●	●												●				
Grenada																								
Guadeloupe																								
Guyana					●	●	●	●																
Haiti				●		●	●	●					●								●			
Jamaica																								
Martinique																								
Trinidad & Tobago																								
Central America																								
Belize																								
Costa Rica					●	●	●	●								●								
El Salvador	●	●	●	●				●					●	●	●	●				●				
Guatemala	●	●	●	●				●					●	●	●	●		●	●	●				
Honduras		●	●	●										●	●	●				●				
Nicaragua				●				●					●	●	●	●			●	●				
Panama					●	●	●	●																
West Africa																								
Benin		●	●	●					●	●	●	●		●	●	●								
Guinea Bissau																								
Equatorial Guinea																								
Gambia																								
Liberia					●	●	●	●			●	●												
Sierra Leone					●	●	●	●																
Togo				●						●	●	●			●	●								
Comoros																								
Cape Verde																								
Reunion																								
East Africa																								
Mauritius																								
Somalia																								●
Central Africa																								
Burundi				●				●	●	●	●													
Gabon																								
Rep. Congo									●	●	●													
Rwanda																								
São Tomé									●	●	●													
Southern Africa																								●
Botswana																								
Namibia																								
Swaziland														●	●	●								
Lesotho																								

Note: X indicates if value is greater than US $309 900. (1 United States dollar (US $) = 1.33 Canadian dollars (CA $ 1).
Source: Adapted from Gamble, W.K., Trigo, E. (1985) Establishing agricultural research policy: problems and alternatives for small countries. In *Agricultural Research Policy and Organisation in Small Countries*. International Service for National Agricultural Research (ISNAR), The Hague, Netherlands. 41 pp.
*Potatoes in Cuba and sorghum in Somalia and São Tomé. Research on beans was not considered for Africa.

What this means is that as the large countries invest more at this level of productive activity, it will raise the technological content of commodities and thus increase the threshold level of S & T activity in terms of the necessary supporting S & T infrastructure. There are important economies of scale in the production of many major consumer goods. These may present major barriers to starting production except where countries can identify particular "niches" in the range of productive activities. It is also likely that the threshold level of capital to invest in R & D on industrial activities is increasing for manufactured commodities, limiting the range of feasible goods (and research) for small countries' production.

The implications of a changing international division of labor and of the complexity of commercial and investment decisions facing small countries argues in favour of their building some independent capacity to carry out research on policy (economic, S & T, etc.). They need to ensure that they have adequate access to external technical and marketing information, and an ability to analyse this information in such a way as to ensure that major policies and investment decisions are based on the best available knowledge.

Agricultural research

But for many developing countries, large or small, agricultural research is the most important research sector. The issues of economies of scale, minimum critical mass, and the potential to tap external research findings are just as relevant here. It is useful to explore some of these issues specifically for agricultural research as it is typically the largest and most organised sector (see Table 4). It is also the sector which is the best documented and where there has been some preliminary analysis of the specific factors mentioned above.

It has been suggested that a minimum research mass is necessary in agricultural research. Much further work is required on this notion for this minimum will probably vary by kind of research (varietal crop selection, animal disease research, etc.) and be affected by the experience of researchers and their access to external information.

M.E. Pineiro and E.J. Trigo made estimates for the cost of a minimum module for research on one crop in 1982 and explored some of the implications of this concept. They suggest that a minimum package required annual expenditure of US $500,000 (90 percent operational expenses; 10 percent for innovations and equipment). This module included 4 "chief researchers"—at the M. Sc. or Ph. D. level (3 person-years in plant breeding/agronomy and pest and disease control and 1 person-year equivalent in socioeconomics and other specialisations) with support costs, training and so on. This cost was then compared to what might be available for research-based on a percentage of agricultural production. In comparing this estimate to 1982 budgetary levels for agricultural research, only the larger countries would be in a position to finance a broad coverage (multi-product) research infrastructure. They looked at six basic commodities (wheat, rice, corn, potatoes, cassava and beans) in Latin America and the Caribbean. Using their estimates of minimum annual expenditures, they estimated that the production value of individual crops was high enough to cover the minimum costs in only 40 of 114 possible crops programmes if one assumed research expenditures equivalent to 1 percent of the crop value. In many cases, research expenditures on a crop are much less than 1 percent of the value of production of that crop. Of 17 "small" countries,

there were only 10 where the minimum research module for a crop could be justified on the basis of these figures.

Later analysis was undertaken by W.K. Gamble and E.J. Trigo on seven prime crops in 38 small countries in Central America, the Caribbean and Africa (and presented at a workshop on Agricultural Research Policy and Organization in Small Countries in 1984). By using the same module but varying the costs, they arrived at an annual minimum research expenditure of $309,000 per crop. They compared this to four different percentages of value of production being allocated to agricultural research: 0.5 percent, 0.75 percent, 1.0 percent and 2.0 percent (see tables 5 and 6). According to their analysis, "in Latin America and the Caribbean, of 102 country/product combinations for maize, rice, cassava, cotton, beans and potatoes in only 10 cases is the economic base large enough to support a minimum research effort if 0.5 percent of the value of production is spent on research. If expenditures are increased to 0.75 percent of production value, 14 cases would be viable, and at 1.0 percent (double the actual expenditures for 1980), the minimum research module could be supported in 16 cases".

According to Gamble and Trigo's analysis, "the African situation is not much different. Out of 105 cases covering 5 products, 4 combinations are feasible at the 0.5 percent level, 10 at 0.75 percent, and 11 at 1.0 percent. According to these calculations, not one of the countries examined could support sorghum research at the defined minimum level, only one could support maize research, and in two cases a minimum effort in rice would be viable. In cassava, there is a better situation, especially at the 0.5 percent and 1.0 percent level, where 6 and 7 cases respectively are viable".

Admittedly, the concept of a minimum research module is still an artificial construct and the actual levels required for crop research programmes in different countries may vary widely. This kind of analysis does suggest, however, that there are serious issues to be addressed in terms of economic levels of research programmes.

The question of economies of scale is linked to the notion of the minimum research module but distinct from it. In a smaller agricultural research system, research investment per hectare will have to be higher than in a larger system in order to achieve equal effectiveness. One review suggested that research is justified only where at least 100,000 hectares are devoted in a particular country to the crop concerned. This would automatically exclude 48 developing countries where total arable land for all crops is less than 100,000 hectares. A USAID document discussing countries in Africa on this basis divided them into "technology generators" and "technology adaptors"—where 8 countries were in the former (only 3 with a population under 10 million) and 22 in the latter group.

The level of investment required for agricultural research will also be affected by agroclimatic differences within country—the cost of developing productive farming systems for a small country with great agroclimatic variations will be greater than for another country with more homogeneity. W.V. Ruttan has also pointed out that a small nation with a strong research programme but a limited agricultural or industrial base cannot capture as high a proportion of the benefits from its investment in basic research as can a larger nation with a more diversified economic base.

The arguments above (minimum research mass and economies of scale) concern the level and type of of research activity that could be undertaken in a

small country. It is clear that, just as in the case for the small countries in the OECD, small developing countries cannot by themselves solve the whole range of problems they face. They must look for ways to tap into external research programmes. This requires adequate access to external information. However, even here there are indications of constraints on small countries. Studies suggest that the greater the investment in domestic R & D, the greater the potential for absorbing and utilising external research. Estimates by R.E. Evenson and Y. Kislev indicate that for a low-income country with average research capabilities, an investment of US $1,000 for research performed in other countries located in a similar geographic and climatic zone would produce annual benefits of US $55,000 for the receiving country. If the recipient country had no domestic research capabilities, the annual benefit of the same investment would be only US $1,700. These figures obviously argue for the importance of achieving a minimum level of investment in agricultural research to ensure ability to benefit from advances in knowledge and technology being generated elsewhere.

This analysis, though based on assumptions that are complex and controversial, does serve to underline that the capacity of smaller developing countries to generate the technology and knowledge they require is severely limited. Further work and extension of the analysis to areas other than agriculture is required. The amount of resources that can be devoted to research is limited by size and the importance of overall production. The demands placed on the research system are much less so. The question of size has not often been addressed explicitly in countries' decisions on their R & D activities. Clearly it has always been present as an implicit factor in allocating limited funds and trying for greatest possible effect from these. Some of the key areas that require attention are:

1. *Research or borrow*: countries have major decisions to make as to what they should attempt to develop with their own research and what can be "borrowed" from external work. This choice suggests that small countries should probably focus on applied research tailored to particular national needs that are not likely to be covered by "importable" research. Clearly many small countries are already pursuing this strategy. It also emphasises the importance for these countries to have adequate capacity to undertake policy research to examine their investment decisions in general, and in this case their science and technology or R & D options;
2. *Concentration*: countries have to consider how many research programmes can be supported from the resources available for R & D and whether minimum critical requirements for productive research can be met; and
3. *Getting the best out of external research*:
   (a) *best possible information*: countries that are severely constrained in their own research require access to good information on activities and, particularly, the products of research undertaken elsewhere. The ability to assess this information for its applicability and usefulness in a particular national context itself requires considerable training and research experience. Information can be obtained in part through formal information systems, of which a number exist under regional and international auspices, and

requires a national ability to access. But information is also available through the "invisible" colleges, researchers exchanging information at conferences, through networks and so on, which requires an active research participation—even if only in a narrow area of a broader field;

(b) *support from multilateral research*: there exists a vast array of international and regional institutions which play a role in supporting developing country research institutions. A survey of these (see *Searching* 1985) showed that they accounted for an annual research budget of over $500 million. Some, such as CATIE in Central America, exist particularly to provide services to a network of national research efforts in small countries. Others have a much wider clientele and may need to be encouraged to work more in support of small country research (e.g. the institutions of the Consultative Group on International Agricultural Research (CGIAR)). The conclusions of the CGIAR study of potential (1985) address this need explicitly; and

(c) *support from other national research*: a number of countries continue to rely heavily on links with countries in the north—often as a continuation of relations established under external support to research. All too often, however, these links do not survive the end of a "project" under which assistance was granted. There are also enormous, partly untapped opportunities for South-South collaboration—between countries of a similar size through networks and information on research such as in the SADCC subject networks in Southern Africa. In part, also, these South-South links may be those of smaller countries benefiting from research in larger developing countries facing similar problems.

The limited resources available to small developing countries may make them particularly interested in obtaining external funding from donors for R & D. With heavy reliance on external support for research, small countries risk being vulnerable when donor agencies may, sometimes unconsciously, determine research priorities—or at least decide which of a range of priorities actually receives funding.

To alleviate some of these dangers, developing countries—and perhaps small countries in particular—need to have a clear view of the role they expect research to play and the priority areas in which they wish it to be undertaken. Some overall coordination of national research and of external support to research seems required.

IDRC has tried to be mindful of these problems in contributing to small country research activities. Some recent support to small developing countries is described in *External Support of Research in Developing Countries*.

EXTERNAL SUPPORT OF RESEARCH IN DEVELOPING COUNTRIES

*W. Doug Daniels**

Introduction

The search for new knowledge and alternative ways of applying what is already known is a vital component of the development process. The contribution that relevant research can make to development has been increasingly recognised by Third World countries.

The role of research has not always been perceived as clearly as it is today. In the 1950s, in the early days of what has now become the "economic development field", dominant theories of economic growth were so capital-centred that they seemed to slight the effects of everything else. This itself was ironic, for at that very time, econometric studies of the sources of growth in the industrial economies were finding that changes in the quantities of capital and labour explained only small fractions of growth performance. Instead, most of the latter reflected increases in the productivity of these physical factors. In turn, many of the productivity advances plainly were caused by the improving technology that was being generated by ongoing fundamental and applied research.

This view of the salience of research spread quickly to the Third World: it extended to almost all sectors. Agricultural progress was seen to hinge on supplying new technologies. The Green Revolution was research-intensive. Industrial, energy, and transport advances reflected the abilities of applied research to adapt or innovate appropriate technology. Health and population programmes were full of unanswered questions: not only the shape and context of optimal education programmes, but the very role of education in development demanded analysis. The Third World was confronted by a major requirement for economic and other policy research. At the same time, it was clear that it could not rely solely on research imported from industrial countries; such knowledge had been generated and its application undertaken in an environment that differed markedly in terms of ecology, resources, characteristics of available factors of production, and of social and cultural values. There were abundant examples of technology being incorrectly applied

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*Adapted from the introductory section of *Searching* 1986 (December 11, 1986, edition. International Development Research Centre, Ottawa, Canada.) This introductory section reviews some features of Third World research, focusing particularly on the contribution of development assistance in the field of research and on some attempts that have been made to assess the impact of research. It borrows heavily from data collected on some donor agencies' funding of development research by Professor John P. Lewis, who was Chairman of the Development Assistance Committee (DAC) of the Organization for Economic Co-operation and Development (OECD) from 1979 to 1981, and from a preliminary report he has written for IDRC. (Professor Lewis is not responsible for the way material is presented here.) All figures are in Canadian dollars.

and inappropriate solutions being imported into developing countries. This, of course, did not imply that developed country research was irrelevant for developing countries, but that careful judgment of its usefulness in sometimes radically different circumstances was required.

In addition, developing countries were faced with intractable problems that were of little or no importance to the so-called industrial countries. The bulk of research undertaken in developed countries has been concentrated in sectors that play little role in the economies of developing countries. Thus, it was essential for developing countries to build up their capacity, both to undertake research and to judge the quality and appropriateness of research undertaken elsewhere. This development of research capacity implied building new institutions and providing training and opportunities for on-the-job experience to individual researchers.

R & D in the Third World

It is extraordinarily difficult to provide an assessment of the amount of resources—both financial and human—that the Third World devotes to research. Where estimates exist, they are seldom constituted on a comparable basis; indeed, comparison of different sets of data may well reveal major discrepancies. There is a great need to improve the data available in this area. Mahdi Elmandjra has noted recently that "it was not until 1978 that the General Conference of the United Nations Educational, Scientific and Cultural Organization (Unesco) adopted the recommendation on the international standardisation of statistics on science and technology. It will take many more years before we can dispose of relatively reliable and internationally comparable data on research and development expenditures."

Those estimates that do exist on developed and developing country overall expenditure on research and development (R & D) provide some basis for making a number of major points—such as the stark contrast between the proportion of world R & D expenditure being realised in and for the two sets of countries. It is at the individual country level, however, where major decisions must be taken about the allocation of resources to research that the need for better information is most crucial. Along with others, IDRC hopes to play a role in facilitating the collection of information and quantitative data by countries to assist in planning future research expenditure.

In the case of agriculture, most countries have a better picture of the resources devoted to research than for other sectors, although even here the information is only partial. The International Service for National Agricultural Research (ISNAR) is developing a data base designed to provide comparative information on agricultural research throughout the developing world; data will be based, where possible, on responses from countries themselves, supplemented by information from other primary and secondary sources.

Notwithstanding the difficulties of finding or collecting data in this area, there are a number of preliminary statements that can be made to provide a sense of the situation:

- One of the earliest estimates (in the 1960s) in this area was that developing countries accounted for 2 percent of world R & D expenditures. An estimate was made for 1973 and gave the same ratio as being about 3 percent.

- Unesco data shown in the 1985 Statistical Yearbook suggests that developing countries accounted for 2.3 percent of R & D expenditure in 1970 and for as much as 6 percent in 1980. Similar figures on numbers of R & D scientists show developing countries with 7.9 percent of the total in 1970 and 10.6 percent in 1980.
- There is a major imbalance between the proportion of world-wide research undertaken in the Third World and its share of world population (81 percent) or of combined world production (21 percent). The figures would tend to show that over the last 20 years, there has been some small reduction in this imbalance; however, the developing countries, as a whole, continue to invest usually less than 0.5 percent of gross domestic product (GDP) in research activities, whereas the corresponding figure for the leading developed countries is 1.5 percent to 2 percent.

More detailed estimations exist for agricultural research; however, even here there is a range of estimates. In 1979, one study estimated that 15 percent of global expenditure on agricultural research was spent in the developing countries; another study completed shortly after suggested that one-quarter of global agricultural research was related to expenditures in the developing countries.

Most studies indicate that whatever the relative proportions of developing and developed countries in R & D expenditure, the absolute amounts spent in this field by developing countries have increased enormously in the last 20 years. In agriculture, a study covering the data for 67 developing countries estimated that, in 1980, expenditures on agricultural research at 1975 prices were in the order of $1,082 million—71 percent higher than the amount spent in 1975 and 170 percent higher than the level reached in 1970.

There is enormous imbalance, even in the amount of money spent on R & D by the developing countries. A few major countries account for a very large percentage of overall expenditure, e.g., Argentina, Brazil, China, India, Mexico, and South Korea. Unesco figures on the R & D scientists show that, of the number estimated to be working in the developing countries, 4 percent are in Africa, 8 percent in the Arab world, 23 percent in Latin America and the Caribbean, and 65 percent in Asia. (Comparable figures for overall developing world population distribution are 11, 7, 11, and 71 percent respectively.) One should also note, however, the imbalance between developed countries where, of the 24 OECD members countries, 88 percent of expenditures devoted to R & D in 1984 was taking place in five countries.

If the 1960s and 1970s were characterised by rapid growth in absolute expenditure on R & D in developing countries, present circumstances would seem to suggest that the rate of growth is likely to slow and that increasing attention will have to be paid by developing-country governments to the question of increasing returns to the funds invested in research.

The R & D industry in developing countries probably accounts now for somewhere in the order of $16 billion per year and yet the broad parameters of this major activity remain largely under-researched and unknown. The equivalent figure for OECD countries is about $245 billion (1984)—a further indication of the striking global imbalance in this area of development investment.

Role of external funding

Although national funding is by far the most important, it can be argued that there are compelling reasons for external agencies to provide a significant share of Official Development Assistance (ODA) to research. First, research is essentially a long term activity. At the same time, countries that are faced, as many of the developing countries are, by urgent and pressing problems of poverty and macroeconomic imbalance, both in terms of funding of public expenditure and in terms of balance of payments, must find it tempting to regard research as an expendable item in some short term calculations.

Second, research is characterised by major externalities—the majority of benefits of research in one part of the developing world may well accrue elsewhere and the decisions on research may well require a broad global or regional view of the opportunities and payoff for research on particular areas. Although this must be first and foremost the responsibility of national governments within a region, donor funds can also often be used to take account of these externalities. This is particularly important when a large number of countries with a population of less than 5 million is considered: it may be difficult to create the necessary critical mass for research on particular topics in some of these countries, even where the research problem should be given priority.

Third, research has a significant requirement for foreign exchange in terms of equipment and advanced, specialised training outside the boundaries of the individual country.

Fourth, donor funding has played a major role in the development of a substantial set of multilateral research institutions in the Third World (and some in the industrial countries). This set was reviewed in the introductory section to *Searching* for 1985—it was estimated that the research for those institutions could be as high as $550 million/year. They represent a growing and important new dimension to R & D in and for the Third World and account for a significant share of ODA funding to research.

It is also worth noting, of course, that research carried out in the Third World is likely to contribute not only to Third World development, but also in some cases to prove of benefit to the developed countries as well.

Donor funds are clearly making a major contribution to research on some topics in particular parts of the world. For example, a recent report on agricultural research in the Southern African countries belonging to the Southern African Development Coordination Committee (SADCC) showed that more than 50 percent of agricultural research being undertaken in those countries was externally funded. Where external funding is accounting for such a major proportion of current research, there must be adequate safeguards to ensure that national priorities are really being followed and, at the same time, that there is adequate provision for building research capacity for the future so that activity can be continued after external assistance ceases.

External aid

As a development agency whose major role lies in supporting research for development in developing countries, IDRC is conscious of the value of knowing the broad contours of Third World R & D to ensure that its own activities are most effective. The improvement of input indicators on Third

World R & D, however, is essentially a long term task for national authorities, although it can obviously be assisted by outside agencies. As a first step in improving its knowledge of the environment in which it operates, IDRC determined to fund a study of support provided to Third World R & D by major funding agencies. This was undertaken by Professor John P. Lewis, and will be published later as a separate paper. A brief presentation of some of the survey's findings follows.

Professor Lewis encountered major difficulties in collecting information, by questionnaire and through visits, on a consistent and comparable basis; a considerable part of his report deals with these problems and suggests methods for donors to capture information on this set of activities more easily. As it is, there are still anomalies apparent in the data presented—probably in part because of responses of "agencies" capturing slightly different sets of activities. It is hoped that the presentation of preliminary data will contribute to better information being available in future.

The survey data cover eight Development Assistance Committee (DAC) countries, the World Bank, the Asian and Inter-American Development Banks and the United Nations Development Programme. The DAC countries covered accounted for some 82 percent of DAC's overall ODA in 1984 and so provide a fairly representative picture of DAC funding. According to OECD statistics, the same eight countries account for 63 percent of all world ODA. As a group, these eight appeared to be devoting some 4–5 percent of ODA resources to research for development. This overall percentage would be higher if it related only to direct flows to developing countries because, typically, some 30 percent of ODA is to multilateral agencies (agencies of the United Nations system and the aid branch of the European Economic Community, for instance).

Individual countries' percentages of ODA devoted to research range from nearly 10 percent (Netherlands and United Kingdom) down to 3.1 percent for the USA. Table 6 shows the figures for the DAC countries concerned and also provides a rough sectoral breakdown. Table 7 shows similar figures for the four multilateral agencies. The overall current annual funding to development-related research that has been covered in the present survey is $1.9 billion. (It is worth noting at this juncture that Canada alone spends more than $6 billion per year on R & D as of 1985 which is more than triple the total R & D support flow to the Third World.) Currently, nearly $1.3 billion/year of external funds to R & D goes to research on rural and area development, which includes agricultural research. This compares to an estimation made for the 1976–1980 period that the value of external resources for agricultural research in developing countries was running at a rate of $407 million per year (1975 prices). It should be remembered that the figures for the World Bank are incomplete and that the survey did not cover all donors (a number of foundations, e.g., Rockefeller and Ford, play an important role in research funding and Australia also has a centre dedicated to supporting international agricultural research). With these omissions in mind, it may not be far off the mark to estimate that the current overall volume of aid to development-related research defined along lines comparable to the average usage of respondents to the survey is in the range of $2.1–$2.2 billion/year.

Although data were requested for 1970, 1975, 1980, and 1984, it was extremely difficult to establish time series for the countries and agencies responding to the survey. For four countries where data were reported for both 1975/76 and 1984, there was a clear upward trend as a percentage of total

ODA. In three out of the four cases, the percentage of ODA going to research had more than doubled in the period. This fact adds support to the generally held view that most donors, over this period, have been giving greater assistance to research and that the World Bank has been giving an increasing number of loans to research.

When the World Bank reports in its annual report on loans to borrowers by major purpose, it refers to agricultural research (research does not figure as a agriculture and rural development). In 1982–85, loans to agricultural research and extension by the World Bank were 3.6 percent of the total loans to agriculture and rural development—2.5 percent of International Bank for

Table 6. Estimates of funding for development-related research from eight Development Assistance Committee (DAC) countries, 1984 (CA $ million/year).

Country	Rural and area development[a]		Technology, science, and national policy[b]		Human resources development[c]		Other		Total
Canada	102	(67)[d]	17	(11)	27	(18)	5	(3)	151
France	272	(60)	105	(23)	74	(16)	5	(1)	456
Federal Republic of Germany	35	(24)	56	(37)	22	(15)	39	(24)	152
Japan (1980)	70	(63)	14	(13)	27	(24)	0	–	111
Netherlands	119	(69)	38	(22)	9	(5)	6	(4)	172
Sweden	13	(32)	5	(14)	21	(52)	1	(2)	40
United Kingdom	164	(88)	16	(8)	8	(4)	0	–	188
United States	263	(79)	0	–	69	(21)	0	–	332
Total	1038	(65)	251	(16)	257	(16)	56	(3)	1602

[a]Rural and area development includes agriculture and rural development, environment and ecology, natural resources (including energy) transport and communications, and human settlements and area planning.

[b]Technology, science, and national policy includes engineering and technology, including adaptation and transfer; natural sciences; and industrial development and management, development planning, economic policy, and applied social sciences.

[c]Human resources development includes research on education and training; health and nutrition; income distribution, poverty, and employment; and population.

[d]Values within parentheses are percentages of total for row.

Table 7. Estimates of funding for development-related research from multilateral agencies, 1984 (CA $ million/year).

Agency	Rural and area development[a]		Technology, science, and national policy[b]		Human resources development[c]		Other		Total
Asian Development Bank	7	(73)[d]	1	(9)	0.4	(5)	1	(13)	9.4
Inter-American Development Bank	61	(64)	34	(35)	1	(1)	0	–	96
United Nations Development Programme	0.4	(45)	0.3	(33)	0.1	(11)	0.1	(11)	0.9
World Bank	212	(97)	0	–	7	(3)	0	–	219
Total	280.4	(86.2)	35.3	(10.9)	8.5	(2.6)	1.1	(0.3)	325.3

[a, b, c, d]See footnotes to Table 1.

Reconstruction and Development (IBRD) loans, and 5.5 percent of International Development Association (IDA) loans. (IBRD and IDA are the two main funding arms of the World Bank.) To the extent that the IDA countries are the least wealthy, this would seem to go counter to the observation made elsewhere that the emphasis on poverty eradication in some aid programmes has reduced the percentage of donor funds going to research.

The donors have given strong sectoral priority to research bearing on rural and area development, as can be seen from the tables. During the past 10 years or so, the allocations in this direction have claimed over half their research-supporting budgets, and the inclusion of the World Bank, at least on the basis of the data available here, only intensifies this emphasis. As between the second and third categories—technology, science, and national policy on the one hand and human resource development on the other—there has been something approaching parity, but with a tilt lately toward the former. The more interesting point that can be seen from these figures may be the extent to which particular agencies specialise in one or other of these two directions. Where data are available on sectoral preferences over time, it appears that, although all agencies have sustained a principal emphasis on rural and area development, for most of them, the technology and policy sector has been accounting for a growing proportion of funding, whereas their inputs to human resource development have been declining relatively.

Within the broad categories for which information is shown in the tables there are major concentrations worth noting. Within rural and area development, annual support to research on agricultural and rural development accounted for $1.1 billion or about 85 percent of total funding. The other topic attracting major research support was energy, which accounted for most of the outlays on the natural resources subsector. Energy research funding picked up after the first energy price shock in 1973/1974. By 1984, for the 10 respondents where data are available from the survey, it accounted for $144 million or 11 percent of their total support to research.

Donors have been giving the other components of rural-and-area development research a light touch. Outlays on environmentally related research jumped in the latest reported year, but only to some $5 million/year. Transport-related research claimed $3 million in 1970 (on the part of a smaller set of respondents) and less since. Relatively little appears to have been spent on studies of human settlements and related matters.

For the 11 respondents with data available on technology, science, and national policy, investment was most heavy in engineering and technology research and in research on industrial development. The former appears to have been a rising trend, the latter a declining one, but between them they claimed about three-quarters of the category's research budget in each of the last three benchmark years.

As to the balance of the technology, science, and national policy research budget, work on management, development planning, economic policy, and applied social sciences has attracted greater funding than work in the natural sciences. But both have received good support and obviously some of the activities classifed under "technology" have a good deal of natural-science content.

Of the four subcategories into which the survey divided funding of research on human resources development, education/training and health/nutrition claimed at least 80 percent of external support in the last three

benchmark years. Work on education and training received two-thirds of this assistance, but the figures suggest that the receipts of the two subcategories are converging. In the way the data were collected, research into the subjects of income distribution, poverty, and employment seems to have been comparatively neglected, although they are shown as picking up some latter-day strength (oddly enough after donors' antipoverty and basic-needs efforts of the 1970s had peaked). As Professor Lewis points out, this is somewhat accidental and misleading. One knows, for example, of a good bit of World Bank and United States Agency for International Development (USAID) funded research into these subjects in the 1970s that the present survey misses because of the single-year nature of its information about those two respondents. Moreover, some income distribution-, poverty-, and employment-related research has been included in activities attributed to "agriculture and rural development". Nevertheless, the current investment in poverty and employment research looks rather sparse. The same, by the estimates of many, could be said of outlays on population-related research. Nevertheless, there seems to be a steady base of support for such activity.

Aid effectiveness

The presentation of information here has emphasised the supply of resources to the research process, predominantly that provided by external funding to developing countries. The information on developing-country national investment in research is available in less detailed form; the aggregate figures might lead one to think 10 percent of developing-country research activity is being externally funded.

A natural and compelling counterpart to the consideration of the input of resources to the research process is to examine the outcome or products of this research. This is an issue that clearly requires and deserves more space than will be devoted to it here, but the examination of input data would not be complete without acknowledgment of some major issues on the output side. In the case of IDRC, some investigation of these issues has been presented at greater length in a study published in 1986, *With Our Own Hands—Research for Third World Development: Canada's Contribution Through the International Development Research Centre*, 1970–85.

The general question of aid effectiveness is a major area of inquiry at present. Its debate has been influenced by the Cassen report on aid effectiveness commissioned by the International Monetary Fund (IMF)/IBRD Task Force on Concessional Flows, recently published as a book, which has generated a number of studies, particularly in the last 2 years. To the extent that the Cassen report and the debate in general caution against trying to suggest that one can know the precise degree of the effectiveness of aid, they have lessons for the research area as well.

The overall supply of funds to development research has two major objectives: problem-solving and capacity building. In other words, funding to research seeks to contribute to the process of finding solutions to urgent development problems, solutions that need to be available as soon as possible. It seeks also to contribute to building indigenous problem-solving capacity in the developing countries. Donors, as shown in their replies to the Lewis study, exhibit sharp differences on the weight they attach to the different functions. One donor says the purpose is to find solutions to development problems, as

quickly and satisfactorily as possible, who does the problem-solving, and how, are secondary issues. Another donor insists its purpose is to build problem-solving, i.e. research capacity, in the recipient country. A third says capacity building is the real objective; however, the best way to build capacity is to help the recipient learn by doing. It is this third way that is closest to the approach adopted by IDRC. Other donors choosing the same way, however, have put greater emphasis than IDRC on the provision of outside expertise to work with developing-country researchers. Professor Lewis has concluded that it is the latter two ways—those referring to research capacity-building—that most donors prefer.

This difference in donor practice illustrates one opportunity for working toward greater effectiveness in the use of donors' resources: consideration by the donors as a group of their present and future funding intentions with respect to sectors and practices. Some mechanisms exist already to ensure donor coordination in support of research, for example, informal meetings of donors to energy research and the Special Program for African Agricultural Research. There is also the basis for a more systematic exchange of information between donors—the Inter-Agency Development Research Information System (IDRIS) was created jointly by a number of publicly funded agencies that have supporting research as a major part of their mandate and it is managed by IDRC. Other agencies have also expressed interest in the data base and are potential contributors.

The major consideration of effectiveness of aid to research, however, will depend on the general view of how well, overall, research is serving the process of development. Research can be treated as an economic activity; it requires scarce resources and it provides something of value, but it is the value of the new knowledge that is difficult to determine, even when one can show it is being used. In the productive sectors, particularly in agriculture, where research feeds into the process of production of a commodity that has a market value, studies of the rates of return to investment in research have been undertaken. The calculations involved are not without their complications and controversy, nevertheless, the increasing number of studies on the rate of return to investment on agricultural research in developing countries show high rates of return to the investments made. Indeed, they can be used to show that there has been marked under-investment in this area; the marginal rate of return from investment to agricultural research being higher than that on many other development investments.

For some areas of research, however, the economic argument is not possible in such precise terms as a rate of return. In *With Our Own Hands*, IDRC has sought to show that research for development is making a difference to the way people live and work in the developing countries. The publication reports on a number of cases where IDRC had some role in supporting the research, but where the essential work of carrying out research and following it through to the point of its being beneficially used involved a multitude of agents and actors. Much research must be judged on this "micro-level" rather than in the "macro-aggregate" calculations of rates of return.

It is these small pieces of the action that together make a difference and contribute to the well-being—or better being—of developing country populations. Several of these activities supported by IDRC are reported on in *Searching* 1986.

THE LAND-GRANT COLLEGE IN AFRICA—THE ETHIOPIAN EXPERIENCE

*Michael McD. Dow**

Background

The Imperial College of Agriculture and the Mechanical Arts was the result of a meeting in 1951 between the Ethiopian Emperor, Haile Sellassie I, and Dr. Henry Bennett of Michigan State University. Dr. Bennett persuaded the Emperor that the future development of the Empire would require the kind of trained Ethiopian counterparts to the American graduates produced from the US land-grant university system. The Emperor allocated 40 gashas (1000 acres) of land in the Alemaya Awradja of Harar Province (where he had been raised, and where he felt he had a responsibility to assist development) on which the campus would be built. The Oromo-speaking farmers on the land were summarily dispossessed. The Imperial Ethiopian Government negotiated an agreement with the US Point Four program, later USAID, that provided for US assistance to build the campus, staff the college, and train an Ethiopian faculty. The contract for arranging the technical assistance was negotiated in the USA with the Oklahoma State University (OSU), Stillwater, Oklahoma.

Early days—the Oklahoma State University contract

From the outset, OSU was faced with formidable problems. There were few, if any, Ethiopian high school graduates to enter the OSU-level of programme. Therefore, the first order of business was to create a high school, at Jimma, that would prepare students for the first African land grant college—the Imperial Ethiopian College of Agriculture and Mechanical Arts. The high school took in students in 1953, and in 1957 the first class graduated, of which about 30 alumni were matriculated in the same year into the Alemaya degree programme. (A second feeder school, at Ambo, was added after a few years, and these schools were the main sources of agricultural undergraduates until the combined First University Examination was introduced around 1970, in which all incoming students were given a common curriculum in arts or sciences "streams" at the Addis or Alemaya campuses and admitted to their degree programmes in the following year.)

The first Alemaya graduates in 1961 were almost all employed by the Imperial Ethiopian Government Ministry of Agriculture, or selected to go to OSU for further degrees. This process continued over the years until 1968, by which time qualified Ethiopian faculty numbering nearly 100 were trained or were being trained, and a majority of the staff, though not the senior staff, was

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Ethiopian. In addition to the USAID programme, assistance was provided by the Rockefeller Foundation, under whose funding about 10 M. Sc. students completed Ph. D. programmes at US universities between 1961 and 1972.

By 1968, several forces were operating which led to changes in the character of the College. The initial charge to the College was to develop programmes based on the original land grant university premise—that the institution should stand on the "three legs" of the agricultural "stool"—teaching, research, and extension. These three functions were pursued by Oklahoma State University. OSU faculty, with staff recruited from other US universities as needed, taught, undertook research, and even established research stations and extension offices in a number of other provinces. However, as time went on and the costs of the programme mounted inexorably, there were questions raised regarding the cost-effectiveness of the project. These were compounded by criticism, polite at first, then increasingly vocal as the numbers of Ethiopian faculty grew, that the Oklahoma group (i.e. the faculty and administration at Alemaya, and the administration of OSU in Stillwater) did not promote Ethiopian faculty to positions to which their training and experience qualified them, that they were not responsive to the views of the Ethiopian government, and that they viewed the USAID contract as "open-ended" and did not plan to complete the task and leave Ethiopia. The Ethiopian government established an extension service within the ministry of agriculture, and limited Alemaya's extension activities to the local area around the College in Harar Province. It also asked the UNDP and FAO to assist in creating an Institute of Agricultural Research under the Ministry of Agriculture, located in Addis Abeba with experiment stations in the rural areas in many of the provinces.

The creation of Haile Sellassie I University

During this period, plans were completed for incorporating in 1961 the component university-level colleges (the College of Arts and Sciences, a Jesuit-run institution in Addis Ababa; the Public Health College in Gondar; the UK-supported Medical School; the Federal Germany-supported Engineering School; and the US-supported Alemaya College), into the Haile Sellassie I University, with a single administration based at the College of Arts and Sciences campuses at Arat Kilo and Sidist Kilo in Addis Ababa (so called because they are located at 4 and 6 km on the road up the hill towards Entoto north from the city centere). In addition, since by this time many secondary schools around the Empire were now taking their pupils through the "O"- and "A"-level examinations of the English Cambridge School Leaving Certificate that enabled them to qualify for admission to the University, the agricultural high schools at Ambo and Jimma were redirected to offer a 2-year diploma in agriculture, designed to produce large numbers of extension agents for the ministry of agriculture at less expense than the Alemaya College. Henceforth, the College would draw its freshmen from the same pool as the rest of the university. Because of its rural location, which though stunningly beautiful on the shores of Lake Alemaya with a spectacular view of the table-top mountain (amba) Gara Muletta 30 km to the southwest was remote from Addis Ababa (a full days bus, car or train journey) or indeed any off-campus entertainment, it was unable to compete successfully against the Addis campuses for the top high-school students.

The College thus lost some of its early privileges; it no longer had the pick of specially-trained high school students reared at its own nursery, and, with all of the university, now came under the ministry of education rather than the more sympathetic ministry of agriculture. The dispute concerning the long term objectives of the Oklahoma State University project was not resolved, and in 1968 the contract was terminated at the request of the Ministry of Education. This had two consequences: the integration of the College with the University was completed, and the bulk of the College's budget now came from the ministry of education through the University's financial administration in Addis Ababa.

The termination of the special relationship with OSU also meant that there was no budget for the type of informal assistance in obtaining information, spare parts, and other minor but critical needs for running a complex programme in rural Ethiopia, and the two-way flow of people between the two institutions was greatly reduced, though not completely. As part of the agreement terminating the OSU contract, USAID agreed to continue to provide support for 10 faculty positions: for basic science teaching, and senior advisers for the major departments—Plant Science; Animal Science; Agricultural Economics; Agricultural Education; Agricultural Engineering and Home Economics (some were already in place, hired by OSU, though not OSU faculty, and were kept on.) However, and this was a big change, instead of providing all of their salaries through the OSU contract, the USAID, OPEX programme provided only the difference between the local salary for the position and the salary level the US faculty could command in the US, or that would be required to attract them to rural Ethiopia by covering, for example, continuation of TIAA-CREF retirement investment payments which the university did not provide. This "topping-off" of salaries was paid in the US in dollars. The University, which in turn meant the College budget, had to meet the cost of these additional salaries from existing levels of funding. At one stroke, the proportion of the budget devoted to salaries increased from about 50 percent to 75 percent, and thenceforth only "essential" costs were covered. Non-essential expenditures that were not provided for included research not supported from outside the University, scheduled maintenance, library acquisitions other than an approved text for each specific course, travel, and student employment. Utilities were no longer provided free, and it was threatened that housing on campus would be rented to faculty, not provided free as it had been, to be uniform with the situation in Addis Ababa.

The academic programme

The academic programme comprised one year of basic sciences and introductory courses, including math, science, English, Ethiopian studies (later integrated into the common curriculum with the science stream of the University in preparation for the "First University Examination", at the level somewhere between "A" level 6th form of high school, and first-year of university level in the USA) and a second year of general courses, including two semesters of economics, entomology, biochemistry, rural sociology, more English including humanities, and introductory agriculture courses and surveying. The final two years were composed of agricultural courses leading to majors in Plant Science, Animal Science, Economics and Marketing, and Education. A General Agriculture major was available, but few students

resisted specialisation. An Agricultural Engineering major was added later, taking three years after the two-years of introductory courses, because of the additional time needed to meet requirements in many basic engineering subjects—and a matter of heated argument with the Federal Germany-assisted Faculty of Engineering in Addis Ababa concerning how much of these basic courses agriculture majors should be required to take to qualify to be permitted to call the B. Sc. Agricultural Engineering, rather than Agricultural Mechanisation.

Each course was accompanied by laboratory and field practical experience. In addition, until the fiscal crunch, students were employed by the departments to learn about running agricultural enterprises. The Animal Science department ran a dairy, a hatchery and a poultry operation, selling the products on campus to faculty and staff, to the local villagers, and in Alemaya, Harar and Dire Dawa towns. Plant Sciences had demonstration fruit and vegetable production, in addition to growing crops for feeding animals. The Economics Department organised a marketing co-operative for local farmers to supply the French army in Djibouti with about 5 tons of fresh vegetables and fruit per week. The Maintenance Department workshop serviced campus vehicles, and those of faculty and staff, on a cost-reimbursable basis. The Engineering Department provided consultancy services to local government and individuals, including assistance to design the layout, housing construction, water supply and drainage, and electrification for local villages and new townships. However, this assistance mainly benefited Amhara settlers who had been brought to the region by Ras Makonnen (Haile Sellassie's father) at the time of the consolidation of the Empire in the early 1900s, and little trickled down to the local Oromo-speaking, Galla inhabitants.

All of these College projects and services employed students, and gave them, in addition to a very small hourly wage, wonderful practical experience. By the early 1970s, Alemaya was recognised throughout Africa for the quality of its practical training, and each year, students from many other African countries (particularly Kenya, Tanzania, and Cameroon which did not yet have their own degree programmes in certain fields) were sent for degree training under various programmes, principally the INTERAF programme administered, with USAID support, by the Association of African Universities based in Accra.

Student radicalisation

The University also organised the Ethiopian University Service (EUS), in which students between their 3rd and 4th year spent one year in the rural areas. Most of them taught in schools as a welcome supply of teachers for the government policy of improving the availability of education in the rural areas. In his later years, His Imperial Majesty increasingly focused on education, and considered his support for education the most important contribution of his reign. This perception was not shared by many of the student beneficiaries, who became increasingly radical as their numbers grew. EUS gave the students, the bulk of whom came from an urban background where the necessary high school facilities were available, a new and unique view of the feudal conditions under which most of the 35 or so million Ethiopians still eked out a miserable existence, largely unchanged since biblical times. They saw the inequity perpetuated by the political system, in which they were unwilling or

unwitting tools of the maintenance of the status quo. The EUS Programme was thus an enlightened, productive and effective means of internal self-help while at the same time sowing the seed of the overthrow of the Empire. After the revolution, the Dergue (the ruling military committee) sent all students (high school and university), faculty and other "intellectuals" out to bring the masses literacy and access to modern technology, in the "zemacha" programme of "development through co-operation". This soon led to conflict between the students and the new regime, as the promise of the revolution was tempered with political conflict and the students' idealism came up against, as it had before, centralised authority in Addis Ababa.

Quality of the programme

The quality of the classroom academic programme was also high. It was sufficiently high for many graduates to be admitted to M. Sc. programmes at US universities with minimal "remedial" coursework. With the imprimatur of OSU, and recognisable transcripts, qualification was perhaps easier for Alemaya graduates than their African brothers from other systems whose records were less easy to interpret by admissions' offices. The top 10–15 percent were able to obtain scholarships. Although a few dropped out, most went on to complete their Ph. D.s.

However, this was accomplished at a price, the price of tailoring the curriculum towards the top of the scholastic pyramid, at the expense of the 85–90 percent of students who did not achieve sufficiently high grades to qualify for graduate studies. The Ethiopian employers, the ministry of agriculture, the ministry of education, and private sector or parastatal employers (oil companies, development corporations, etc.) increasingly complained that Alemaya students were not sufficiently broadly trained for their needs. The major departments demanded their majors take a heavy load of courses in their field of specialisation, with the result that the "service" courses from other areas received less time, or attention. As a result, it was possible for a student to plead ignorance to his employer—that he had not taken this course or that, which he might have been expected to have taken.

Yet, because they had not achieved sufficiently high grades in their major subjects to merit admission to graduate work, they were neither specialists nor generalists—they were failed specialists. This problem pervaded the Ethiopian educational system; students who did not pass on to the higher levels of courses were considered to have failed, rather than to have achieved the level they had reached.

At Alemaya, there was a determined attempt to devise a "core curriculum" containing the array of basic courses that all graduates should have taken, to ensure that they would not be over-specialised. Though a scheme was proposed which enabled the better students still to take more than the required minimum of major courses in addition to the core curriculum, it was opposed by the senior Ethiopian faculty as limiting the curricula of their major degree programmes, and was never implemented.

Limits to the programme

Several factors limited the ability of the College and the University to continue to evolve programmes and activities of benefit to the Empire and its peoples. These included:

- *Increasing student activism*—student strikes for the removal of cabinet ministers and other concessions, though unsuccessful, would nonetheless result in prolonged discussions and closure of the faculties and facilities. Subsequently, the Emperor usually requested that both His government and the university permit the students to return to classes. Much attention of faculty, students, and officials was diverted into political activism, or coping with the effects of it.
- *The reduced level of funds following integration into HSIU*—the inability to maintain previous activities (quality of support for staff and students, student employment, research, travel of staff, etc.) which had contributed to the quality of the programme.
- *The loss of autonomy*—of the College to the University, and communications problems across the 500 kms. to the capital.
- *Drought, loss of income and food*—fluctuations in agricultural productivity, loss of income, food and animals by many people, especially in the Ogaden, the region adjoining the Alemaya campus, and a demoralised government system unable to cope with the problems which increasingly used police tactics and infiltrated the university campuses with informers.
- *The inbreeding of the inherited OSU system*—compounded by a faculty that was almost entirely drawn from the first two classes from Jimma high school, all about the same age, with equal expectations, ambitions and frustrations–this was perpetuated through graduate studies Alemaya faculty took at OSU and a few other US land-grant colleges, and there was little cross-fertilisation by graduates from European universities (indeed the few that returned to Ethiopia from Europe were not "in-the-pipeline" and so had no job waiting, or were thereby more easily excluded from the "Alemaya club").
- *The quality of general education*—Prof. Odhiambo and many others feel that successful science education and research is fostered at an early age, and depends on quality exposure to the principles and concepts in primary and secondary schools. Facility in English also seems to be important for those who are to work mainly in that language. As the amount and type of instruction in English changed in Ethiopia, there was a marked reduction in the ability of students to deal with the material they were taught in what was often their third language (after Amharinya and Tigrinya or Oromo, Somali or many other minority group languages). Experience is too limited to indicate how effectively good science is being taught in Amharic since the introduction of the vernacular throughout the school system, and what impact this has had on the subsequent effectiveness of Ethiopian researchers whose work requires their familiarity with publications in English.

Issues arising from this brief analysis

1. *Education.* The US land grant model, in its Alemaya form up to 1970, was an excellent training institution for producing practical, problem-oriented graduates, many of whom went on for graduate work, and almost all of Ethiopia's distinguished corps of agricultural researchers (many of whom now occupy senior positions in international organisations, such as FAO and the CGIAR international agricultural

research centres) received their basic training there. It was however, as mentioned above, oriented especially to the needs of the top 10–15 percent who went on to graduate school. The quality of the training was appreciated beyond the borders of Ethiopia; during the period following 1966, the INTERAF programme supported up to 35 students each year from other African countries in Alemaya's B. Sc. programme. Most of these were diploma holders from Egerton College, Kenya, Morogoro, Tanzania, and N'Kolbisson, Cameroon, who obtained a B. Sc. in 2 or 3 years; few spent the entire 4-year period.

2. *Research.* The quality of the research produced by Alemaya was mixed. There was some excellent work, and much that was mediocre. In this, it is probably no different from many other universities the world over. The reasons included isolation of the staff and inbreeding; much of the work was aimed at local problems, repeating applications already done elsewhere, and much of it was of a relatively mundane, practical but parochial type. This was particularly so in later days, when there was no money to fund travel to collect information from the field, and research in much of the Empire was now funded by the government to the Institute of Agricultural Research in Addis Ababa. Donor agencies increasingly funded projects at the IAR, not at Alemaya. Especially in the later stages when funds were short, especially foreign exchange, ordering supplies and equipment could take more than a year, so it was hard to plan good research.

   Though there were many visitors to Alemaya, few of them stayed longer than a few hours. An exception was the arrangement with the Netherlands Landbouwhogeschool in Wageningen Laboratory of Taxonomy, through which a fulltime resident taxonomist was provided to Alemaya to work on the Flora Aethiopiae. This project continued through very difficult conditions following the revolution; I believe it has now been suspended, and the herbarium needs attention. This type of twinning arrangement was remarkably productive, and is a good, but by no means the only, useful mechanism for international co-operation.

   Another limiting factor was the absence of a graduate programme, and the impetus young students can bring to departmental research programmes, as well as the challenge to the instructors. In 1971 the President of HSIU established a Committee on the Establishment of a Graduate Studies Programme which reviewed the status of a number of departments and recommended creation of M. Sc. programmes in a number of departments that had the requisite facilities and qualified staff. These included agriculture; however, the intervening financial and political problems delayed the implementation of this recommendation until 1975. By 1980, 30–40 students a year with M. Sc. degrees were graduating from the University, with their numbers increasing as resources permitted.

3. *Extension.* The notion of giving US land grant extension responsibilities to an analogous African counterpart does not seem to make sense. The situations are entirely different: in the US farmers are highly educated relatively wealthy rural taxpayers, not peasant farmers, for whom the university is a logical place to send children and to obtain the latest information about technical developments, or solve problems of an economic or technical nature. In Africa, the university trains mainly the

children of the elite, or at least the urban population who probably have little interest or intention of becoming interested in agriculture. They are, however, often interested in the plight of the rural poor, and usually thereby end up being the sole organised source of opposition to the government. This is not the type of institution to which the government is likely to entrust, along with the necessary funds, the responsibility for rural animation.

The production of good researchers, and the provision of adequate support for them on a sustained basis is a difficult problem, but one for which there are good examples of successful approaches in Africa if funds are available. The creation and support of an effective extension system seems a much more difficult problem, for which there are few examples of success, and those (e.g. AGRITEX in Zimbabwe, and the colonial or post-colonial commodity systems for cocoa, coffee, and tea, especially in Kenya) are atypical because they are supported mainly by the private sector, rather than government organisations helping peasants produce food.

ISSUES IN AFRICAN SCIENTIFIC INSTITUTION BUILDING

Michael McD. Dow

Research: why is African scientific R & D important?

The symposium is based on the premise that many African countries, 25–30 years after independence, face new sets of problems created by the economic, demographic and ecological conditions arising in the last decade. The development of solutions to these problems will require research, mainly done in Africa by Africans (of which ICIPE is the focal paradigm for the symposium). Considerable investments in African university facilities and government research institutions have been made over the past century, and there are many distinguished African scientists and excellent institutions. However, these institutions (with some notable exceptions) suffer from the results of the same problems: many African governments have been unable to support them at the levels that were originally conceived when they were set up; many of the African scientists are either drained from the local system by better opportunities elsewhere, or do not have the complex supporting environment required to permit them to sustain their focus on the issues. Hence the need to reexamine the current state of African R & D, and to focus on the role of international co-operation. Research capacity in Africa is only one component of scientific institution building in the larger context of development; development in many countries will depend on the sustained growth of a learned community of knowledgeable people who are able to analyse, understand, and communicate wisdom to others, especially those in government, agriculture and industry in what Professor Odhiambo calls "knowledge-driven development". Research, however, provides a convenient focus if it is seen in this larger sense. In this symposium, because of limitations in time and participation, we are concentrating primarily on agriculture, health and university education and training, and this paper follows this agenda.

Why international co-operation?

The economic problems that beset most African countries have roots that reach back into the colonial period in which some critical assumptions and investments were made, as will be discussed below. They assumed crisis proportions in many countries following the precipitous rise in oil prices in late 1973–1974. Few African countries have their own oil resources, and most earn foreign exchange from traditional agricultural export commodities, suffered disproportionately from their inability to adjust their economies to meet the new conditions. After 1974, more foreign exchange was needed to pay for the oil, less was generated as slumping industrial economies reduced their imports

of raw materials; loans were required to tide the fragile African economies through the crisis, and interest and loan repayments added an increasing burden. Inept or unfortunate political and economic decisions which were made, but can be absorbed by wealthier countries, are in Africa exacerbated by drought, poverty, and internal and external conflict. Inexorable population growth more than paced growth of food production, particularly with the increased prices of oil-based fertiliser and other inputs, including mechanisation and transportation.

International co-operation to assist African countries with their economic difficulties is morally required, and is also in the economic and political self-interest of the industrial countries, for whom future markets for manufactured goods and services will be important, as will the reduced potential for conflict that might involve the major (or indeed minor regional) powers. Recent experience shows that this is recognised by the donor countries, and even those that are cutting their technical assistance budgets are maintaining Africa as a priority region. The level of donor support overall, however, is insufficient, and more is unfortunately provided in aggregate for military and relief purposes than for development, or given in disproportionate amounts to countries for political gain, rather than to meet needs. Many African governments, for their part, have given signs of willingness to change past policies, to provide more incentives to producers, and to seek new ways of solving their problems.

This symposium is, therefore, based on the premise that more effective support is required to strengthen African scientific institutions and their research capabilities, that it will contribute to solving long term developmental problems, and that an examination of past experience will provide useful information on how future efforts should be focused by African scientists and planners, and through international co-operation.

The African research tradition

Prof. Odhiambo (1987) has summarised the history of research in Africa in his introductory paper to planning meeting for this symposium, noting that its roots are ancient and distinguished. In the past century, the development of "modern" research derived largely from the institutions established by the colonial powers in support of their political and economic policies, in which research was primarily focused on problems affecting a productive sector that was directed towards agricultural commodities for export. Thus were the research institutes established for commodities such as cocoa, (WACRI and IFCC, see page 5–6 for acronyms), oil palm (NIFOR and IRHO), cotton (CRC, IRCT), coffee (IFCC), and the great national or regional centres (great in terms of staff and budget, larger than many metropolitan institutes) in the Congo (INEAC), in East Africa (EAAFRO and EAVRO), in the Sudan (Gezira ARC, Wad Medani), Zaria (Northern Nigeria) and Bambey (Senegal). Health research was also distinguished (e.g. Robert Koch's laboratory in Dar-es-Salaam, Tanganyika, on bacterial diseases, the Princess Marie Louise Hospital in Accra, Ghana, on kwashiorkor, Pasteur Institutes in several francophone countries, and pathobiology institutes in Liberia and Ethiopia). However research was supported at a very low level, as it was assumed that most of the research would be carried out at European centres. This difference between the

investment in agriculture and health research was partly due to the inherent nature of agricultural research as it was then viewed, practical and with quick returns to the economy, and partly by the long term nature of research on tropical diseases and their intractability, especially as they were perceived before the development of antibiotics and in absence of knowledge about the role of vectors, disease cycles, and other ecological aspects of disease prior to the Second World War.

Almost all of the research was carried out at that time by expatriates. In the period from the end of the war until well after independence, the colonial services employed large numbers of career scientists in Africa. However, much of the research was paid for, directly or indirectly, by the private companies for whose benefit it was undertaken. And these companies were highly efficient in translating results into higher yields or lower pest infestation. Very little research went into food crops, except for those, such as Irish potatoes and strawberries, that were not available in the local market. The assumption was that the "traditional" African (or local Asian) sector could supply all that was needed for the local market for African consumption; and at contemporary population densities, that was probably correct.

This comfortable arrangement of close co-operation between the commodity research structure and the private sector continued after independence for some time; indeed it still continues in a few countries. However in many countries, the principal economic activity could not be left in foreign control, however "benevolent", and a wave of nationalisation swept over African agriculture. At the same time, population increase resulting partially from the spread of antibiotic and antiparasitic public health measures made greater demands on food crop production. So did the new awareness of nutrition and the need for more protein in the diet. The larger international community in the capital cities with their new embassies, and the increasing numbers of "been-to" Africans returning from abroad, created demands for locally-produced and imported commodities that greatly exceeded previous needs. And many countries began to curb the more blatantly ridiculous types of imports that the colonial connection had maintained to the benefit of the expatriate community, the national shipping line, and producers at home. (Until 1957 in Ghana there was no attempt to produce locally for the urban market on any scale poultry, eggs, swine, small ruminant or dairy products using modern breeds or intensive husbandry techniques. All these products were imported from Europe, along with potatoes, and temperate fruit and vegetables from the Canary Islands and Lebanon.) The new interest in promoting local food production led to the strengthening of research in these areas, mainly through the creation of national research agencies under the ministry of agriculture, and linked to a national extension system. An exception, for a short period, was Ethiopia, which adopted the US land-grant university model at the Alemaya "Imperial College of Agriculture and the Mechanical Arts", but later transferred responsibility for much of the research and all of the extension from the College of Agriculture to the Ministry (Dow, 1988).

This period also saw the growth of the African university systems, as governments expressed needs for larger numbers of trained people. Faculties of agriculture and medicine were created in many countries, staffed initially by expatriates, but increasingly by African scientists. Donor countries, flush with

altruism and benevolent responsibility that postwar prosperity was still able to support in grand style, provided assistance to create, staff and provide training for a plethora of institutes to meet almost every perceived need. By 1973, when the NRC reviewed the state of African agricultural research for the US Agency for International Development, there were estimated to be over 300 research institutes in sub-Saharan black Africa, conducting research on every aspect of agriculture in almost all countries. At many of these institutes the research conducted was of world class, and several of them (the Institute of Agricultural Research, Zaria, Nigeria; the ARC in the Sudan; INEAC in the Belgian Congo) were larger, in both staff and budget, than most analogous European institutions.

However, the pace of growth could not continue indefinitely, and already, at the time of the study, many of the former centeres were in decline. In 1974, the INEAC centre in Kisangani, Zaïre, was manned by 12 technicians, compared to the nearly 400 Belgian scientists who staffed it up to 1960. African governments were unable or unwilling to support research centres at their former level; private companies had been prevented for repatriating profits and had withdrawn their staff; and donor agencies balked at indefinite support of institutions that were not effectively linked to extension systems, or were viewed as colonial redoubts. Politics and ideology framed perceptions of institutions. Universities were, as universities are everywhere, sources of vocal opposition (often the only sources) to governments and their policies. Governments understandably told them to teach, and funded the ministries' research institutes rather than the "ebony towers".

The role of universities

University education in the Western tradition in Africa dates back to the 19th Century when Liberia College was established in 1862 and Fourah Bay College was established in Sierra Leone in 1876. They were, however, the exceptions, and it was not until after the Second World War that they were followed by the University Colleges of Ibadan, Nigeria, of the Gold Coast, Makerere, Uganda, and the Ecoles Superieures in Dakar, Abidjan and Yaoundé, that became the francophone universities (Table 8 gives the dates of founding and consolidation of the universities and important research institutions, staff and student numbers and library size). Early emphasis was heavy on law, administration, and subjects of immediate interest to the staffing of departments of the colonial administration; agriculture, engineering and scientific disciplines followed later.

The universities were elite institutions, with small classes especially in the anglophone institutions which attempted to emulate "Oxbridge", and had demanding entrance examinations. Though primarily teaching institutions, faculty were expected to spend their time when they were not in class pursuing research activities. Much of the research was descriptive, and indeed there was much that required describing botanically and zoologically, geologically and geographically, anthropologically or sociologically. Departments though small had adequate funds, staff turnover was leisurely, and many produced excellent published work. From this period came an important database that still serves as the basis for development. (It should also be indicated that during this

Table 8. Date of founding of African institutions and basic statistics

Country	Institution	Date Founded/ reorganised	Staff	Students	Vols.
Bénin	Univ. Nat. du Bénin	1970	304	8717	40K
	Inst. Rech. Coton et Textiles	1942			200
	Inst. de Rech. Appl.	1942			8K
Botswana	University of Botswana	1976/82	226	2414	
Burkina Faso	Univ. de Ouagadougou	1969/74	240	4100	55K
	Inst. de Rech. sur l'Huile et des Oléagineux	1949			
Burundi	Univ. de Burundi	1960/80	333	2237	
	Inst. des Sciences Agron.	1962			
Cameroon	Univ. de Yaoundé	1962	562	13082	90K
	Centre Univ. de Douala	1977			
	C.U. de Dschang (agric.)	1977			
	C.U. de Ngaounderé	1977/82	60	480	6K
	C.U. de Buea	1977/86	15	48	
Cent.Af.Rep.	Univ. de Bangui	1969	134	2874	28K
Chad	Inst. Rech. Coton et Text.	1939			
	Univ. de Tchad	1971	93	1372	12K
Congo .	Cen.d'Ens. Sup./Univ. Marien-Ngouabi	1961/71	682	10636	
	ORSTOM	1950			
	Centre Tech. For. Trop.	1958			
	Conseil Nat. rech. S.et T.	1966			
Côte d'Ivoire	Univ. d'Abidjan/ Univ. Nat. C.I.	1958/64	728	12755	64K
	Inst. Rech. Coton et Text.	1946			
	Org. Rech. S & T Outre-Mer (ORSTOM)	1946			
	Institut des Savannes	1968	25		2400
Ethiopia	Univ. Coll./Haile Selassie I Univ./				
	Addis Ababa University	1950/61/74	899	12110	
	Coll. Agr./Alemaya Univ. of Agric.	1952/86	181	1568	
	Inst. of Agric. Research	1968	2411		
	Asmara Univ. Italian/English charter	1958/68	153	3457	50K
Gabon	Univ. Libreville/Univ. Omar Bongo	1970/78	295	2400	12K
Ghana	Cocoa Research Institute	1938	217		13K
	Univ. Coll. Gold Coast/Univ. of Ghana	1948/61	543	3416	
	Univ. of Science & Technol.	1951/61	486	3082	
	University of Cape Coast	1962	190	1494	
	Council on Sci. & Industrial. Res.	1958/66			
Guinea	Inst. Past./Inst. Rech. Animal Past.	1923/65	18		254
	Université de Conakry	1984			
Kenya	Egerton Coll./Fac. Agric., Univ. Nairobi	1938/72		1400	38K
	Univ. Nairobi/Kenyatta Univ.	1972/85	400	500	163K
	Roy. Tech. Coll. E. Afr./Univ. Nairobi	1956/70	863	9274	
	Moi University	1984	31	112	2K
	Ken. Ind. Res. Dev. Inst.	1948			
	Inst. Med. Res. and Training	1964			

(continued)

Table 8. (Continued) Date of founding of African institutions and basic statistics

Country	Institution	Date Founded/ reorganised	Staff	Students	Vols.
Lesotho	Univ. Bots. Les. Swaz./Nat. Univ. Les.	1966/75	161	1143	
Liberia	Liberia Coll./Univ. of Liberia	1862/1951	250	3317	
	Central Agric. Res. Institute	1946			8700
	Liberian Inst. Biomedical Research	1952/75			
Madagascar	Université de Madagascar	1961	843	40000	
Malawi	University of Malawi	1964			
	Bunda Coll. of Agric.		48	404	26K
	Chancellor College		165	1023	177K
Mali	Cen. Nat. Rech. Zootechnique	1927			1000
	Office du Niger	1932			
	Cen. Nat. Rech. Fruitière	1962			
Mauritania	Univ. de Naouakchott	1981	72	2850	
Mauritius	Univ. of Mauritius	1965	72	619	69K
Niger	Univ. de Miamey	1971/73	273	1825	
Nigeria	Inst. Agric. Res.	1924	206		
	Nig.Vet. Res. Inst., Vom	1924			16K
	Cocoa Res. Inst. of Nig.	1938			10K
	Nig. Inst. of Oil Palm Res.	1939			
	Univ. Coll./Univ. of Ibadan	1948/62			353K
	Ahmadu Bello University	1962	1643	15103	
	Univ. of Nigeria	1960	859	12400	423K
	Univ. of Ife/O. Awolowo Univ.	1961/87	1037	13500	313K
	Univ. of Lagos	1962	600	10000	250K
	Univ. of Benin	1970	682	10000	100K
	Univ. of Calabar	1975	406	4591	
	Univ. of Ilorin	1975	424	5817	39K
Rwanda	Inst. Rech. Sci. Afr. Cen.	1947			3K
	Univ. Nat. du Rwanda	1963	217	1570	110K
	Inst. Sci. Agron. Rwanda	1962	1000		2500
Senegal	Centre de Rech. Agron., Bambey	1921			6700
	Lab. Nat. Elevage et Rech. Vet.	1935			12K
	Inst. Sén. de Rech. Agron.	1974			
	Univ. Dakar/Cheikh Anta Diop Univ.	1949/57	722	11474	273K
Sierra Leone	University of Sierra Leone	1969			
	Fourah Bay College	1827/1876	155	1448	132K
	Njala University College	1963	80	887	
Somalia	Somali National Univ.	1954/69	549	4640	
Sudan	Agric. Res. Corp.	1918	140		15K
	Univ. Coll./Univ. Khartoum	1945/56	685	14000	209K
	Nat. Council for Res.	1970			
	University of Gezira	1975	140	1000	
	University of Juba	1975	151	1050	

(continued)

Table 8. (Continued). Date of founding of African institutions and basic statistics

Country	Institution	Date Founded/ reorganised	Staff	Students	Vols.
Swaziland	Univ. Bots. Les. Sw./Univ. Swaziland	1964/82	150	1300	
Tanzania	Nat. Inst. Med. Research	1949			
	Univ. Coll./Univ. of Dar-es-Salaam	1961/70	884	3615	350K
	Morogoro Coll./Sokoine Ag. Univ.	1948/84	215	586	50K
Togo	Inst. Nat. Rech. Agron.	1965			
	Université du Bénin	1965/70	269	5223	50K
Uganda	Makerere Tech. Coll./Univ. Coll./ Makerere University	1922/49/70	700	7000	400K
Zaïre	Ins. Nat. l'Etude Agr. du Congo/ Ins. Nat. l'Et. Rech. Agron.	1933/75	6010		41K
	Univ. Lovanium/Univ. Nat. Za./ Université de Kinshasa	1954/71/81	700	7000	300K
	Univ. Lubum./Univ. Nat. de Za./ Université de Lubumbashi	1955/71/81	403	4370	92K
	Comm. Gen. Ener. Atom.	1959	80		2400
	Univ. de Kisangani	1963/81	216	2439	90K
	Inst. de Rech. Scientifiques	1975	96		12K
Zambia	Univ. of Zambia	1965/79	534	4006	
	Trop. Disease Res. Centre	1976	32		2200
Zimbabwe	Cotton Research Institute	1925			
	Blair Res. Laboratory	1927			
	Henderson Res. Station	1949			
	Univ. Coll. Rhod. & Nyas./ Univ. Rhod./Univ. of Zimbabwe	1955/70/80	500	6873	355K
	Agric. Research Council	1970			

Source: The World of Learning. Europa Publications Limited, London (1988 Edition).
NB: This illustrative, not comprehensive, list includes dated WOL entries only.

period much important scientific data was collected by botanists, zoologists, geologists and anthropologists attached to government departments in the colonies, many without formal academic credentials.) Faculties of agriculture and medicine were added relatively late, involving very substantial investments in land, facilities, and high-priced medical faculty. Ghana added agriculture just prior to independence in 1957, medicine soon after; Nigeria's universities were begun in 1948, and an astounding proliferation of them followed the civil war as each state of the reorganised Federation established its own, if it did not already have one. Francophone students still went to the metropole until the universities of Dakar, Abidjan, and Yaoundé and their counterparts in other francophone countries were created.

The universities soon became overwhelmed by numbers. There was pressure to produce more qualified students to do advanced degrees to indigenise their instruction; to fill the establishments of the new, numerous and swelling ministries of the indepedent governments; and soon, to provide more spaces for the growing numbers of high school leavers. In the early days, university education was not free, but costs were relatively low and bursaries

or scholarships liberal. In Ghana, all students reading agriculture were provided a stipend by the Cocoa Marketing Board, by which it was hoped to attract better brains to the land rather than to the law. After Independence, Ghanaian education was free to all as a right of a free people. At the university level, this came with the proviso that students could be admitted up to the limited numbers of residential spaces, as in the pursuit of equality all should be housed equally, and there were no day-students as there were in the teeming francophone institutions. Standards were maintained at high levels through the competition this entailed. School building proliferated at all three levels, and the country spent of the order of 25 percent of its budget on education, including additional universities at Kumasi (the erstwhile Kwame Nkrumah University of Science and Technology) and Cape Coast (mainly for producing teachers), which were filled to capacity. Much support for research, expansion and faculty development was provided by external sources, through governmental development agencies, but particularly by the US private foundations, which played an enormously important role in supporting higher education and research and in so doing helped shape the present form of African institutions.

Large numbers of students and pressure to cut costs as the government payrolls increased, increasingly led ministries of education to emphasise universities as teaching institutions, with research implicitly as a secondary activity and (explicitly in Ghana and Ethiopia) directed towards generating locally relevant teaching material rather than generating new knowledge *per se*. Many institutions also required faculty to participate in departmental "bread and butter" research, i.e. research deemed by the institution hopefully to be of direct and early use to meet a local priority need, and this further limited the time and resources left for individual investigative preferences. The ministries of agriculture, health, mines, energy, water resources, etc. were encouraged and assisted by bilateral agencies, and international organisations such as FAO through UNDP funding, to establish their own national research capabilities separate from the universities. This was attractive, because by this time the commodity-supported research institutes had been nationalised, but the ministries needed practical research capacity in food crop, water, soils and other areas not adequately provided for, and in which the universities were unable or unwilling to provide the type of timely information they required. There thus came to be established separate and parallel systems of research: university departments, though funded by the government (typically under the ministry of education) usually maintaining an arms-length academic purity; and, governmental national research institutes carrying out applied research, also funded by government through the line ministry; and both competing for their share of the national investment in R & D.

The competition for scarce resources was accentuated by the phenomenon of student activism, which arose in many countries. The universities were frequently the only source of organised vocal opposition to government, regardless of where government policies lay on the ideological spectrum. It drew strength from opposition to what were thought of as neo-colonial attitudes of donor governments, in regard to their investments in the country and the strings that were actually or presumed to be attached to them; from opposition to apartheid in South Africa, and the policies of the countries in that respect (given greater urgency by the Sharpville massacre, and the

Unilateral Declaration of Independence in Rhodesia, as well as the indignation at the tentative pragmatism of the Côte d'Ivoire, Malawi and several other countries towards South Africa); from their faltering economies, and the failure of social programmes in many countries, leading to frustrated expectations; and to corruption and excesses of power. Later, as we shall see, student activism was fueled by attempts of governments to recover from the students, and their families, some of the costs of housing, feeding and teaching them.

The universities were thus frequently viewed by governments as repositories of opposition, and the budgets were affected by this perception. Not only local funds, but donor projects were often directed away from universities towards the government's own facilities. This was also a result of declining donor interest in funding universities; there was a feeling that the job had been done, that enough higher education infrastructure had been created with considerable outside investment, and it was time the local institutions should stand or fall on their merits.

Following the oil-price-induced crisis of 1973–74, and the subsequent recession, inflation and debt period which set back most African economies by several decades, the universities entered a period of increasing hardship. Governments simply did not have the resources to meet all of their obligations, and faculty were lucky if their salaries were met, let alone the subscriptions to journals, book and equipment purchase which are the normal features of the research environment. In some countries, it was necessary to take other jobs to make ends meet, and to rely on family in the rural areas to supply food. Under these conditions, many top researchers were attracted to positions abroad; in many countries effective research was only possible where it was largely supported from external sources. In many cases individual researchers have appalling difficulties and distractions which prevent them from concentrating on their research; the bureaucratic structure tends to militate against them instead of helping them. Often they are not permitted to control their research budget, even when it is provided to them individually in an externally-funded project, and approvals to do anything take time, while the supporting infrastructure of maintenace, spare parts, library and collegial assistance taken for granted in more fortunate institutions, is often absent in many. To further complicate this already difficult milieu was added a more recent new factor, as a number of governments, in response to the pressures towards greater "fiscal responsibility", attempt to trim their education budgets by recovering costs of food, board and teaching by introducing, or re-introducing, fees or charges. This assault on the previously sacrosanct principle of free education has provoked an eruption of student strikes, sit-ins and demonstrations, and universities all over Africa have been forced to close, for short periods or even as much as an academic year, with enormous disruption to the teaching programme and the calm routine and reflective atmosphere in which university business, especially research, is best accomplished.

International co-operation is an essential component of much African R & D, education and training, as these institutions face a continuing shortage of resources. One premise of this symposium is that it will remain an essential component for the foreseeable future, until African economies have recovered to the point where they can shoulder the bulk of the responsibility for meeting the costs. The questions to be answered include, what are the priorities, what

are the essential institutions that need to be saved from collapse, and how is this to be accomplished? With regard to the universities, these issues include:

- What is the role of the university in R & D, other than producing trained personnel? Can universities produce the manpower required (i.e. through M. Sc. and Ph. D.) without a strong research capacity?
- Should there be a streamlining of universities to focus on essential areas, cutting back non-essential departments, and relying on training abroad in areas where a local critical mass cannot be maintained? Should universities become more, not less, elite, smaller and less democratic?
- What are critical areas? One example is the problem of collections of material, such as botanical specimens in herbaria and botanical gardens. Many of these, built up over decades through the aggregate work of thousands of researchers and collectors, are severely deteriorating. The more we learn about tropical ecology, the more important these collections are for future resource management. Yet these collections are not usually of high priority to governments or donors. Another issue is libraries: as publishing becomes more expensive, books, journals and other periodicals and reference materials are becoming prohibitively expensive. To what extent can hard copy be replaced by access to international computerised databases and related services?
- Can countries continue to see government as the principal source of university funding; is there a role for increasing private support? Could private regional universities (analogous to the American University in Beirut) provide sustainable, useful alternatives?

First- and second-cycle education

An additional area for re-examination by the symposium is basic education: are universities turning out the types of graduate required, and able to keep up standards? In many countries, there is a perception on the part of thoughtful observers that the problem of producing effective scientists begins with the absence of a tradition of critical inquiry in the African home and traditional social structure. (It is recognised that these attitudes are changing, but the rate of change is slow.) In the traditional system, young people are not encouraged to question, but expected to accept information and learn from their elders. Contemporary curricula have substituted new information, but without instilling a new perception of how to use it, and the result is the worst of both worlds. In addition, the "democratisation of education" as David Court calls it, spreads enormous resources thinly over the country, with poorly qualified and poorly paid teachers attempting to teach alien concepts. The children are removed from their traditional apprenticeship possibilities, without being offered a really useful alternative. Mission schools which used to serve the devout and elite, are either nationalised or carefully controlled. In some countries there is a re-examination of the desirability of looking after the special needs of the brightest children at an early age, and providing them with an alternative, science-based curriculum and environment to produce elite students for the universities. But in many places the curricula neither promote

excellence, nor provide a satisfactory educational base for the majority of average pupils who will not proceed through the 2nd and 3rd cylces.

National research institutions

National research capacity, outside the universities, derives from three sources:

- the commodity institutes, mainly but not entirely nationalised after independence (c.f. Kenya Tea Research Institute);
- the former colonial institutions responsible for mainly applied research on soils, water resources, health etc.; and
- institutions created following independence, usually with donor support, to meet perceived needs not already addressed (e.g. Ghana, Food Research Institute; Ethiopian Institute of Agricultural Research; Nigerian Federal Institute for Industrial Research; Tanzanian Industrial Research and Development Organisation).

It is difficult to generalise about these institutions; they tend to suffer from excessive bureaucracy that makes it difficult to respond quickly to new circumstances, from stultifying promotion procedures that tend to drive out good people, and from compartmentalisation that prevents easy interchange of information with universities, the private sector, and extension or outreach. Frequently, they have less than optimal numbers of scientists of the right kind, the critical mass that permits fertile interchange of ideas, and attracts the best people (and support for them) at a "centre of excellence". They are widely perceived as being unproductive; other parts of government, sometimes even their own ministries, have low expectations of their output, and this is often a self-fulfilling prophecy. There are good people doing good work in them, and some are more productive than others, but the overall level of achievement, innovation and productivity is poor. A recent analysis (of BOSTID's African research grants) showed a variety of problems encountered by researchers that erode the individual researcher's ability to perform (including many of the same problems identified above for universities).

In agriculture, the CGIAR International Service for National Agricultural Systems (ISNAR) provides support for local systems as far as food crop research is concerned; no such assistance is provided in quantity for commercial crop research, and the institutes responsible for this research are suffering. (USAID provides small grants for innovative approaches to biotechnology, including cash crop commodities, for co-operative research between US and LDC investigators; the International Foundation for Science provides small grants to individual LDC scientists.) The focus on food research is partly in response to local political pressures, partly to the priorities of donor agencies. One major issue confronting both recipients and donors is the extent to which this focus should continue. The argument is made that while food self-sufficiency is an attractive political objective, it has led to opening up marginal lands that would be better used for other things. How much forest should be cut down to grow food, when it may cost up to 10 times the world market price? Would it not be better for development (through "sustainable

agriculture") to produce commodities for which Africa has a comparative advantage, such as high quality timber in the rain forest, and to add value as much as possible to primary commodities, such as coffee and cocoa, prior to their export, rather than concentrate so exclusively on food? Another aspect is the possibility of returning commodity production, and much of the support for its research, to private industry.

This will require a re-orientation of priorities. A recent International Fact-Finding Mission of the African Academy of Sciences identified critical areas of basic science, related to drought, desertification and food deficit, that are receiving insufficient attention and should be strengthened through co-operation among national systems, with international support and co-operation of scientists outside Africa. These include: basic soils research on long term management of the 10 major soil types; research on soil microbiology; research on biotechnology, especially the use of modern tissue culture and other techniques of manipulating germplasm; on indigenous germplasm, to select among species important in traditional use those of potential to agro-industrial diversification; and on postharvest technology.

National S & T co-ordinating and supporting bodies

A related issue concerns the role of national S & T co-ordinating bodies: the research councils, councils for scientific and industrial research, ministries and similar organisations. There is need for a mechanism for planning, analysing and co-ordinating research, establishing priorities, promoting international co-operation and collaboration, seeking funding both internal and external, and above all, seeing that research is used by line ministries and the private sector (with contract arrangements where appropriate). In the period following independence, as the role of S & T in economic and social development came to be recognised, many countries set up these organisations or agencies, with and without assistance from outside, using a variety of approaches or models.

A number of countries established National Academies of Science, as either governmental with responsibility for actually running research institutes (Soviet Union analog) or private honorific and advisory bodies (Royal Society or NAS analogs). National Research Councils were established, especially in anglophone countries, along the lines of the British ARC/MRC quasi-governmental bodies, and in some cases these were attached to ministries, or reported to the ministry of planning or the office of the prime minister/president. In the francophone countries, these responsibilities were usually vested in a department of a line ministry, often higher education, but sometimes sport *et jeunesse*. An active Unesco programme assisted a number of countries (including Ethiopia, Kenya, Nigeria, Sudan and Tanzania) to establish research councils, the science policy division in Paris providing senior expert advisers to help with the planning and implementation of a recognisable Unesco model. In other cases, advisory bodies or institutes established by the colonial powers were nationalised and absorbed into the reorganised structure.

On the whole, these bodies have not played as important a role as might have been hoped. There are many factors involved: where they are not part of the line ministries, they are viewed as diverting resources from the real needs, meddling in other ministries' affairs, or interposing a further level of

bureaucracy; where they are attached to a line ministry, they cannot co-ordinate national policy and may be ignored by other ministries. Those (such as Sudan and Tanzania) that use government funds to support research by providing grants, may be viewed as useful by the recipient scientists, but the ministries or universities feel they could have used the money better without the council filter. There is also criticism that the grants are spread around thinly and equally to researchers regardless of quality (for political reward rather than scientific merit), with little focus or insufficient concentration to make an impact on a critical problem, and that the projects funded are too academic.

This problem results partly from a general perception of science and scientists on the part of politicians and the public in Africa that science is an interesting phenomenon, essentially alien, that is required as part of the process of becoming a modern society, but that has little impact on the real business of the world. There is deference to it, but little is expected of it: even medical science is not excepted, since it is well-known that hospitals are places you only go if you are in extremis, because many people die there; universities are places where children can become initiated in the other culture that gives them access to resources to which most people could never aspire; research institutes have to be borne by the community, like taxes, but you don't see where the money goes. These perceptions are often self-fulfilling prophecies. Seldom do the institutes produce anything useful in the political time-span, and small wonder they seldom receive the attention or support that might make them useful.

There is an important need not to popularise science, but to popularise understanding of the relevance of scientific knowledge of everyday processes, and how this knowledge is important to fundamental problems of society.

Effectiveness of research institutes and councils is a function of leadership as much as structure. Arguably, pragmatic S & T structures that have been erected around leaders with vision to meet particular needs have been more successful than standard model approaches in which the structure is created bureaucratically, and the position advertised. No comprehensive analysis has yet been undertaken (though Tebicke, 1987, has made a start in a number of countries for SAREC).

What, then, are successful models of research councils? How can they be made more effective, and more influential (where the influence is deserved) in national S & T management? This is partly a national political problem, but can have international co-operation aspects.

Management of S & T and the private sector

Most research in Africa is in government hands, and one issue is the extent to which that should be changed. It is probably fair to say that if the commodity research was turned back to the industry, and if in turn the industry is able to control its own affairs, and not be operated as a government monopoly, then there might be a more robust and responsive system. An interesting analogous situation comes from the People's Republic of China, where the government is converting many of its functions to semi-autonomous or private status. The US is assisting this process through the Dahlian Institute of Management, at which American experts provide seminars and lectures to

high-level government officials in theory and practice of management of entreprises and institutions in the private sector and their relations to government departments. This model has received acclaim for its relevance and effectiveness during a critical period in which government bureaucrats need to be retrained. It has also been suggested that the Dahlian example may have relevance for African needs. While recognising that Africa and China in many ways are very different, and that there are already many institutions in Africa where management is taught, there does seem to be a particular need for experience in managing R & D linking government to the private sector, encouraging investment of risk capital, and generally supporting agro-industrial development as countries move from a subsistence agricultural sector to more modern treatment of food and commodities. The symposium may have some guidance on needs in this sector and the relevance of the Dahlian model.

Regional and international research institutions, and supporting organisations

Prior to independence, colonial administrations had established a number of regional research organisations to co-ordinate research within their territories and among them; these included the Conseil Scientifique de l'Afrique, and the Comité de Coopération Technique Africain, which, following independence and the creation of the Organisation of African Unity, were converted into the Scientific and Technical Research Commission. The OAU/STRC undertook a number of regional projects, notably the Joint Project JP15 to eradicate the livestock diseases rinderpest and contagious bovine pleuropneumonia in East and West Africa. This project almost succeeded, howeve, outbreaks of hostilities in key reservoir areas (Chad, Ethiopia, Somalia, and Western Sahara) plus declining government support for the sustained veterinary vaccination programme allowed the diseases to recur.

In response to the needs for regional research capacity in agriculture, as opposed to implementation of technical solutions, the Consultative Group on International Agricultural Research (CGIAR, a voluntary association of bilateral governmental and private donor organisations chaired by the World Bank with a secretariat provided by FAO and the Bank) created a number of African research institutes: the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria; the International Laboratory for Research on Animal Diseases (ILRAD) in Nairobi, Kenya; the West African Rice Development Association in Monrovia, Liberia; and the International Livestock Centre for Africa (ILCA) in Addis Ababa, Ethiopia. Regional sub-centres of CGIAR centres in other parts of the world have also been established, including an ICRISAT sub-centre for sorghums, millets and pasture legumes in Bamako, Mali, and a regional potato program of the Centro Internacional de Papa (CIP) in Cameroon. The performance of these regional centres has been mixed. There has been some extremely fine work, such as the biological control of the cassava mealy-bug that threatened to wipe out this major staple in much of the continent, that was successfully developed by IITA over the decade 1978–87. ILCA has revived earlier work on trypanosomiasis-resistant strains of cattle, such as the West African N'Dama that were discovered in the 1950's to have evolved this defense mechanism, and IITA has achieved success in developing

some intercropping agroforestry systems, involving maize and Leucaena, that show promise of sustainable systems of continuous production without requiring uneconomic levels of fertilizer, pesticides and herbicides. However, compared with the International Rice Research Institute (IRRI) in Los Banos, Philippines, and the Centro Internacional de Mejoramento de Maiz y Trigo (CIMMYT) El Batan, Mexico, output of improved strains of crop, or what the Bank calls "technical packages", has been limited. This is partly due to the nature of the problems the African centres are tackling; IRRI and CIMMYT are developing improved strains of high-yielding varieties of staple food crops, and have been successful in promoting the use of these strains in Asia and Latin America, in countries with motivated farmers, good extension systems, and a responsive private sector to make available seed, fertiliser and other required inputs. IITA and ILCA are dealing with the development of new farming systems, as opposed to strains of staple crop, and without the centuries (in the case of rice, millennia) of recorded experience on which to base the research. The national research systems, on which the CGIAR depends for the countries to adapt their varieties and techniques for local distribution, as we have seen, are limited in their capacity to support the work. The new African CGIAR centres also were created at the end of a period of almost unlimited funding for the CGIAR system, and as hard priorities have been imposed, have been relatively underfunded. Furthermore, it has been discovered that few of the improved strains and technical packages that have been so successful in supporting the "green revolution" in Asia have been transferrable to the African context, because of the different edaphic and ecological conditions. Thus while the general approach remains valid, the basic breeding research and field trials must be repeated in Africa. In addition, basic soils research (on management, nutrition and microbiology), which provides the critical underpinning for the crops research programme, has been seriously neglected until recently, as reflected in recommendations by African Academy reports and the creation of an African regional centre in Nairobi of the CGIAR International Board for Soil Research And Management (IBSRAM).

Two other associated regional centres are the International Council for Research in Agroforestry (ICRAF) and the International Centre for Insect Physiology and Ecology, (ICIPE) both located in Nairobi. Though not formally part of the CGIAR system, they are closely linked to it, and receive the bulk of their funds from the same group of donors. The ICIPE story has been told elsewhere (Rabinowitch, 1986) and its success in creating an African centre of excellence for research on the main insect-borne diseases is well-known. ICRAF's research programme experienced some difficulties in attracting support during its early period, but it now seems firmly consolidated and commands sufficient support to assure sustained efforts for the foreseeable future. Like IITA's farming systems research, it has a much more intrinsically difficult type of research to accomplish than that of the commodity centres, since agroforestry (and its cousin, silvo-pastoralism) concerns complex multifactoral systems in which cause and effect relationships among constituent organisms are very hard to establish.

Both organisations have experienced lengthy soul-searching concerning the degree to which they should focus on basic and applied research. Though the dichotomy is in many ways artificial and the distinction blurred, it is real in the practical sense that to attract support from donors and governments they

must be perceived as being useful, and this means that results are obtained, whether from basic or applied research, that justify the investment. Much of this is accomplished through auxiliary training programmes, and assistance with the improvement of management of research in these fields in national research systems.

There are many other regional organisations, either undertaking research, or assisting with training, co-ordination of research, information dissemination or other related aspects. These include:

Intergovernmental agencies:

- Sahel Institute (INSAH), Bamako, Mali;
- African Regional Technology Centre (CRAT), Dakar, Senegal;
- IDEP, Dakar;
- CODESRIA, Dakar;
- UN Economic Commission for Africa (ECA), Addis Ababa;
- Organization Commune Contre les Grands Endemies (OCCGE) Ouagadougou, Burkina Faso; and
- Organization Commune pour la Lutte des pestes Aviennes (OCLALAV), Dakar.

Non-governmental organisations:

- The Association of African Universities (AAU), Accra;
- The Association for the Advancement of Agricultural Sciences in Africa, (AAASA), Cairo;
- The West African Science Association; and
- the MIRCEN's—Unseco-sponsored Microbiological Resources Centres (in Nairobi and Dakar) which serve as regional foci for such important things as sources of rhizobia inoculant for nitrogen fixing legumes and trees.

Most of these organisations were created with excellent intentions to meet worthy needs, and were supported initially from external funds, and in some cases with matching funds from African governments. However in the cold light of tighter budgeting, most of them now limp along on minimal budgets, and the services they provide to their clients are episodic and, though interesting, seldom sufficient to attract adequate support from within Africa to be self-sustaining. This is particularly important for small countries, with small scientific communities, that cannot cover all the fields they would like to. In principle, regional institutions would provide for their needs; in practice, so far the experience has been disappointing.

The issues are, therefore:

- What is the role of these organisations, and to what extent should external funds continue to support them? Is there need to streamline, and consolidate? This has arisen recently in exploration of co-operation between the US AAAS and the AAASA, the Association of African Faculties of Agriculture and other bodies, in which support for this co-operation may depend on the ability of several African agricultural

research supporting organisations to combine their efforts so that, at least, they do not require separate secretariats. The recently-formed African Academy of Sciences and Pan-African Union of Scientists and Technologists (headquartered in Nairobi and Brazzaville respectively) both represent important African initiatives to strengthen indigenous scientific capabilities, to identify priorities and draw attention to the critical role of S & T, and to consolidate African resources. They should be assisted where appropriate in absorbing the membership and programmes of smaller regional bodies.

- What are successful examples of regional organisations?

  * ICIPE has received attention and praise as an example of an African regional organisation successfully carrying out both fundamental and applied research in important areas at world-class levels.
  * IITA has been very successful in developing several areas of biological control of pests and intercropping/minimum tillage technical systems; its impact is limited by constraints of working through national research systems, and only on food production problems.
  * The MIRCENS in Dakar and Nairobi are working usefully in the crucial area of soil microbiology and some aspects of industrial fermentation; they have some Unesco support but essentially work on shoe-string budgets with part-time scientists. A recent African Academy-sponsored International Fact-Finding Mission drew attention to the importance of supporting this work at a more substantial level.
  * CODESRIA in the social sciences is an example of an organisation that has been influential in bringing together African scholars to write on current problem areas from a regional focus.

It would be helpful for the symposium to review these cases and others and comment on the factors affecting success.

International co-operation

International co-operation has been a feature of African S & T institution building since the Second World War. It has been manifested in a variety of ways, as this paper and others at the symposium indicate. The premise is that the need for international co-operation is greater than ever, and is likely to continue to be important for the foreseeable future through a period of austerity affecting many African countries as a result of current economic woes. Several main lines of co-operation can be identified:

- *Policy level co-operation*: assistance with planning, priorities, and identifying external resources are needed. African governments are already spending huge sums on many aspects of institution building, particularly in education. Often preoccupation with current problems preempts time and effort given to longer term planning, and of looking

inwards at the effectiveness of local scientific institutions and how they should be strengthened. Assistance which provides resources to permit reflection (sabbatical leave; participation in a workshop with uninvolved neutral outsiders) can often provide stimuli to clarity; neutral external organisations, such as private foundations, can often provide informal information and insight about potential resources available from their countries, beyond what are often of necessity rather more formal government-to-government negotiations with aid agencies. (A feature of international co-operation is the demand placed on local officials by visiting donor agency fact-finding or aid negotiating groups. Assistance to co-ordinate information to respond to these demands can be a critical way institutions are able to perform.)

- *Institutional support*: assistance with training and manpower development through universities and colleges, scholarships and similar mechanisms; assistance with infrastructure, usually not buildings, but often equipment, libraries and other information activities where an injection of foreign exchange can be crucial (the role of private firms has been influential in introducing microcomputer/electronic data handling information systems); support of research through grants to institutions and individuals. A recent development has been the possibility of supporting a local organisation to administer a programme of competitive grants. African researchers and institutions may require additional assistance resulting from the lack of support structures that are available elsewhere, that requires them to spend inordinate amounts of time on solving bureaucratic problems. It appears that foundations and other private organisations are able to provide the level of continuity, and freedom from representing government interests, that government agencies cannot.
- *Assistance to focus on technical areas*: often African governments have difficulty in responding institutionally to new situations, new problems areas which arise, or take advantage of emerging technologies—their resources are already stretched to the limit to meet current obligations. There is an important role for international co-operation in assisting with timely response to problems (such as drought and environmental problems, health such as the response to AIDS, and taking advantage of new technologies—biotechnolgy techniques; microcomputers and information management systems; or new material technologies).

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AFRICAN SCIENTIFIC INSTITUTION BUILDING: THE CASE OF THE CENTRE RÉGIONAL D'ETUDES NUCLÉAIRES DU KINSHASA (CRENK)

*Malu Wa Kalenga**

Introduction

African scientific and technical institution building, indeed any institution building in Africa, is supposed to be a demanding if not an impossible task. This opinion derives from the fact that Africa is confronted by many well-known and well-documented complex and severe problems in all sectors of its socioeconomic life.

The recent ICIPE Foundation discussion on International Cooperation to Strengthen African Science and Technical (S & T) Institutions has dealt extensively on some of those problems. Yet as the case of the CRENK demonstrates, building African institutional capacity in science and technology, even in high technology, is far from being an impossible task although it is, as in any part of the world, a demanding one. What is needed is the right combination of leadership, good management and scientific-political "entente cordiale".

In the case of nuclear research, another good example in support of this statement is the building in India by Baba of what can rightly be considered a first-rate nuclear research establishment.

The history of nuclear activity in Zaïre

Nuclear activity in Zaïre (former Belgian Congo) started with the mining of radium by the "Union Minière du Haut-Katanga," in the famous Shinkolobwe mine in today's Shaba region (formerly Katanga province). Before 1939 radium, a by-product of uranium, was far better known than uranium on account of its use in medical research. The use of uranium was limited for the most part to the ceramic industry. The total consumption of uranium in the world was less than 100 tons, with 80 percent coming from "the Belgian Congo".

Scientific activities and developments related to nuclear fission going on in Europe before 1939 and in the United States after the start of World War II made the matter of uranium procurement an urgent international concern.

Just after the outbreak of the World War II, the Belgian Congo was able to provide to the US government 1,200 tons of high grade ore (65 percent uranium oxide) which was stored on Staten Island by the "African Metals Corporation", an affiliate of the "Union Minière du Haut Katanga".

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Even when the war nuclear research efforts were proceeding, concerns were expressed that the US government supply of uranium ore for post-war military or commercial purposes might be exhausted. To control the world's best source of uranium ore located in the Belgian Congo, the United States and the United Kingdom were able to secure from the Belgian government-in-exile virtually the entire supply of the Shinkolobwe mine through the provision of a secret "Memorandum of Agreement Between the United States, the United Kingdom, and Belgium regarding control of Uranium". The memorandum was signed in August, 1944.

Over the years 67,400,000 pounds of uranium oxide were delivered to the United States with the condition that Belgium would be able to reserve "such reasonable quantities of the said ores as may be required for her own scientific research and for her own industrial purposes exclusive of any process involving the use of such ores as a source of energy".(1)

To underscore Western concern for secrecy and protection of the uranium ore produced in the Belgian Congo, elaborate steps were taken in the 1950s to protect the Shinkolobwe mine against sabotage. Co-operation between Belgium and the United States did continue at a high level for several years after the war, in spite of difficulties related to the secrecy of the agreement. A nuclear research centre was built at Mol, in Northern Belgium, with the active support and assistance of the US government.

Nuclear activities in the Belgian Congo remained concentrated in the mining sector up to 1958, that is, up to the adoption of the statute of the International Atomic Energy Agency (IAEA), which was set up in Vienna, Austria a year before following President Eisenhower's "Atoms for Peace" programme. One of the first initiatives of the IAEA was to organise the first international meeting of the series of the so called "Geneva International Atomic Energy Conference" which was to take place every four years. During the conference the first TRIGA Mark I reactor, built by General Atomic, an American firm located in San Diego, California, was on display. The nuclear reactor, a small 50 KW swimming-type machine, was bought by the Belgian Congo upon the personal intervention of Mgr. Luc Gillon, a nuclear physicist who was at the time the Rector of Lovanium University in Kinshasa. The nuclear reactor became operational at a site on the Lovanium University campus on June 6, 1959, fifteen years after D-Day.

Having been the first and most important producer of uranium ore, the Belgian Congo thus became the first country on the African continent to operate a nuclear reactor. A small nuclear research centre, the TRICO Centre, was set up with one Belgian technician under the supervision of the "Commission Consultative des Sciences Nucléaires" under the leadership of Mgr. Gillon. The machine was used primarily by the university staff for teaching purposes and some activation analysis studies.

As the independence of the country loomed large, the Belgian government decided to create a more elaborate and permanent body to deal with nuclear energy in the Belgian Congo. On June 10, 1960, King Baudoin of Belgium took an *arrêté* creating the "Commissariat des Sciences Nucléaires (CSN)" with the following aims:

1. promoting and sustaining research in nuclear science in order to apply its results to the development of the Congo;

2. assisting in the building and running of nuclear power plants and of installations for the production of radioisotopes; and
3. insuring the centralisation of information and documentation related to the work done or projected in the Congo in the nuclear fields.

In the first five years of the post-independence period, nothing of substance was achieved in the nuclear research fields due to upheaval in the country. Concerning mining activity, the Shinkolobwe mine was shut down in 1962 because of poor economic prospects related in part to strong international competition fostered by the rapid diversification of uranium suppliers, and in part to serious technical problems in the mine caused by repeated flooding of the ore body.

In July 1965, President Kasa-Vubu took the remaining measure to make the CSN operational. He signed the *ordonnance* nominating the members of the governing body, and the author of this paper was put in charge of the entire nuclear programme in the country. The same year we decided to launch an upgrading programme of the nuclear centre and to organise its work around a more powerful TRIGA Mark II nuclear reactor to be built by the local staff.

In 1967, the annual gathering of the Heads of State of the Organisation of African Unity (OAU), which took place in Kinshasa, decided to transform the TRICO nuclear research centre into a regional centre. Thus was born the present CRENK whose aim was to provide nuclear research facilities including radioisotopes to any interested member of the OAU.

The new status of the Kinshasa nuclear research centre put a new urgency into the upgrading programme of the nuclear reactor. The first stone of the concrete building to house the new reactor was laid down in 1969 during the first-ever OAU nuclear research conference organised jointly by the CSN and the IAEA.

The new TRIGA Mark II nuclear reactor was completed on March 30, 1972. Two years later, on November 20, 1974, the nuclear reactor was pulsed to more than 1,600 MW becoming, in the process, the most powerful research reactor on the African continent, which it is still today. This remarkable feat was accomplished, as planned from the beginning, by the local staff. That is, all the new facilities including the TRIGA Mark II reactor and associated laboratory facilities, were designed and built by the local staff with some assistance in some electronic instrumentation from the Mol nuclear research centre in Belgium.

In 1978, the CSN was restructured to become the Commissariat Général à l'Energie Atomique (CGEA) with the author of this paper as the head. Nuclear research in Zaïre has diversified over the years to encompass all the traditional fields of nuclear research, from nuclear engineering to nuclear chemistry through agriculture, nuclear medicine, radio-biology, activation analysis and others.

The CRENK has been able to provide countless services to the local market. New varieties of soybean, maize, rice, and groundnut obtained by radiation mutation have been produced. Some of the varieties have been distributed to local peasants. The laboratories of the CRENK are doing routine activation and chemical analysis for the local industry. We produced radio-immunoassay kits and are in the process of becoming self-sufficient in radio-pharmaceuticals.

Today, 154 persons work in the CRENK of whom 56 hold at least the basic university degree (4 years of study). Eighteen people hold Ph. D. degrees. Over the 28 years since the "criticality" of the first TRIGA Mark I nuclear reactor in 1959, Zaïre has gained invaluable experience in the peaceful applications of nuclear energy, particularly in the field of nuclear engineering, as demonstrated by the successful building and operation without accident by the local staff of the TRIGA Mark II nuclear reactor. This experience is at the disposal not only of Zaïre but also of the entire African continent through the CRENK.

It is appropriate to conclude this short history of nuclear research activities in Zaïre by quoting the report issued by the US Presidential Mission sent by President Reagan in February 1985 to survey, at the request of President Mobutu Sese Seko of Zaïre, the state of agriculture activities in Zaïre.(2) The composition of the US Presidential Mission was as follows:

Dr. Benjamin F. Payton, President of Tuskegee Institute, Alabama; (Chairman of the Mission),
Dr. Rifat Barokas, President of the International Phoenix Corporation, Herndon, Virginia (legal adviser),
Dr. Daniel G. Aldrich, First Chancellor of the University of California at Irvine, California,
Mr. Russel C. Barbour, Agriculture Expert from Tuskegee Institute, Alabama,
Dr. Patricia W. Barnes-McConnel, Director of a research programme on beans, at East Lansing, Michigan,
Dr. Walter C. Bowi, Dean of the Veterinary Medicine Faculty at Tuskegee Institute, Alabama,
Mr. Terrence Brown, Vice-President and Director General of Construction, Control Services Corporation, Durham, North Carolina,
Dr. Michael L. Colegrove, Regional Director for Africa of Pioneer Overseas Corporation, Johnston, Iowa,
Mr. Kent Bruce Crane, President Director General of Crane Group, Limited, of Washington D.C.,
Dr. Kenneth R. Farrell, Director of the National Center for Food and Agriculture Policy, Resources for the Future, Washington D.C.,
Dr. Jake Halliday, Director, Battelle-Kettering Research Laboratory, Yellow Springs, Ohio,
Dr. Norman E. Johnson, Vice-President for Research and Development, Weyerhaeuser Company, Tacoma, Washington,
Mr. Roger J. Poulin, Development Alternatives Inc., Washington D.C.,
Dr. Charles Riemenschneider, Vice-President and agricultural economist of the Chemical Bank, New York and
Dr. Harold Robinson, Honorary Chancellor of Western Carolina University, Cullowhee, North Carolina.

Under the title *High Technology Research* the report states:

> National programmes of non-cash crops are necessarily centred on adaptive research oriented toward production. But there exists in Zaïre one institution, the Centre Régional d'Etudes Nucléaires du Kinshasa (CRENK), which has the personnel and the equipment allowing it to undertake much more fundamental studies to help

the agriculture development. The CRENK could utilise its expertise in microbiology, in biotechnology and in plant and microbial molecular genetics to undertake for Zaïre particularly useful research which can not be taken up by the big research programmes in biotechnology of the industrialised countries. The researchers could give themselves various objectives: to maximise the advantages of the biological fixation of nitrogen; to reinforce the amount of protein in cassava; to reinforce the symbiotic fixation of phosphorus; and to realise biological control of plants diseases.(3)

We have been doing just that for almost two decades in the CRENK. The nuclear centere can indeed increase its contribution to the development of Zaïre provided that sufficient funds are made available.

The lessons of the CRENK's experience

What are the lessons that one can drawn from the history of the development of nuclear activities in Zaïre?

One of the lessons is that it is possible to achieve excellence in science and technology in Africa without necessarily vast outlays of funds and elaborate planning exercises. What is needed above all are acceptable public policies, organisational leadership from those involved in the science sector, good management of the available resources from those in charge of running the day-to-day activities of research centres, and excellent interaction between the scientific and political community.

Acceptable public policy is of course essential to any successful project in any sector of a country's socioeconomic life. This is obvious in Africa today as far as the agricultural sector is concerned.

On the scientific and technical policy front Africa is on the right track if one considers various African political statements including the provision of the *Lagos Plan of Action* adopted in 1980 by the Heads of States or of Governments of the OAU. However, taking into account African conditions, it should be pointed out that good public policies certainly do not mean interventionist policy from the state. Indeed, according to the World Bank, the best projects in Africa are those in which the state has done the least to manage them.(4)

This is not to say that the science and technology sector should be left entirely to the play of the market forces in Africa. It does mean that what is needed in Africa is a strong commitment in favour of the development of scientific and technological activities from the part of the state, coupled with a fair degree of *laissez-faire* from those in charge of the political life of the country. After all, science is a long, unpredictable activity which very frequently achieves what one was not looking for at the start of the investigation.

In the case of nuclear activities in Zaïre, the public policy of the state has always been good, being dictated from the beginning by sound economic considerations tied to the exploitation of natural resources. From that sound economical basis, anything that concern the nuclear energy sector has had good press, particularly when it has the prestige associated with a high technology project. We succeeded in building a good research centre around the TRIGA

Mark II reactor because we were left alone to complete and run the project as we saw fit.

The second requisite for a sound S & T project is good organisational leadership on the part of those involved in the management of the scientific and technological sector. Of course this requisite holds for any sector, but it is particularly crucial in the S & T sector because of the long time required to implement any major scientific or technological project.

Organisational leadership means setting appropriate goals tailored to the available or expected human and material resources that can be used to achieve them. Here a touch of teleological approach is advisable. By "teleological approach," one means setting goals and then working backward to institutional and material changes needed to achieve them.

When I took charge of the CSN in 1965, we decided to build ourselves a new more powerful nuclear reactor. The goal was sufficiently challenging to mobilise the imagination of the few people directly involved in the project, yet fairly attainable since the chosen reactor was not completely new. What was needed to reach the goal was to secure sufficient funds to buy what the team could not design and build itself. Of course this is possible only if one has the needed expertise to set up realistic yet sufficiently challenging goals that can task the imagination and thus inspire passionate commitment from the team.

Organisational leadership means also political acumen to obtain the needed consensus on goals from all the people inside or outside the organisation who are involved directly or indirectly in the project.

From the above listing of the needed qualities to achieve good organisational leadership, it is obvious that this part of the management task is the most difficult to fulfill because it is at the same time an art, a science, and just plain good luck. In fact, history shows that, more often than not, it is the right man, at the right place and the right time who is choosing the right project, rather than the other way around. As far as nuclear research is concerned a good example in support of this statement is the case of Baba in India.

The third requisite to achieve excellence in science and technology is good administration of the day-to-day business of the institution. This requisite is not necessarily the easiest one to fulfill, but it is certainly the most technical one. Methods of good management abound. Yet a good administrator must also have the right political touch to overcome, without undue stress, the constraints associated with some cultural and mental superstructures that constitute huge stumbling blocks in any exercise of modern management in Africa. Indeed, abusive use of public goods for private ends are anchoured in the mind of many in Africa where family or tribal obligations are very important.

Some recommendations

When assessing the success or failure of scientific institution building in Africa, one must be careful to take fully into account all the pertinent factors. To consider just the end result is not sufficient. In fairness, one must make a complete "cost-benefit" analysis. What were the inputs and what is the end result? What was put in and what came out of it? This approach serves to sharpen the focus on the pertinent factors to consider in order to really help Africa overcome the many constraints that inhibit its development.

Taking for granted that the goals are realistic enough and that the team is qualified to see them through, our experience has shown us that the most crucial factor to insure the success of a scientific or technological undertaking in Africa is a steady support from a credible financial source. The financial support should not be necessarily huge but it must be tailored to the objectives, and above all it should be predictable for a very long period.

For example, the CRENK has been able to secure, over the last 20 years, about US$150,000 to US$200,000 per year from the International Atomic Energy Agency to buy new equipment or to repair old. This has enabled us to keep the institution running satisfactorily without accident or serious problems. Our aim is not so much to increase the amount of hard currency as to insure that it will remain sustainable in spite of the financial crisis affecting the international scientific and technological communities.

The second most important factor to ensure excellence for a scientific institution in Africa is a strong and lasting leadership. Nothing of substance can be achieved in science in the short run with frequent changes of the top manager.

The third important factor to ensure the success of a scientific or technological institution in Africa is tied to the staff's sense of mission. To instill this sense of mission any paternal attitude from outside donors should be discarded. Indeed such attitude is reminiscent of the colonial past. It tends to revive the kind of dependence mentality which end up transforming a dynamic staff into a lethargic one.

Technical assistance in personnel should be minimal and should be, as much as possible, of short duration. It makes no sense to staff an African institution primarily with foreign researchers, with just a few *natives* filling in the gaps. There are no foreigners in the staff of the CRENK on a permanent basis. However we welcome each year a steady flow of experts and researchers for short periods of time to discuss or launch specific projects or programmes.

Conclusion

To achieve all the previous recommendations an excellent interaction between the scientific and political community is essential. Each of the two communities should be aware of the constraints and the needs of the other in order to work out the right type of partnership which is the prerequisite for any successful endeavour anywhere in the world.

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AFRICAN SCIENTIFIC AND TECHNOLOGICAL INSTITUTION BUILDING AND THE ROLE OF INTERNATIONAL CO-OPERATION

*Alexander A. Kwapong**

Introduction

The objective of this symposium is to review the experience of the past three to four decades in building African institutional capacity in science and technology. It will address this important subject from both an African perspective and from the perspective of regional, international and bilateral organisations that have been involved in this process. The aim is to explore the needs and mechanisms for support from the international scientific and technical assistance community so as to help strengthen the critical long term research and training capability and to modify and renew institutional structures.

We are invited to share and review together our experience of scientific and technological institution building in Africa, to recollect what happened, why the process proceeded in particular directions, and how international co-operation was involved. We are also requested to draw the key lessons for future institutional development and to capture past experience in a form that will assist the Bellagio analysis, while recognising that there is really insufficient time the topic really requires. Essentially, therefore, our task as I see it would be both retrospective and prospective.

In the very valuable background papers that accompanied the invitation letter to me, which summarised the ICIPE Foundation discussions of a year ago, I find that attention was rightly drawn to the success story of institutions like ICIPE. The question, however, needs to be asked: why did it happen that so few ICIPEs were able to survive and succeed after the initial promise of the post-independence years; and why was it that the many more similarly promising initiatives failed to weather the storm of the crisis of development that has overwhelmed Africa since the middle of the seventies?

To this symposium, therefore, I would like to bring the perspectives that I have acquired of some 22 years of university teaching, administration, research and development in Africa, especially in the University of Ghana, as well as the 13 years of my involvement in the founding and development of the new global institution of the United Nations University (UNU). From both my earlier African Legon-based experience, and my present UNU involvement, I would like to underline certain factors which appear to me to be highly relevant to the issues in question. From the UN experience, I would like to draw upon certain global institution building initiatives with which the University has been concerned in order to underline the mechanisms and

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possible directions for future international scientific and technological co-operation.

This symposium comes at an opportune moment at the time of crisis in Africa. The Organisation for African Unity (OAU), has celebrated its silver jubilee anniversary. The occasion was marked with reviews of the successes and failures of African nation-states and sober reflection on how to proceed in the coming decades. The reaction of several African countries to the present crisis of development has been encouraging. As a result of the hard thinking and bitter experiences, the African nations have drawn up the African Priority Programme for Economic Recovery (APPER), which the United Nations adopted in 1986. Various adjustments have been made and they offered to put their house in order and invited the international community to respond. Although the international response has, so far, not been adequate in providing the necessary resources to cope with the twin problems of the crushing debt burden and falling commodity prices, APPER does provide a useful background to the subject of our symposium.

Nations responded generously to the famine situation brought on by years of successive drought that threatened the lives of several million African people; but one thing which has emerged from all this is the consensus that such emergency responses, however generous, are not likely to bring any lasting solutions to the deepening African crisis unless the root causes of the political, economic and social malaise are seriously dealt with. It is now generally accepted that effective capacity building in science and technology, harnessed to appropriate political, economic, and social policies, constitutes a long term way out for Africa in its present malaise.

Actions for the future

The recent World Bank policy study, *Education in Sub-Saharan Africa: Policies for Adjustment, Revitalisation, and Expansion*, has done a signal service in providing us with a basic framework against which we can review this issue of institution building and international co-operation. Few will dispute the basic analysis and the main policy recommendations it puts forward, and it is against this background that I wish to make my comments. A major premise on which institution building in science and technology is founded is that education as a whole provides a key role to development. As the President of the World Bank, Barber Conable, puts it in the opening words introducing the document, "Without education, development will not occur. Only an educated people can command the skills necessary for sustainable economic growth and for a better quality of life." The key role of education, despite the vagaries of development theories and fashions during the past decades, is now accepted as indispensable for any effective development. All African governments were certainly convinced of this in the early years of their independence, and as Mr. Conable points out, African governments have accordingly placed heavy emphasis on expanding educational opportunities from primary school to university in the past two or three decades. The key role of education in the development process is the reason the World Bank has put so much emphasis on supporting educational expansion and improvement in sub-Saharan Africa. Yet, he observes, education in sub-Saharan Africa is in crisis today.

The report analyses the two main issues affecting African education: the stagnation of enrolments and the decline in standards of quality. At all levels,

but especially in the primary sector, education enrolments has declined, but more serious is the conclusion that cognitive achievement is low in African students by world standards. Recent decline in supplies of the key inputs at all levels, such as books and other learning material, has had deleterious effect on the quality of performance of students as identified in cross national studies.

The Bank has proposed three policy remedies:

1. adjustment to current demographic and fiscal realities through the diversification of the sources of finance, and the containment of the unit costs of education throughout all three sectors;
2. revitalisation of existing educational infrastructure, through renewed commitment to academic standards, restoration of inputs, greater investment in the operation and maintenance of physical plant and equipment, and greater expenditure on inputs for these capital assets; and
3. selective expansion in all three sectors, through universal primary education, adoption of distance education programmes, training programmes for both school leavers and those who have had no formal schooling, and expansion of Africa's own intellectual talent to fill the higher scientific and technical jobs through research and postgraduate education.

It is within the latter area, i.e. undergraduate, postgraduate university education, and research that I would now like to concentrate my remaining remarks, but it is important to observe that the primary, secondary and tertiary sectors should be looked at as a whole. One of the basic problems affecting institution building in African countries like Ghana was the existence of parallel systems of higher education and national research which were not effectively co-ordinated or integrated into an overall national educational and research programme. More serious was the lack of an effective interface between these and agriculture, industry, and commerce.

Few would quarrel with the conclusion of the report that preparing and supporting people for government, business and the professions is the essential role of the continent's universities. While in numbers, African universities rose impressively (with enrolments increasing twenty-fold over the past 25 years, from 21,000 in 1960 to 430,000 in 1983) higher education's contribution to development is now seriously threatened by four interrelated weaknesses: (1) an excessive number of graduates of dubious quality and relevance and the fact that universities are generating too little new knowledge and direct development support; (2) the serious deterioration of the quality of their output, calling into question the fundamental effectiveness of several of these university institutions; (3) the excessive costs; and (4) the pattern of financing higher education which is socially inequitable and economically inefficient.

The four policy reform objectives that the Bank has proposed—to improve the quality of universities, increase their efficiency, change their output mix by reducing enrolments in certain fields of study and increasing them in others, and finally by reducing the serious burden on public sources through the sharing of costs between the beneficiaries and the governments—are basically acceptable and flow from the experience . There have been, of course, arguments about the specifics, but a revitalisation and collective

expansion of universities will make an important contribution to the recovery of the higher educational sectors on the continent.

Although Ghana, at the time of its independence, was relatively better off in terms of graduates and trained manpower, we began with a shortage of skilled people in the many responsibilities of nation building—government, business, industry and agriculture—and of development generally. The initial emphasis was to produce, in increasing numbers, graduates of high quality and competence. The initial preoccupation was to expand undergraduate teaching, improve its quality, and maintain these improvements. We employed various mechanisms, such as establishment of a "special relationship" with London University, external peer review of exams, external assessment of teaching and research staff, and concentration on the quality of books and the infrastructure. The three-fold functions of the university were always in our minds—high quality teaching, research, and the dissemination of the knowledge generated to the community at large. Initially, colleges were overwhelmingly staffed by expatriates from former colonial countries. After the attainment of these colleges of full-university status, the issue of their "Africanisation"—adapting them to their environment and staffing them with qualified Africans became the major preoccupation.

Therefore, the foremost priority in our institution building efforts became staff development. We could produce teachers, lecturers and professors for these universities by providing students with the basic undergraduate training and then supplementing this with postgraduate qualifications, first abroad, and then at home.

At this stage, the issue was not so much lack of public resources as of the capacity to utilise these resources effectively in order to promote undergraduate training programmes and the production of high-quality graduates for the civil service, government, the professions, and agriculture and industry. However, as more universities were set up and began to grow in maturity, it became essential to develop local graduate programmes and to promote research capacity. A well co-ordinated staff development programme provided the key.

First, there was the need to insist on high academic standards (first class honours or upper second class bachelor's degree) for selection for the graduate scholarship programmes abroad. Second, to build up networks of institutions overseas to which local universities could link; and third, to designate key subjects and disciplines for emphasis and to arrange programmes between the African universities and overseas institutions. At the University of Ghana, we drew up a coherent strategic plan emphasising agriculture, science, mathematics, economics, sociology, and demographic studies. In medicine we nurtured natural science and clinical teachers and researchers. Engineering and architecture were similarly being developed in the University of Science and Technology in Kumasi.

In agriculture, for example, a link established with the University of Guelph covered not only the main area of agriculture but also home science and home economics. In exchanges undertaken, qualified staff—about six professors and lecturers from Guelph—spent two to three years at the University of Ghana teaching and helping to organise research programmes. Carefully selected postgraduate students were sent from Legon to Guelph for training at the master's and Ph. D. levels and subsequently returned to become staff members. There were also similar links between the University of Ghana

and the University of Western Ontario in economics, and the Institute for Tropical Agriculture in Prague which sent excellent animal scientists and agronomists to manage the agricultural research stations.

The sound pioneering plant breeding research of these Czech scientists laid the foundations of the citrus industry in Ghana today. There were also links between the University of North Carolina at Chapel Hill in population dynamics and demographic research and the University of California in geology and community medicine. The faculty of law at Oxford organised the law faculty in Legon and post-graduate students undertook advanced training at Oxford; many returned to teach in Legon. This arrangement was later extended to Temple University in Pennsylvania, USA. Language teaching, especially French, benefited from similar links with the universities of Paris and Bordeaux, and later with the universities of Dakar and Abidjan in Senegal and Côte d'Ivoire. Several other examples could be mentioned, but the point is that staff development programmes are proceeding. As the problems of independence emerge, it is abundantly clear that only locally identified and highly qualified graduates, researchers, and faculty will provide long term stability needed.

To arrange for such exchanges, it was necessary not only to formulate strategies for development and a coherent programme of work, but also, to win the support from either foundations, donor governments, and agencies for financial aid and foreign exchange support that underpinned these links. Substantial grants by CIDA funded the Canadian exchanges; USAID and the US foundations, especially Ford, Rockefeller, and Carnegie, supported programmes with the US; and the UK ODA, especially through the British Expatriate Supplementation Scheme (BESS) for British faculty and researchers, underwrote the UK links and exchanges. However, in the early years of Ghana's cocoa boom and healthy sterling balances, the Government of Ghana financed the local costs and a considerable portion, if not the bulk, of the postgraduate training scheme and exchanges from its own resources. By the time of my departure from Legon at the beginning of 1976, over 80 percent of the staff of Legon were Ghanaians, most of them trained under these programmes.

Fundamental to the success of all these efforts in institution building were the scientific integrity and academic autonomy of the institutions on the one hand and their commitment to the basic development needs of the country on the other. Entrepreneurial leadership and a capacity for effective bilateral and multilateral negotiations with the donors were indispensable. In order to grow and progress, the universities had to be able to draw upon healthy primary and secondary education sectors with good teaching in the sciences and the other basic disciplines. The efficiency and quality of these sectors assured the three universities of Ghana a constant and growing stream of well-trained students. Initially, the staff had to correct imbalances in the mix of students between those who had a strong science background and those who did not, through special remedial courses; the admissions staff also paid special attention to correcting the under-representation of females among the undergraduates. Every effort was made to increase enrolments and to optimise the training of students. Admission standards were kept fairly high but open; there was an insistence that the basic principle of equal opportunities for all should go hand in hand with an insistence upon a high quality end product or output. The quality of the institution was to be measured first and foremost by

the quality of its graduates and their ability to assume vital roles. As these universities began to mature, the calibre and relevance of their research and involvement in the development of the country became another important factor.

The essential task of managers and builders in such institutions was the issue of protecting academic integrity and addressing their relevance to the political, economic, and social aspirations of the new nations.

The World Bank analysis has certainly brought out most of the factors with which we contended, but one element missing from the report is the impact of the overall macroeconomic and political environment. A stable environment was absolutely vital for the success of the institution building efforts. Ghana's political situation was sufficiently stable and its economy viable to ensure that inputs identified by the Bank as necessary for institution building were available. Then, leadership in management and administration which could make the universities cost effective and efficient, and their postgraduate training and research relevant were needed. Political instability and the collapse of the economy, however, undermined the viability of these universities and made all the difference to Makerere, for example, before and after Amin or the universities in Ghana in the late 1970s and early 1980s.

An element which is also not explicitly addressed in the Bank's report is the "brain drain". The brain drain was both a symptom as well as the effect of macroeconomic and political collapse in Ghana and many other African nations. An example (perhaps a very apt illustration of the crisis to which the higher educational sectors of our countries have been subjected) can be provided by the Medical School of the University of Ghana. This institution was built largely through Ghana's own self-reliant efforts. In the 1970s, it had acquired an international reputation for competence second to none in meeting the health needs of the country, thanks to the exceedingly high intellectual intake and competent management of its various teaching and research departments. Nevertheless, in the early and mid-1980s, when the political and economic crisis of Ghana had taken its heavy toll, the hemorrhage of the medical faculty from Ghana into other regions of Africa and (more importantly) of the industrialised world, provides a conspicuous example of the emigration of highly skilled people. I myself, for instance, encountered two years ago as many as 30 doctors from the University of Ghana Medical School in one medical school alone in Saudi Arabia!

I recently had the pleasure of taking part in the 25th anniversary celebrations of the University of Ghana Medical School. Let me quote from the silver jubilee brochure the words of the Medical School's Dean in 1985:

> "In terms of hard figures, the trends make disturbing reading. The percentage of staff in the establishment of posts has progressively dropped from 60 percent in 1979 to 51 percent in 1980 to as low as 32 percent in 1984."
>
> "Now stabilised at about this figure but chiefly for purely human reasons—the harsh realities of running a home, caring for and educating their children and looking after themselves. Many homes were on the verge of a collapse. There is also the question of job satisfaction as practitioners with such severe and chronic shortages in supplies, drugs and rather obsolete equipment.

Academic fulfilment was also wanting as research virtually ground to a halt."

Whatever its complex causes, there is little doubt that the emigration of highly trained and skilled people in all disciplines and professions, from all the universities and research centres affects almost all aspects of skilled manpower—qualified people in science and technology in particular being the most vulnerable, but the other areas no less so. Such a drain constitutes a particularly severe loss—a financial loss as well as a human resource loss from the countries which have spent limited public funds on their education and training. While it may be easy to repair again dilapidated buildings, refurbish libraries and replace obsolete equipment in the short and medium term, what is urgent over and above this is to be able to meet the twin challenges of attracting skilled doctors, professors, lecturers, scientists and scholars back and to add to and retain all those studying in the various institutions of higher education and research.

Providing the specific appropriate material incentives, improved political, economic and social conditions and attractive policies that guarantee job satisfaction is a job which the African nations must undertake. Donors along cannot do this, however well-motivated or benign they may be, although imaginative schemes like the UNDP TOKTEN Programme can help to alleviate some of the problem. One urgent task for institution building is thus to rebuild and being together as soon as possible a critical mass of teachers, researchers and practitioners for the African universities and research centres, and it is in this respect that selected, nodal centres can be identified and international donors and agencies can be involved. The greatest challenge is to find the necessary modalities for strengthening national institutions on a sustained and comprehensive basis.

In the issue of the brain drain, which obviously we shall be discussing at some length at this symposium, I would like to suggest that the experience of Asian countries like the Republic of South Korea, Singapore and Taiwan can provide very useful lessons from which African countries can learn. These nations did set up incentive schemes and mechanisms within a benign socioeconomic framework that helped to attract back home quite a lot of their own highly trained expatriate people from the various industrialised countries who helped to fuel the revival of agriculture, industry, commerce, higher education and high-tech research within these nations and to transform them into the so-called newly industrialising countries (NICs).

Recent experience at UN University

Let me now turn to my UN University involvement. As you are all aware, the United Nations University is a worldwide network of institutions covering some 60 or so countries with the main programming and co-ordinating headquarters based in Tokyo. Working in this university, which has a mandate to identify solutions to the pressing global problems of human survival, development and welfare that are the concerns of the United Nations and its agencies, has provided me with a larger dimension to my earlier African-based experience of helping to build institutions.

Essentially, the argument for the mandate of the UN University as now constituted is that there is no need to duplicate the work of national

universities. Instead, global networks with the necessary resources, co-ordinated to work on global issues—human survival, development and welfare—and equipped with independent and autonomous capital would make a unique, long term impact in the world. The UNU's mandate accordingly places special emphasis on research, advanced training, and dissemination of knowledge of these issues. My responsibility as Vice-Rector has been to organise this global institutional framework and resource development. The University's experience in organizsing such relationships with institutions selected for specific programmes and (in the second phase of the growth) in building its own research and training centres could, I believe, provide us with a useful example of what could be done at the regional level in Africa through international co-operation.

Two new institutions have recently been created by the UNU which are relevant to this discussion. The first, the World Institute for Development Economics Research (WIDER) has been in active operation since 1984, while the other, the Institute for Natural Resources in Africa (INRA) is about to start operations. WIDER, based in Helsinki, is charged with undertaking research, postgraduate training and the dissemination of knowledge concerning the global economy. WIDER has been making quite an impressive contribution. It was relatively easy to establish such a "New-World" institution once the concept and rationale had been united with an infrastructure and the supporting resources of a host country. In this case, Finland was prepared to commit US$30 million to the endowment fund of WIDER. Subsequently, a high quality, international staff could be rapidly assembled, operating with autonomy, academic freedom, and management provided by the University's Charter, but accountable to the international community through the director, the board, and the UN University Council. The Council guided the development of WIDER programmes within the framework of the UN University's own global system.

The second such institution, INRA, is the first to be located in a developing country. The host of the Institute is to be Côte d'Ivoire, with a subsidiary in Zambia. The University has been endeavouring to set up INRA and is now near fulfillment. The framework has been approved by the University Council, but the difficulty with creating such an institute in Africa is linking the host country with the endowment pledges (US$7 million total), and equipping it with facilities and an infrastructure. The rationale and concept of this Institute were subjected to more rigorous international scrutiny and a longer feasibility critique than was WIDER. Furthermore, the securing substantial donor support has proven to be more difficult and drawn out. It would be valuable for us to examine the experience of INRA because it provides answers to some of the concerns articulated in the discussions at the ICIPE conference of last year.

I have brought the INRA prospectus, which outlines this institute. The central premise is to strengthen African national institutions. In its structure, there is a director, a board, and expert scientific and technical panels in charge of research and training activities. There is also a network of institutions under the overall direction and supervision of the UNU Council. The programme is derived from priorities set down in the Lagos Plan of Action. As an integral part of the UNU, it enjoys autonomy and academic freedom. The Institute has been strongly endorsed by the OAU and the ECA. Both have signed a tripartite

agreement of co-operation with the UNU that stands as guarantor to INRA's scientific quality and the relevance of its work and also links it to a global network of programmes and institutions.

In my opinion, the structure set out in the prospectus provides an acceptable framework within which the network of institutions can really achieve success. Donors' contributions are effectively utilised, and priorities in training and research are soundly based. It should also allay African concerns about and understandable sensitivities to unacceptable bilateral and external influences.

In order to develop such an institution, it is quite clear that there must be the strongest possible support from the host countries. They should be prepared not only to guarantee scientific and intellectual integrity but also to provide the infrastructure, physical facilities and, above all, the political and social conditions necessary for such an institution to perform its functions satisfactorily. It has been proposed that the Council of the University and the Rector appoint the board. Ideally, the board would be:

- representative of various parts of Africa,
- independent of specific political considerations on the continent and
- placed within a collaborative, international network.

The proposed method of appointment would ensure a combination of integrity and institutional autonomy, married to technical and scientific rigor and competence, whereby donors could support the institution as a whole or specific programmes when these are established. The World Bank and other donor organisations have provided a thorough technical and scientific assessment of the programme proposals. An institution like INRA will, I am sure, be replicated in form for other purposes and disciplines—if the continent is to be able to overcome the present malaise and come to terms with African scientific and technological requirements for the coming decades.

I think that an institution like INRA will succeed or fail in as much as it enjoys or lacks consistent support, both materially and financially, from within and outside Africa. However, the intellectual and social atmosphere whereby INRA attracts and retains well-trained people (both Africans and non-Africans) will be even more critical. In connection with this, an interesting feature of INRA is the proposed college of research associates. The college is designed specifically to ensure that while INRA is able to draw upon qualified scientists and scholars from national centres to work on specific programmes, it will not exacerbate the brain drain. Associates will retain their links with their national institutions and will return to them from time to time to work on their centre's programmes. Such a mechanism will allow institutions like INRA to draw upon and enrich institutions like ICIPE, IITA and other regional and national centres that must be nurtured and supported to fulfil their own mandates.

Finally, I would like to express my own personal pleasure at seeing the conclusions of the World Bank report and the recommendations it makes for changes in the organisation and level of international aid for African educational development. These are very much in line with the proposals to support INRA that I have described. As you will recall, the report recommends that seed money for local and foreign costs of development policies and for improving management be provided in increasing amounts by the donor

agencies and governments. While the African governments should seek to meet local costs, the donors should provide matching support to this and so give important incentives for African governments to follow suit.

The Bank stresses the importance of providing African institutions ready access to the experience of countries in other parts of the world when formulating and implementing policy reforms and dealing with issues that others have already had to face. Topics would include the establishment and financing of a reliable source of technical experts who do not have direct financial or political ties to any external government or international donor agencies. Such scientific experts would be called upon to assist with policy formulation and to monitor, evaluate, correct, and implement these programmes.

The international community, we agree, should help to finance programmes, yet encourage institutional autonomy and intellectual integrity, long term perspectives, and flexibility and responsiveness needed for implementation. All this should be done on a continuing and generous basis, and political will should be behind such initiatives. The total level of aid to education and research obviously should be increased. As the report rightly concludes, the greater the investments in such institution building and general educational reforms, the broader the economic and social benefits. Quality will be enhanced through the revitalisation as a prerequisite and a complement to the restoration of the momentum whereby African countries in the immediate post-independence years were able to move rapidly from colonial status to self-government and participation in the international arena. The nurturing of leaders who can address the increasingly complex tasks of nation building in an interdependent world will be a continuing responsibility of African educational institutions.

Particularly relevant to what we have been saying is the Bank report's general conclusion:

> The stock of human capital will determine whether Africans can harness the universal explosion of scientific and technical knowledge for the region's benefit or whether Africa will fall farther and farther behind the world's industrial nations. Above all, education is a basic right, an intrinsic part of life and development. When all the benefits of education are considered, the case for the revitalisation and expansion of schooling and training in Africa is compelling even in this period of unusual scarcity.

Within the educational spectrum, we should lay particular stress on institution building at the highest echelons and the effective application of the output of these institutions to the development process. The co-operation that the international donors can offer is thus seen to be extremely critical in reversing Africa's present malaise.

TOWARDS NATIONAL CAPACITY BUILDING IN AFRICA: MOBILISING AND STRENGTHENING EXISTING INSTITUTIONS AND EXPERTISE FOR MULTISECTORAL SUPPORT AND COMMUNITY EMPOWERMENT FOR CHILD SURVIVAL AND DEVELOPMENT

*Aklilu Lemma**

Introduction

One death in every three in the world is the death of a child under the age of five. And each week that goes by, more than a quarter of a million young children still die, in the developing world, from frequent infection and prolonged undernutritionment.

This opening statement of the *State of the World's Children 1988* reflects the still-continuing desperate state of children and the alarming rate of infant and child mortality in the world, reinforcing the fact that there is still a long way to go in the struggle for survival of the world's children. And yet, this is after the last 30 years of progress in infant and child mortality reductions that have been characterised by a recent study as "historically unprecedented."

A 1986 joint study by the United Nations Population Division and United Nations Children's Fund (UNICEF) has provided new estimates of the mortality rates for children under the age of five and the number of infant and child deaths in developed and developing countries, by regions, for 1950 and 1980, with a projection for the year 2000. The global reduction in infant and child mortality since 1960 has indeed been phenomenal. Infant mortality rates (IMRs) for developing countries as a group declined by more than 50 percent, from about 190 per 1,000 live births in 1950, to 80 in 1986. During the same period, the under-five mortality rate (U5MR) in developing countries fell from about 300 per 1,000 births, to 125. This corresponds to a decline in total infant and young child deaths in developing countries from approximately 23 million in 1950 to some 14 million in 1986, in the face of an increase in births from nearly 98 million to some 125 million annually during the same period.

A disturbing feature of these trends, however, is that the actual number of infant and child deaths in Africa has been growing absolutely in contrast to the decline in every other region of the world. Unless trends improve, Africa, which now accounts for about 30 percent of all infant and child deaths (up from 15 percent in 1950), will experience a further increase in the number of infant and child deaths and account for over 40 percent by the year 2000, despite the fact that at that time its population will be only 14 percent of the world total.

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*Prepared as an example of an ongoing UNICEF project on national capacity building and international co-operation, using child survival and development as a point of entrance to community support and empowerment. The author is Senior Adviser, UNICEF New York, and Deputy Director-designate of the proposed UNICEF International Child Development Centre at the Spedale degli Innocenti, Florence, Italy.

Intervention strategies

In its continued and evolving attempts to reduce infant and child mortality rates, in 1982 UNICEF launched a *Child Survival and Development Revolution* (CSDR) as a strategy that is based on the conviction that a large proportion of children who die every year in the third world could be saved if the application of available and affordable technologies already in existence could be placed at the disposal of their families and communities. This broad concept has further been narrowed down to specific achievable goals for child survival through a systematic application of growth monitoring, oral rehydration, breast-feeding, and immunisation (GOBI) at the family and community levels. These services have now been extended to include food self-sufficiency, family spacing and female education (GOBI-FFF). In some cases, specific targets have been set, such as Universal Child Immunisation (UCI) by 1990.

It has now been demonstrated that most child deaths and malnutrition caused by preventable diseases, including diarrhea, measles, tetanus, whooping cough and acute respiratory infections, are being reduced by parental actions which are almost universally affordable, based on knowledge which is already available. The combined effects of increased immunisation and usage of the low-cost breakthrough known as Oral Rehydration Therapy (ORT), for example, has achieved remarkable results in defeating the greatest threats to the lives and the normal growth of children. Countries which have doubled and tripled their immunisation coverage are saving hundreds of thousands of young lives in different parts of the world, including Africa.

However, in spite of all efforts to improve the situation, the prevailing conditions for many children in several African countries are leading to frequent infections, malnutrition, and other factors which impose severe constraints to their growth and development. Tropical diseases, which have been associated with the same conditions of poverty and underdevelopment that spawned high mortality rates in the 19th century, and today's ecological deterioration represent increasing threats to child survival and development. The result is that a fifth or a quarter of all children in Africa may not experience their fifth birthday.

The elaboration of strategies to prevent disease and promote health in infants and children has been enhanced by popularisation, advocacy and investment associated with the concept of the CSDR, GOBI, food self-sufficiency, family spacing and female education. Further practical approaches to acute respiratory infections, malaria control and essential drug usage have also been included.

Some remarkable achievements have occurred particularly in the field of immunisation and oral rehydration. During 1987, the evaluation of the immunisation efforts in 39 African countries revealed an increase of 65 percent in overall coverage, from 20 percent in 1984 to 33 percent by the beginning of 1986. In 20 of the reporting countries, total coverage rose sharply to over 50 percent, an increase of over 150 percent. The impact of expanding and accelerating immunisation is becoming apparent as the frequency of measles and polio each show rates of decline of over 50 percent in the past five years.

Oral rehydration and national CDD programmes have increased by over five times in the past years. The use of ORT has become the principal low-cost technology used in the treatment of diarrhea in most African countries.

In spite of these remarkable achievements for the African infant and child, there remains a fragile balance between health and disease. Infant mortality rates—over 150 in 17 African countries and between 100 and 149 in a further 21 countries—shows the situation to be still serious. Diseases such as measles, tetanus, acute respiratory infections (ARI), and malaria continue to be responsible for a majority of the deaths of the young child.

Related to this is the necessity to improve the organisational means of meeting children's needs: the need to recognise the linkages between various services to children from different sectors, supported by different ministries, and the need for innovative approaches and "starter" activities to prepare a country-base for expanding services for children. This has required the development of a more comprehensive view of children, both in terms of their vulnerability and their potential as individuals, and as future participants in social and economic change.

Sustainability of interventions

In the long run, the continuous and sustained improvement of child survival and development depends on community participation and responsibility, as well as on certain support services from the government and other concerned sources outside the community. Contrary to popular belief, affordable techniques and know-how are presently more widely available than the capacity for their promotion, organisation, management and application in a community context.

Numerous countries, particularly in Africa, face constraints arising from: the lack of an organised programme in a specific site where a reasonably comprehensive set of community-based child survival and development services may be seen in operation; insufficient national budgetary resources and a weak basis for continuity following the termination of any external support; insufficient training in methods of promoting community responsibility and working methods for relations between communities and government support services; and insufficient orientation and training for the mutual support of various concerned sectors and disciplines at the community, district and national levels.

Thus, the major constraints to the more extensive application of appropriate life-saving strategies are not mainly the lack of technology or supplies, but inadequate management skills and absence of acceptance of these measures at the community level. Social mobilisation promoted by improved communication and education must be developed so that all members of the community will assume a far greater responsibility for their own health and that of their families.

Realising that at present there are more readily available and affordable treatment techniques than the capacity of governments and communities alone for its implementation, universities and other institutions of learning and research are believed to have some major roles to play.

One of the proposals is to establish African "chairs" for interdisciplinary studies on CSD at selected universities, around outstanding national experts who could play the role of "prime-movers" on matters relating to the well-being of children. Such a proposal is not new—UNICEF has had some experience in supporting various universities and other higher institutions (for example, in India, where support for some agricultural colleges led to the

establishment of *Human Nutrition* as a discipline, and for some medical colleges for social pediatrics, social obstetrics and preventive medicine). The most notable examples in Africa were the UNICEF Chair of Social Pediatrics at Makerere University in Uganda, and the UNICEF support for the establishment of the Nutrition Department at the University of Ibadan, Nigeria, launched in co-operation with the University of London.

During the late 1950s to the mid 1970s, the Makerere University Medical School had established and run a service, training, and research programme in community child health that was recognised as a model rural health care delivery system in Africa. This pioneering work was led by Professors Jeliffe, Musake, Nombooze and Bennet, with some UNICEF support through the Chair of Social Pediatrics.

However, since such programmes in the past have tended to be primarily biased towards the medical and public health areas (for the obvious reason that they were established and run by medical people), they were either too weak or lacked a balanced consideration of the other non-medical needs of the child. Psycho-social problems of the child, early childhood stimulation and development, special problems of the urban child (street children), educational needs of the child and their mothers, basic needs fulfilment including nutrition and family food security systems, the problems of children in war-stricken areas or other difficult situations, and questions about the rights of the child for protection from abuse, labour, neglect and abandonment, were often not given as much attention and importance as health care promotion and child survival programmes in rural and urban areas, particularly in Africa.

In order to overcome these difficulties, the original proposal to promote UNICEF support for the establishment of "chairs" for specific child-related studies, was changed in favor of establishing a "nucleus" or "centre" for interdisciplinary, multisectoral, and integrated training, research and community-based service-rendering mechanisms for child survival and development. This concept encompasses the physical, mental and social needs of the child, which are crucial not only for his/her survival but also for the full development of the child in his/her own natural environment.

If universities and other institutions of higher learning are to play the key role in improving child survival and development, the new, "holistic" approach requires a major change in their thinking about the problem and a commitment to working with the community, using the "total needs" of the child as an entrance point, towards fulfilment of complex, long-range development needs of the community. A re-orientation of their existing curriculum and instruction methods is necessary to emphasise medical, agricultural, nutritional, social, cultural, anthropological, educational, and other disciplines in an integrated, "total need fulfilment" approach. Such programme changes will have to be backed by both practical, operational research and firsthand experience. Training and practice in actual field situations should be undertaken to involve the community.

The practical development and operation of such a programme will call for a new type of collaboration among experts from different faculties and departments at the university or institutional level, and between such experts and policy-makers, planners, service-rendering ministries, and non-governmental organisations at the top and grass-root levels. The involvement of students, as the future practitioners in the field, the training of trainers and other multiplier agents (teachers, journalists, etc.) and the active participation

and involvement of community leaders and parents (particularly mothers) in the processes of self-help and empowerment, are all essential components of the programme.

University-community linkages

It is in pursuit of the potentials of this strategy that the present initiative aims at linking UNICEF with universities and communities, to promote CSD capacity building at the levels shown in Figure 3.

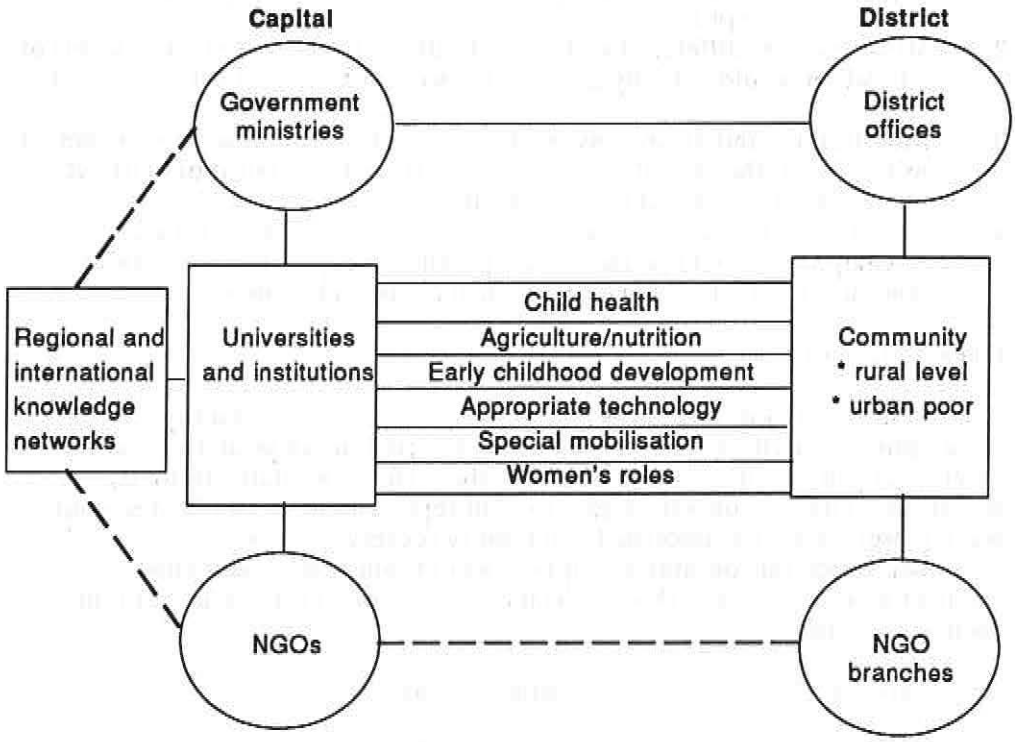

Figure 3. Institutional framework for multisectoral approaches to university — community linkages

Additional or alternative activities to be gradually included as resources and capacities permit:

1. Economic resources for children
2. Child abuse/neglect/rights
3. Urban child
4. Basic education

University/higher education institution level

Within existing structures and as part of ongoing priorities and activities, national "units", "centres" or "institutes" for interdisciplinary studies and community support and empowerment for child survival and development at the rural and urban levels should be established. This would be organized along with following guidelines:

1. Concerned staff including university professors, researchers and community development experts from different faculties and departments would be identified and mobilised to serve as "prime-movers" of the project.
2. Students from different faculties and different programmes and levels of education would actually get both theoretical and practical training on CSD.
3. Mobilisation and awareness creation and collaboration with government ministries at the capital and district levels, and collaboration with NGOs and international organisations would occur.
4. Action-oriented research on different aspects of child-health and development would be conducted parallel to support services and community involvement, communication and education.

Community level

Within existing structures and as part of ongoing community development activities, "practice areas" in selected urban poor and district level rural communities would be established. Here, the staff, students, researchers and the concerned government representatives and NGOs would work closely with the concerned community representatives.

Multisectoral community support would follow from students' application of theory and their assistance to the community on a continuing, "self-help" basis.

Co-operation at the regional and international levels

Intra-country linkages of project would be promoted. Links with knowledge sources in different parts of the world (knowledge-networking) would be created. Funding and other support sources would be mobilised, accompanying the promotion of north-south and south-south co-operation through exchange of experiences, information, and "twinning" mechanisms between universities and institutions, and promotion of the development of both the university-based centres for interdisciplinary studies and the community-based pilot and demonstration areas.

On the basis of these ideas, the Programme Division of UNICEF, in co-operation with interested regional and country offices, particularly in the Eastern and Southern Africa sub-region, helped a number of countries to develop specific proposals for implementation as part of the individual country UNICEF programme of co-operation. Accordingly, proposals from Kenya, Uganda and Zimbabwe, along with a few more countries to be added later, were put together as a Regional Programme and were presented and "noted" by the 1987 UNICEF Executive Board for extra budgetary resources at the level

of $7.5 million for 5 countries for 5 years. Preliminary explorations of funding sources showed that among others, FINNIDA, NORAD, and private foundations such as Rockefeller and Ford were interested.

Lahti Workshop

As a follow-up to the above efforts, UNICEF and FINNIDA co-sponsored an International Workshop on *National Capacity Building and International Co-operation for Child Survival and Development*, held in the City of Lahti, Finland, October 18–21 1987. Thirty-five experts from Canada, Ethiopia, Finland, Kenya, Norway, Somalia, Uganda, United Kingdom, and Zimbabwe participated. The purpose of the workshop was to review, enrich, and recommend a future course of action for the African Regional Programme. (Copies of the report of the workshop can be obtained from the UNICEF Secretariat in New York.)

The major tasks of the workshop were undertaken by three working groups. Drawing from the experiences of the participants, and in the context of individual country proposals, the working groups focused their attention on the following issues:

Working group I considered specific areas of activities on child survival and development which the university, the participating community, and the concerned governmental and non-governmental organisations could participate. The group recommended a range of specific activities—health care promotion, nutrition and food security, psycho-social issues (early childhood stimulation and development), basic education for children and their mothers, basic needs fulfilment, appropriate technologies, and the rights of the child for protection from abuse, labour, neglect and abandonment.

Working group II considered the subject of methods and experiences of linking universities and other concerned institutions to society at both rural and urban community levels. Problems associated with intra-faculty, intra-departmental, and intra-ministerial co-operation were examined, and ways of linking these to community-level multisectoral support systems for the total "holistic" needs of the child were suggested. Serious consideration was given to possible difficulties in working with ministries and NGOs in bringing about interdisciplinary approaches to the diverse needs of children. The underlying value of a broad educational base and improved social communications and community mobilisation techniques were stressed, as a key component to the successful promotion of a multidimensional learning process that involves students/professors/researchers on one side, with different ministries and governmental and non-governmental officials on the other, and the important link of all these to benefit the society at the community and district levels.

Working group III discussed modalities of regional and international co-operation in capacity building for child survival and development. The group identified specific issues, prospects and barriers to regional and international knowledge-networking and recommended a number of approaches that would make this possible. Highly encouraged were the exchange of information and staff resources at the regional and international levels, in the context of south-south and north-south co-operation. The use of teleconferencing and other electronic communication methods were specifically recommended. The experiences of Canada in the use of teleconferencing and telemedicine, was cited as an example that could be applied in Africa.

In conclusion, the participants unanimously recommended the timing and appropriateness of this UNICEF initiative to assist member states to build their own capacity for CSD and the potentials of international co-operation in this field. They recognised this to be an essential step towards the attainment of the goals of Child Survival and Development Revolution (CSDR). The necessity to start this programme in Africa, where the need for such capacity building is more acute, was also recognized. Finally, the workshop encouraged universities and other concerned institutions to play an active role in the training of appropriate manpower and in the implementation of such a capacity building program through regional and international cooperation and close working relationships with governmental and non-governmental organisations and with the society at the community level. Strong governmental commitment, and long-range financial support for this project was considered mandatory. International funding organisations were also urged to support this initiative.

Follow-up actions

Following the Lahti Workshop, FINNIDA informed UNICEF that it is interested in supporting the Kenya and Uganda projects to start with and serve as models for similar projects in other Eastern Africa countries. A FINNIDA-UNICEF project appraisal mission was to visit these two countries in early March, 1988.

In the meantime, the UNICEF Kenya Country Office has adopted the Kenya proposal as part of the existing UNICEF-Kenya country project and is supporting the work from its own budget, while waiting for extra budgetary support to strengthen and expand the programme to its full potential.

At the UNICEF headquarters level also, a major decision has been made to have this "national capacity building for child survival and development" idea as one of the major programme areas of the proposed UNICEF International Child Development Centre (ICDC) at the Spedale degli Innocenti, Florence, Italy. At ICDC, this programme is to be taken in a broad and experimental context, to develop models that could benefit developing countries not only in Africa but also in other parts of the world. The work of the Centre in this regard will be assisted and guided by a *Consultative Group* of prominent international experts, in a way similar to the *Commission on Health Research for Development: An Independent International Initiative*, based at Harvard University in Cambridge, Massachusetts.

Comments and suggestions on this UNICEF initiative will be most welcomed and appreciated. Additional information on the programme can be obtained from the UNICEF Secretariat.

SCIENCE AND TECHNOLOGY IN AFRICA: SOME REFLECTIONS ON LESSONS LEARNED AND PROSPECTS AND CHALLENGES FOR THE FUTURE

*Aklilu Lemma**

Introduction

Some of the issues which I would like to reflect upon will include such questions as, why, in spite of the serious drives and political will of Africa to promote the use of technologies for accelerating our development, are we not making much progress in this endeavour? What are we not doing right? What are the problems and challenges associated with the integration of science and technology policies with overall national and regional development plans and priorities? What can we learn from others, especially to harness the fruits of modern technologies for the revitalisation of our socioeconomic development and for our dignified coexistence in this world in the years to come?

Because of the possible overlap of these questions with many of the topics that would be covered by others during this meeting, and in the interest of limiting my presentation to save time, I shall touch only briefly on highlights which have relevance to these questions.

The basis of my reflection will be the repeated realisation that:

1. Science and technology are not ends in themselves. They are both the product of the genius of a given culture as well as an instrument for the advancement of the welfare of man as understood by that culture. Science, therefore, is not necessarily always universal, nor is it absolutely neutral. It is intimately linked to value systems and to a specific vision of the world.
2. The application of science and technology to development should have as its main purpose the attainment of the goals of a society, including its basic needs, and the aspirations of its people, with full respect for human dignity and cultural identity. As the impact of science and technology can have both positive and negative effects which are only felt over a relatively long period of time, decision-makers must be forward-looking and future-oriented in their approach, while also attending to pressing short term objectives.

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3. Before considering the process of the application of S & T to development, it is important to be aware of the fact that true development only occurs when science becomes part and parcel of culture. Hence, the vital need for an endogenous development of science as an integrated part of national culture. Without this, only superficial transfers of science and technology are made—with no lasting effect and with a risk of socio-cultural disruption.(1)

These goals and aspirations, which were articulated by a group of concerned African scientists who met under the foothills of Mt. Kilimanjaro nearly 10 years ago, are true now as they were then. Some of these goals could be realised, hopefully, through collective self-reliance amongst African countries and by co-operation with the rest of the international community, through scientific organisations such as the African Academy of Sciences and the US National Academy of Sciences, the co-sponsors of this symposium, as well as political organisations such as the Organisation of African Unity (OAU), the Economic Commission for Africa (ECA), other concerned United Nations bodies and bilateral organisations.

However, learning from the unfulfilled promises of the 1979 United Nations Conference on Science and Technology for Development (UNCSTD), in which I was involved as the Principal Scientific Co-ordinator, Africa should not expect miracles from any such conferences and mega-activities, especially those concerned with long range development issues. Indeed, countries themselves must first develop the necessary motivation and political will to use science and technology effectively for their own development. They should do this by formulating appropriate science and technology policies, establishing the necessary infrastructure and institutional mechanisms for their implementation, and supporting their scientists more effectively as part of the overall socioeconomic development strategy. These should be some of the lessons learned from the past upon which any future prospects and challenges should be built.

Reflections on the past

Reflecting back into the question of what went wrong in Africa in the area of S & T policy over the last 20–30 years of independence, there are many useful lessons to be learned.

First, we were young and enthusiastic. We had no basic infrastructure, experience or tradition in the application of science and technology to development. Immediately after independence in the 1960s and 1970s, many of our enthusiastic leaders had great hopes for what science and technology could do to accelerate or even "leap-frog" the development of their countries. Some, like Nkrumah, immediately set up national structures, such as the Ghana Academy of Sciences (GAS) and the Council for Scientific and Industrial Research (CSIR), designed to promote S & T for national development. Such initiatives were heralded all over Africa, and many other countries followed in creating similar policy-making bodies, often with the help of UNESCO.

At the regional level during the early days of OAU, many well-intentioned, ambitious regional programmes and activities were initiated. I remember, for example, the establishment of the high-level Scientific Council for Africa, which some of us here had the honour of serving, and the initiatives

to establish "centres of excellence" in different fields, with strong political motivation.

Resolutions and recommendations that called for support for the African scientist, promotion of regional professional societies, African Science Prizes, etc. became rituals and remained, by and large, paper tigers. Unfortunately, many good intentions did not materialise, either for lack of funds or strong political will or for different technical reasons. Therefore, with a few exceptions, organised S & T policy has not been the driving force for the application of science and technology for development in Africa.

For a long time, Africa has been bragging about and relying heavily upon its natural endowment of valuable mineral resources and tremendous agricultural potential. In fact, over-reliance on what is readily obtainable may have led to the lack of the motivation to develop basic sciences and technology, with their coincident manpower and infrastructure, as the foundation for diversified development of Africa. Ironically, some countries in other parts of the world such as Japan, which are not endowed with similar natural resources, have relied heavily on their people and made well-planned and concerted efforts to develop S & T capacity; this now puts them in the forefront of socioeconomic and technological development in the world. Africa should learn from this and make extra efforts to develop our S & T manpower, as well as other related structures that would enable us to develop and use our natural resources, under our own control, instead of depending on either export earnings from our raw materials, or imported products, which, we have now learned, have not taken Africa anywhere.

In trying to learn from the past, it appears that sometimes we may have rushed to build structures before having the necessary "bricks and mortar" to go with them. In some cases, S & T policy-making organisations ("bureaucracies") have been built before at least a small critical mass of good scientists were prepared to make such structures work. In most cases, the S & T infrastructure was so weak that it did not serve the role of "mortar"—keeping the scientists at home, providing opportunities to develop their creativity, and enabling them to contribute to the nation-building effort effectively. Instead, in the absence of such infrastructure and support, the bricks fell apart, brain drain followed, and scientists have ended up elsewhere, often much to their regret.

The individual African scientist needs stronger support for his work and encouragement and opportunities for involvement in national development efforts. The average African scientist I know is isolated, has no adequate access to information, very little, if any, financial support for his research, meagre research facilities and infrastructure, low salary and therefore low morale. This situation has to change if Africa is to rely on S & T for future development. There is a great deal that African scientists can and are already contributing in different fields, particularly in agriculture and medicine. This could be substantially increased if they get more support, encouragement and recognition.

Due to lack of financial resources in their own countries, many African scientists have to depend on foreign research grants—for which sometimes they have to go through much frustration and humiliation. Those research proposals more relevant to their country may not be funded; instead, they may be persuaded to accept a counter-proposal that might be forced upon them by the aid-giving organisation. This is particularly true in the field of natural product research. My own personal experience in the development of the

African soapberry plant, Endod (*Phytolacca dodecandra*), for its dual use as a molluscicide for the control of schistosomiasis and as a locally-producible detergent for improved hygiene, is a good example. In spite of over 23 years of extensive scientific studies proofing the great potential of this natural product, it has not yet enjoyed the necessary financial support for the work to be done on a large-scale basis to benefit Africa. Instead, if we had been working on natural products that could be used as artificial sweeteners or as anti-cancer agents, as we were often persuaded to do by foreign interest groups, plenty of money would be put at our disposal by granting agencies.

Another major area of concern is that Africa has become and continues to be a dumping ground for untested technologies and products. We have become a "guinea-pig" for trying out drugs, vaccines, pesticides and other products not normally allowed to be tried out in the developed countries. What is worse is that we even pay for it! This is a multibillion dollar business from which, unfortunately, knowledgeable African scientists are usually kept away. There is an urgent need for policy consideration of such issues.(2)

Scope and objective of science and technology policies and strategies

Science and technology policy should generally consist of principles and methods, with the necessary legislative, executive and budgetary provisions, to mobilise and organise scientific and technological potential (particularly scientists) to generate relevant knowledge and application of available technologies for the solution of specific national problems.

As Sir Winston Churchill once remarked, "Science is too important to be left to scientists alone!" In operational terms, science and technology policy should actually be the business of politicians, managers and specialists in the field, who are dealing with the institutions and processes which determine priorities and development activities for which the technology is to be applied for practical use. The best measurement of a society's technological development should be its ability to use its own technological capacity to produce the goods and services it needs.

Policy-making in science and technology presents specific difficulties not present to the same degree in other aspects of national development planning. First, it must plan well into the future, since the results of scientific and technological activity will only become apparent over a long period. It is difficult to devise a policy without assumptions about future trends in a national production system or, at least, some model of the economic and social structures one hopes to achieve. Secondly, policy-making is almost inevitably selective in the majority of countries. It is practically impossible for all nations to pioneer whole scientific and technological fields because the scale on which national scientific communities and infrastructure for research and experimental development work would have to be established is too vast.(3)

Of course, it would be pretentious to suggest that the advance of science and technology can be centrally directed by arbitrary selection of objectives and the subsequent commitment of national resources. Over-concentration of research planning, particularly of basic research, can lead to ineffectiveness. However, if one is familiar with the scientific and technological principles required to tackle specific socioeconomic problems, such as those involved in Brazil's alcohol project, then there is every reason for mounting concerted

mission-oriented attacks on such problems, based on a centrally-derived consensus.

The question of national capacities for the integration of S & T into the overall development plans and programmes is a major concern. Recently, UNESCO undertook a study to examine the extent to which science and technology are integrated into national socioeconomic development efforts in the countries of the West African sub-region.(4) The results showed that whereas the governments of the countries covered in the survey were aware of the important role that science and technology must play in the socioeconomic development of their countries, very few of them had a clearly defined national science and technology policy aimed at systematically bringing about this integration.

Certain countries such as Sénégal, Côte d'Ivoire, Nigeria, and Ghana, which have relatively well-developed science and technology policy-making bodies, have made some effort to integrate science and technology into the major objectives of their plans. However in other countries, such as Bénin, Burkina Faso, Guinea-Bissau, Mali, Gambia, Mauritania, Liberia, Sierra Leone, Niger and Togo, although research activities exist (mainly in the agricultural sector), development plans do not include a policy for science and technology which can be translated into a national scientific and technological budget. The research budgets which figure from time to time in certain plans (Burkina Faso, Mali and Niger) are committed either by way of national counterpart for bilateral or multinational co-operation projects, or else in aid of existing agricultural development projects (Bénin and Niger).(5)

Generally speaking, in these countries as in other parts of the world over the past decades, scientific and technological activities have been promoted for their contribution to progress in specific sectors such as medicine, agriculture, and industrial technology which, in turn, has represented a factor in economic growth. The challenge ahead is for technology to become a commodity with proprietary rights in a highly competitive market economy. Thus, one of the future challenges for Africa is to build the necessary capacity to know that technologies exist, and where and how to get and apply them.

Technology transfer

The most important aspect of the issue of science and technology is probably that over 95 percent of all research and development activities in the world are carried out in the industrialised countries. This gives a preliminary—but very clear—idea of the importance of technology transfer to the developing world.

This enormous imbalance automatically leads to excessive dependency, which is already creating many problems for developing countries, from a substantial loss of scarce resources (specialised personnel through the brain drain, and foreign exchange) to the imposition or involuntary acquisition of foreign norms, structures and cultural values and the neglect of scientific and technological creativity in these countries.

That is why, even though it is true that science and technology are essential components of the national development process, it must be recognised and accepted that the achievement of their tremendous potential is increasingly dependent on co-operation and action at the international level.

Hence, the Vienna Program of Action adopted by the United Nations Conference on Science and Technology for Development, held at Vienna in August 1979, emphasises two basic concern areas: the strengthening of the science and technology capacities of the developing countries, and the restructuring of the existing pattern of international scientific and technological relations, which obviously includes the transfer of technology.

There is a close interrelationship between the two issues. As regards the transfer of technology, for the acquiring country to make full use of the technology, it must expand its capacity to generate, control, absorb, adapt and apply scientific and technological know-how. It must also create or expand institutions capable of advising the government or the industry concerned on the quality or suitability of the technology and the manner and terms of its acquisition.

At the same time, in its effort to strengthen domestic scientific and technological capabilities, Africa will have to resort, to the extent and under the terms and modalities deemed appropriate, to co-operation with countries that are further advanced in the area concerned. A distinctive feature of this flow is the increasingly important role played by governments in the transfer of technology. Such a flow is generally channelled through transnational corporations and a large part goes from parent company to subsidiary, the latter bring either totally or partially owned by the former.

As is well known, the flow of technology to the developing countries, including Africa, takes place through the following channels: direct foreign investment; turnkey arrangements for the supply of machinery, equipment and plants, that is, embodied technology; the establishment of joint ventures; and the licensing of know-how, patented or not.

In quantitative terms, the most important of these channels are those that provide for the supply of machinery and equipment and for direct foreign investments. However, licensing of know-how, patented or unpatented, has in recent years become increasingly important, especially in absolute terms. It has been estimated, on the basis of a sample considered by UNCTAD to be representative of the developing countries throughout the world that royalty payments increased from $200–300 million in 1965 to over $1 billion in 1975, and to over $2 billion in 1980. This shows how important the market of the developing countries is to the industrialised countries. These figures indicate that the share of the developing countries in the worldwide exchange of technology rose from 8 percent in 1965 to 14 percent in 1980. This may be attributed on the one hand to general economic growth and, on the other, to the industrialisation efforts made by the governments of those countries.(6)

The Lagos Plan and science and technology

Chapter 5 of the Lagos Plan of Action treats science and technology at some length. It starts with Africa's disappointment about the outcome of the 1979 UN Conference (UNCSTD), and builds its hope on having a substantial share (40 percent) of the envisaged resources of yet another institution, which has since then been abolished, the Interim Fund for Science and Technology for Development, now known as the United Nations Fund for Science and Technology for Development (UNFSTD) within UNDP.

The plan calls for a more self-reliant approach to the application of science and technology for integrated rural development through a number of initiatives, including strengthened national S & T bases and centres, development of appropriate human resources, promotion of entrepreneurship, more women's participation, support for the informal sector, stopping the brain drain, more bargaining power for transfer of technology, and increased regional and international co-operation.

With regard to priority areas for the S & T, it puts priority on food and agriculture, industry, natural resources (minerals, water and forests), energy resources, transport and communications, health and sanitation, housing and environment. The Plan further recommends the establishment of national science and technology development funds that would work closely with the policy-making bodies at the national level, and collaborate with similar institutions at the sub-regional, regional and international levels.

While the Plan, as outlined above, is laudable and exhaustive on paper, it does not enjoy the necessary political backing, financing, and infrastructure for implementation at the national or regional level. In order for such a plan to be implemented, particularly for the benefit of the less advanced countries in Africa, a strong political drive and very serious organisational effort at the OAU and ECA levels as well as at the level of professional organisations such as AAS, will be absolutely necessary.

Prospects and challenges of new technologies: the need for technological literacy in Africa

The major prospects and challenges of science and technology in the future lie in the area of the potentials of new scientific and technological developments. Rapid technological change is a major feature of the world economic situation today. At a minimum, Africa needs to develop adequate technological literacy to know what technologies and technological products exist, where and at what cost.

New technologies are already beginning to have profound impacts on developed countries, and, because of the increasingly interdependent nature of the global, economic and political system, on developing countries in Africa as well. Many specific implications are often still unclear, and concerted efforts are required to monitor and assess the technological advances in terms of their potential positive and negative repercussions. A central component of such efforts needs to be oriented towards alerting policy makers in third world countries to the implications of new technologies for the development process in their country and region.(7) Many of these implications open opportunities for development. Others are also beginning to raise concerns in various countries in both the developed and developing world. Planning and action is needed to deal with side effects.

One of the most widely recognised areas of technological change—microelectronics—has been compared in terms of its impact to the industrial revolution of some two centuries ago. Tissue culture technology promises to revolutionise plant production and basic medical research. However, to cite an example of side effects which must be mitigated, development of high fructose corn sweeteners through biotechnology is already substantially reducing the world market for cane sugar, a product on which Africa was heavily reliant as

a major export item. Advanced communication techniques are making it easier to establish contact across long distances in our countries and even among distant points on the globe. Again as a side effect, the use of fibre-optics is leading to a decrease in the demand for copper, and already weakening the economy of major copper exporting countries such as Zaïre, Zambia and Zimbabwe. In other examples, applications of microelectronics and automation techniques are increasing production and quality control, at the cost of displacing labour. Industrial machines and robots are doing tedious jobs and making work easier and safer in large factories. As an example of the need for planning in this field, the mechanisation of the production of "gari", a staple food in West Africa, will probably deprive groups of women of their basic livelihood.

Thus, it is increasingly being recognised that rapid technological progress can and does create opportunities and problems of a pervasive nature for countries at all levels of development. The ability to analyse these problems and opportunities in a scientific manner and to develop effective strategies with respect to new technologies is, therefore, becoming an essential need in developing countries.

Possible response mechanisms: early warning systems

One of the major concerns shared by all countries during the 1979 United Nations Conference on Science and Technology for Development was the potential implication of new technologies to developing countries. This was specifically expressed in the Vienna Programme of Action which recommended "initiating arrangements for the early identification and assessment of new scientific and technological developments which may adversely affect the development process, as well as those which may have specific and potential importance for that process and for strengthening the scientific and technological capacity of the developing countries".

As part of the implementation of this recommendation, the United Nations Centre for Science and Technology for Development, in co-operation with all concerned organisations of the United Nations system, has launched in 1983 an Advance Technology Alert System (ATAS) that could provide developing countries with appropriate information, through a series of special publications and meetings, to alert them to the implications of new scientific and technological advances.

The ATAS project, for which the author of this paper had the responsibility for in its initial conception, development and launching during the period of 1979–86, has three components:

1. *The ATAS Bulletin*, a periodic publication providing concise and integrated information on specific new technologies, designed to alert policy-makers and planners in developing countries to the potential impact and implication of the technology. So far three such bulletins have been published: the first on Tissue Culture Technologies and Development (1984), the second on Microelectronics-based Automation Technologies and Development (1985), and the third on New Information Technologies and Development (1986).
2. *ATAS Network*, linkage of science and technology forecasting and assessing institutions and individuals in developing countries with those

in developed countries where the major sources of such information and technological development exist.

3. *Assistance to member states*, upon request, to provide available information on the potential implications of new technologies at the individual country level and assist member states to develop their own response mechanisms.

Based on the limited experiences gathered by the UNCSTD on the ATAS project, an attempt has been made to initiate a similar alerting mechanism in Africa. An OAU, ECA, UNCSTD and UNIDO-sponsored *African Expert Group Meeting to Assess the Implications of New Technologies for the Lagos Plan of Action*, convened in Mbabane, Swaziland, in October 1984, examined this issue in some detail. That expert group recommended the establishment of an *African Early Warning System on New Technologies*, a sort of ATAS-Africa under OAU and ECA sponsorship. The plan for this is currently under study.

Since the individual needs and levels of development of African countries vary greatly, in the long run, each country should aim at having its own S & T intelligence system so that it can develop the necessary national capacity for the choice, negotiation and transfer of technologies.

Conclusions

In conclusion, based upon the experiences to date and the challenges and prospects in the future, if Africa is to promote sustainable development and dignity of life for its people, the existing patterns of development, including the scientific and technological capacity-building efforts, need to be re-thought and even revolutionised. Among the most important steps are systematic and extensive high- and low-tech training programmes, linking trained scientists and technicians to practical production sectors, and providing the necessary S & T infrastructure and incentives to retain African intellectuals at home as productive individuals connected with the rest of the scientific community in other parts of the world.

At the present rapid rate of scientific and technological development in the world, all countries will need at least some degree of technological literacy, to know what technologies exist, where, and at what cost. Since Africa will remain a major importer of technologies and technological products for years to come, Africa should be an educated consumer in order to be a good customer. Apart from trade considerations which could put Africa in a recipient and dependent position, the prospects and possibilities of Africa's contributions to the advancement of knowledge through its historical, environmental, and natural resources, as well as its cultural and behavioural values should also be seriously taken into consideration.

To take one example, because of its tremendous environmental variations, Africa offers diverse plant and animal genetic resources, unmatched by other regions of the world. Such unique resources would in turn provide the basis for much of the biotechnology revolution that is now taking place in the laboratories of the developed countries. The same can be said about scientific and technological developments related to other areas of agriculture, medicine, and natural resources, including medicinal plants.

Other examples of Africa's historical contributions range from the origin of man through the days of his struggle for survival, the engravings in the

caves of the Sahara before it became a desert to subsequent technological developments such as the pyramids of Egypt, and the Axum obelisks of Ethiopia. The still-preserved cultural values of interdependence and extended family network systems and the ability to keep dignity in poverty are also human values which Africa can proudly share with others. Thus, any S & T policy to be adopted by or institutional capacity to be developed in Africa in the future should take such points into consideration and put Africa not as a total dependent but also as a reciprocal or contributing partner in the development process. We should be more active in identifying and developing our potential areas of contribution to this global process.

In the words of Edward Blyden, a black American who, while residing in Liberia in 1903, reflected on his experience in that country and declared "No people can profit by or be helped under institutions which are not the outcome of their own character."

Notes

(1) *African Goals and Aspirations from the United Nations Conference on Science and Technology for Development.* Report of a regional symposium held in Arusha, Tanzania, February 1978, prepared by Lemma et al.

(2) Ruth Norris ed. *Pills, Pesticides and Profits: The International Trade in Toxic Substances.* (1982). North River Press, Inc.

(3) For more detailed analysis, see *UNESCO Science Policy Studies and Documents,* No. 46 (1982) *An Introduction to Policy Analysis in Science and Technology.*

(4) For more details, see *UNESCO Science Policy Studies and Documents Series,* No. 58 (1985) Comparative Study on the National Science and Technology Policy-making Bodies in the Countries of West Africa.

(5) UNESCO (1985) *Ibid.*

(6) UNCTAD, *Organizational Forms of Transfer of Technology to Developing Countries,* Publication No. TD/B/C.6/77.

(7) See Lemma, *An Advanced Technology Alert System for Africa.* Paper presented at the African Expert Group meeting to assess the implications of new technologies for the Lagos Plan of Action, held in Mbabane, Swaziland, 22–26 October, 1984.

SCIENCE AND TECHNOLOGY IN AFRICA, THE INSTITUTIONAL FRAMEWORK: A BRITISH PERSPECTIVE

*William A.C. Mathieson**

Oh! Africa, mysterious land
Surrounded by a lot of sand
And full of grass and trees.

Hilaire Belloc (1898) *The Modern Traveller.*

The police of science, although arrived late on the scene of the tragedy, were now following many converging clues... A fine spun net is being woven remorselessly around him (the tsetse).

On the epidemic of sleeping sickness in Eastern Uganda in the early 1900's when 200,000 out of a community of 300,000 became fatalities. The tsetse is still elusive.

Winston S. Churchill (1908) *My African Journey.*

Plagiarize, but be sure always to call it research!

Professor Thomas Lehrer, Harvard University (1956)
The Mathematics Song, by Nicolai Ivanovitch Lobachevsky".

This paper seeks to sketch the British approach to the application of science and technology to Africa in the areas in which Britain has had from time to time administrative responsibility. It focuses on mechanisms rather than results or failures, since it is designed to contribute to a discussion on the institutional factor in putting science to work. A scholarly treatment of this theme would require prolonged research into the abundant but widely dispersed archive. This paper has no such pretensions. It is largely anecdotal from personal involvement in an official capacity for thirty years and oblique concern in subsequent incarnations. It surely contains omissions due to ignorance and errors attributable to faulty recollection. Since it is an institutional review, it may benefit from my complete innocence of scientific or technological competence.

The survey is structured around three periods which tend to flow into each other. The first is from the late 19th Century to 1940; the second from 1940 to 1960, the twilight of the colonial presence, and the third from 1960 to the present. My main emphasis will be on the second period, since the first is a prelude and the third an inheritance. Institutions planted in the second have either blossomed or wilted in the third.

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*William A.C. Mathieson was formerly Deputy Secretary of the British Ministry of Overseas Development (1976–1981).

The early days

In the beginning, the colonial administration was both ignorant and suspicious of science. The Indian Government saw no reason why Dr. Ronald Ross should have a microscope at Secunderabad. A great deal of unsystematic enquiry was carried on by district officers and missionaries, mainly in what would now be dignified as the social sciences. Anthropology, ethnology, linguistics, but also botany and ecology flourished unobserved and imperfectly recorded. The medical missionaries were particularly adept at the natural sciences as trained observers, since most missionaries enjoyed a better basic education than traders and administrators, who managed such government as there was.

If one can distinguish between science and technology, it was the latter, derived from exotic antecedents, which blazed the way. As Sir James Robertson, the last Governor-General of the Sudan, observed:

> "When Kitchener defeated the armies of the Mahdi at Omdurman in 1898, there were no railways, there were no telegraphs, there were no schools, there were no hospitals, there was no sort of modern government. When we left the Sudan (1956), there was a system of railways, a system of roads, a police force, hospitals, schools, even a university. We had set up a civilisation which had not existed before."(1)

A surprising omission from this catalogue of pride is the greatest scientific and technological achievement of them all: the understanding and beneficial management of the waters of the Nile. In its exploration and mastery, up to the building of the High Dam, the Nile was a British river. To defend this assertion would require a paper on its own, but it defies challenge.(2) Among other things, this achievement led to the establishment of cotton in the Sudan, which again is another story.

In 1927, the first British inter-territorial agricultural research station in Africa was set up at Amani in the Usumbara Mountains in North-Eastern Tanganyika. It was funded by grudging contributions from the three territories. This was a resurrection of the Usambara Kulturstazion of German East Africa, which on a 2,000 ft. steep incline could replicate many tropical ecologies. Under the Germans, it was essentially a botanical station for the experimental introduction of exotic economic plants. Many of these still persist in a feral state. Among other useful species and cultivars, it introduced sisal from Central America to East Africa. It was visited in 1929 by Dr. Julian Huxley, then lecturer in Zoology at London University and later the first Director-General of UNESCO. He had been invited by the Colonial Office to visit East Africa and assess the relevance of what was then called "native education". As Huxley commented: "The great drawback of Amani is its isolation. But since a laboratory in an inconvenient situation is a good deal better than no laboratory at all, we can be reasonably content."(3) The activity was moved to Kenya in 1948 to an institution to be mentioned later.

Up to the outbreak of the second world war, progress in scientific research was sporadic and poorly funded. Colonial governments were expected to subsist on their own local revenues and dire were the strictures

imposed on any administration which fell into the position of having a deficit grant-aided by the British Treasury. Such investigations as were carried out were undertaken by the technical departments of government but there were few officers who could be sufficiently freed from routine duties to conduct sustained research. Two notable exceptions were the cocoa research station at Tafo in the Gold Coast, later to attain a West African personality, which elucidated the aetiology of the swollen shoot syndrome, and the Veterinary Research Laboratory of the Government of Kenya at Kabete, founded in 1908, which acquired an international reputation in tropical animal disease and became in 1939 the Central Veterinary Research Institute for East Africa.

But the most significant impact arose from the Rhodes Memorial Lecture delivered at Oxford in 1929 by General Smuts. He pleaded eloquently for the launching of a study of the problems arising in Africa south of the Sahara and a review of the extent to which modern knowledge was being applied to these problems. A committee was formed under the chairmanship of the Marquess of Lothian, which included Julian Huxley and Sir John Boyd-Orr (later the first Director-General of FAO), to initiate the work. It appointed as Director of the Study, Lord Hailey, an eminent Indian administrator. The enterprise was largely funded by the Carnegie Corporation of New York and ran from 1933 to 1938. In Chapter XXIV of the report "The Future of African Studies", Lord Hailey illuminated all the problems, social and economic, which still confront Africa today and in many cases defined them better than any subsequent diagnosis.(4)

His critical recommendation was that British government funds should be made available on a sustained basis to promote research in and for the dependencies in Africa. He had noted that the Colonial Development Fund, set up in 1929, had by 1938 disbursed approximately only £250,000 for research related to Africa.

The era of the colonial development and welfare acts

A new era was opened by the enactment in the darkest days of the war of the Colonial Development and Welfare Act (1940), which influenced by Lord Hailey explicitly set aside a proportion of the authorised funds "for promoting research or inquiry", a subtle distinction. The amounts were increased in real terms in subsequent Acts in 1945, 1949 and 1955. In 1961, the funds were transferred to the newly created Department of Technical Co-operation and were no longer restricted to colonial territories.

There was an awkward hiccup when countries moved to independence and lost their money, sometimes permanently. It was even more awkward when some constituents of regional institutions moved ahead of others to non-eligibility. The substantive advances in knowledge and its application funded in this way from 1940 to 1960 are chronicled in detail in a useful compilation by Sir Charles Jeffries, a former Deputy Secretary in the Colonial Office.(5)

The present paper is confined to a sketch of the institutional framework and its evolution. Generally Colonial Development & Welfare (CD&W) money for research in the colonies met the entire initial capital cost, other than land, of new or expanded institutions and a proportion, not less than half, of recurrent expenditures over successive five-year periods of commitment.

The groundnuts scheme

Early in this period, awareness of the value of research in Africa was brutally enhanced by a coruscating disaster. In 1947, under pressure of severe balance of payments constraint and a need to seek edible oils from within the sterling area (no developmental altruism here), the Ministry of Food set up the Overseas Food Corporation. An appraisal mission spent all of nine weeks in Southern Tanganyika and proposed the mechanised clearing for groundnut production of over 3 million acres of virgin bush. If they had been able to converse with the few local people nearby, they would have learned that the area around Kongwa was known in Swahili as "the country of perpetual dryness". Virtually nothing was recorded or discovered regarding water availability, soil characteristics or prevailing pests and pathogens. Departmental professionals had written it off as a "no-go" area. Nevertheless, squadrons of converted Sherman tanks were launched to desecrate the African bush but the target for clearance had been reduced to 500,000 acres by the early 1950's. The maximum export of groundnuts from the scheme was 9,000 tons in 1952, compared with exports from peasant production in Tanganyika of 26,000 tons in 1937. The whole scheme was abandoned in 1954 after the fruitless investment of over £40 million. The new port of Mtwapa reverted to its previous condition as an Arab slave-trading post and tropical Africa demonstrated its capacity to bury mistakes, including the new railway. The debris was bequeathed to the Tanganyika Agricultural Corporation—an off-white elephant!

But the lesson spread widely that in Africa, as elsewhere, time spent in reconnaissance is seldom wasted.(6).

The social sciences

One of the first African recipients of CD & W funds was the Rhodes-Livingston Institute of Sociological Research, proposed by the Rhodes Trust to be set up in 1940 to commemorate Dr. Livingston's first departure for Africa in 1840. It became operational in 1945 in Nyasaland and was moved to Lusaka in 1956. The quality of its work was remarkable for an institution with no other local academic base. The great sociologist-anthropologist Audrey Richards published the foundation stone of her reputation in "Marriage Customs of the Bemba". Sociology had a headstart over other sciences in Africa through the teachings of Malinowski (Kenyatta's tutor) and Raymond Firth (a New Zealander) in London.

The East Africa Institute of Social Research was established in Kampala in 1944. The West African Institute of Social and Economic Research at Ibadan came later in 1950. Both were CD&W funded. These developments were planned and supported by the Colonial Social Science Research Council in London, serviced by the Colonial Office, which advised on the allocation of CD&W funds and helped with publication of the product. The institutions so established were later assimilated to the university institutions which grew up alongside them and which inherited much of their reputation and quality. They had a profound impact on thinking about the human face of development in Africa and inspired a great deal of continuing inquiry by African social scientists.

The natural sciences

In the post-war period, research in the natural sciences was greatly intensified in and for Africa. A panoply of specialist committees was created in London and a considerable administrative burden assumed by the Colonial Office to service these bodies and manage the funds on the apportionment of which they advised. The umbrella body, the Colonial Research Council, was of little practical value, since it was inevitably a forum for dispute between representatives of a wide range of disciplines for their share of the cake. In practice, fairly crude apportionments were made administratively and the specialist bodies given each an arbitrary slice to assign to projects. The most objective in priority setting was probably the Tropical Medicine Research Board of the domestic Medical Research Council, which orchestrated substantial back-up from metropolitan institutions.

The basic approach was that problems could best be identified and tackled on a regional basis, to create a critical mass addressed to an objective which no single territory could effectively tackle on its own. Scientific rationality demanded such economy and focus but progressively it became inconsistent with political reality. Geopolitically the structure in British West Africa was inevitably less centralised than in East and Central Africa. The cocoa research centre in the Gold Coast had a sub-station in Nigeria; rice was focused in Sierra Leone; oil palm, trypanosomiasis and yams were essentially Nigerian; and the Colonial Office peripheral representation, the West African Inter-Territorial Secretariat in Accra, was little more than an accounting office for the partition of CD&W funds.

In East Africa, regionalism was more seriously pursued. An inter-territorial conglomerate, the East Africa High Commission, established by UK legislation in 1948, had the statutory duty of administering the East African research services. Apart from CD&W infusions, these were sustained by monies voted annually by institution and purpose by territorial legislatures. If a territory felt that it was not benefiting from an institution situated in another, supply could be impeded or even interrupted.

The range of institutions created or expanded was impressive. In Kenya, agriculture and forestry (EAAFRO), veterinary science (EAVRO), and leprosy were housed. In Uganda, the Virus Research Laboratory (based on international standards set by earlier work by the Rockefeller Foundation on yellow fever in Entebbe), the inland fisheries station at Jinja and the trypanosomiasis work at Tororo were supplemented by a pioneering outstation of EAAFRO at Serere on sorghum and millet. In Tanganyika, the emphasis was largely medical with work on schistosomiasis at Mwanza and malaria at Amani. The Tropical Pesticides Research Institute near Arusha was wholly funded and directed by the British Government, although it was off-loaded to the East African Community in 1967. A small station for marine fisheries was located in Zanzibar. There were advisory co-ordinating committees to ensure links with territorial services and in 1955 these were overlaid by East African Councils for Agriculture and Medical Research, with outside membership. These councils had no executive function but they reflected a period when the East Africa High Commission had been voted a pool of money from the East Africa Legislative Assembly which freed the institutions from the fiscal tyranny of territorial legislatures.

It is difficult to follow the evolution of the East African research complex separately from the fluctuations in the political environment, which saw change from the East Africa High Commission to the East Africa Common Services Organisation (1961) and from that to the East Africa Community (1967). A "distributable pool" of revenues remained a feature from 1961 from which the common services were financed, with continuing although tapering subventions from the British Government. The taper, designed to encourage increased local contributions, in practice reduced the aggregate. These resources were never adequate to sustain scientific ambitions, particularly the desire to train and employ African professionals. A serious re-examination of the management of research was conducted by a commission chaired by Professor Fraser from the British Medical Research Council in 1961. This recommended that executive research councils for East Africa in Natural Resources and Medicine be set up under general supervision by a triumvirate of territorial ministers. This was done and mitigated the politically inevitable instability. It should not be forgotten that industry funded research in coffee, tea, pyrethrum, and sisal in particular made a substantial contribution to production of export crops. Cotton is a separate story to be mentioned later. The ultimate disintegration of the Community left the national governments heirs to the declining components of what had been a fairly comprehensive and systematic structure for applied science.

Central Africa (now Zimbabwe, Zambia and Malawi) followed a similar institutional pattern of brave attempts at regionalism followed by dispersal. Here there was a formal federation established in 1953. At that time the federal government took over both the responsibility and the scientific facilities for European agriculture on the line of the rail. Native subsistence agriculture was left to the government departments in the three territories, with no explicit scientific component. Tobacco and tea had some industry-funded competence. In 1959, the Federal Government passed a Research Act and in 1960 the Agricultural Research Council for Rhodesia and Nyasaland was established. Through the energetic action of its Executive Director, Dr. H.C. Pereira (now Sir Charles Pereira, FRS) a project-team approach was adopted, whereby task forces with specific objectives were based at and fortified territorial establishments. New facilities, often supported by British funds, were created at these sites and highly productive programmes were conducted. On the dissolution of the federation in 1963, the council was orphaned but, by inter-governmental agreement, was reconstituted as the Agricultural Research Council of Central Africa, with the same policies and vigorous direction.

By invitation the British Government nominated the Chairman, Sir Frederick Bawden, Director of the Rothampstead Experiment Station. Unhappily, the events of 1967 inevitably dismembered the council and its relicts were absorbed in different institutional forms in the three territories. But, in the short period 1960–1967, remarkable advance was made in the understanding of the natural forces and endowments governing productivity in the region.

The metropolitan base

It could be claimed as a beneficial feature of the colonial relationship that it stimulated the metropolitan scientific community, from the Royal Society on down, to take a responsible interest in tropical Africa and to generate or adapt

domestic institutions to further this interest. A sense of duty was heightened by the ample prospects for the exercise of scientific curiosity. A few of these institutions should be mentioned. The resources to sustain them tended to decline or evaporate when the colonial links were severed.

The Liverpool School of Tropical Medicine and the London School of Hygiene (public health) and Tropical Medicine (which includes the Ross Institute), both established in 1899, were pioneers in elucidating the afflictions of the tropics and training those who worked in the field, particularly African doctors who were a generation ahead of agricultural scientists. The Centre for Tropical Veterinary Medicine at Edinburgh (created as such in 1961) was designed to garner and perpetuate colonial experience. The Institute of Development Studies at Sussex was envisaged as having a similar post-colonial role in economics and sociology.

The Royal Botanic Gardens at Kew started by Princess Augusta in 1750 and handed over to government control by George III in 1841, played a notable role in transferring economic plants to far corners of the British Empire. While seeking to translocate breadfruit from the Pacific to the West Indies, one of their principal scientists died in an open boat commanded by Captain Bligh. Rubber and cocoa were major crops left from the New World. In 1898, Sir Daniel Morris, the Assistant Director, set up as a research station the Imperial Department of Agriculture in Trinidad, which in 1922 became the Imperial College of Tropical Agriculture, for over half a century to nurture specialists for Africa and elsewhere and to conduct pioneering research on tropical crops. In the colonial period Kew produced and updated flora for West, East and Central Africa, essential tools for scientists, again CD & W funded. Kew helped to create the East African Herbarium at EAAFRO, which remains as a resource.

The Imperial Agricultural Bureaux, including the Institutes of Entomology and Mycology, were founded as taxonomic and documentary centres in 1929. Today, as Commonwealth Agricultural Bureaux International (CAB), they play an indispensable international role. If access to information and the work of others is the basis of a scientific springboard, CAB have been feeding scientists in Africa for over 50 years.

Another institution which should be mentioned is the Inter-University Council for Higher Education in the Colonies (IUC), established in the period immediately after the war to implement recommendations of the Asquith Report, which urged the creation of centres of tertiary education in Africa linked in a "special relationship" with British Universities. The latter would award their degrees to graduates of their protegees in Africa. A knowledgeable observer has stated: "The overseas universities, whatever their weaknesses at particular places and times, were the most important institutions we established; they have mostly survived and multiplied because they are now national institutions."(7)

In 1944 there were three colonial universities: Malta, Ceylon, and Hong Kong. In 1964 there were 15 in Commonwealth Africa associated with the IUC, plus Khartoum and Addis Ababa. This story has been well told elsewhere (8), but the institutional framework is interesting in that the IUC was an association of heads of British Universities which had a direct relationship, avoiding governments, with emerging academic institutions overseas. All this effort of encouragement and co-operative development was funded by the British Government, which simply blessed the objective and left the rest to academics. Some would say, and did, that this was reckless and irresponsible

frittering money away on the creation of ivory towers, but much enduring good came of it. For the purpose of this paper, however, it must be said that the pursuit of new knowledge was subordinated to creating factories for graduates. It was suspected that certain professors at Makerere in the 1950s urged their pre-clinical colleagues to fail all medical students so that they could get on with their personal clinical research unencumbered by teaching. In the main, African universities did not aim at or create post-graduate capacity in the colonial period. Promising students were sent abroad and many Ph. D.s stayed there, but in the longer term the foundations laid by the IUC are the seed-bed of African science today and tomorrow.

Another British institution with enduring impact was the Empire Cotton Growing Corporation. This organisation was established in 1921 with an endowment from the profits made by the British Government as a monopoly seller of Egyptian cotton during the 1914–1918 war and was largely supported by the Lancashire cotton processing industry. The objective was to replace American supplies by Empire production. India was excluded. The corporation very soon realised that the basic requirement was research on which production by others could be based. The main research stations were Trinidad (basic studies of genetics and physiology) and Barberton in South Africa (agronomy, and disease control). Studies during the second world war (before the advent of chemical insecticides and fungicides) suggested that cotton would flourish better north of the Zambesi. The stations in Trinidad and Barberton were closed and a new central station was developed at Namulonge in Uganda, with operations in Tanganyika, Sudan and Nigeria. All cotton originates outside Africa, so much adaptive research was required to tailor the plant to African conditions. The essential groundwork for this was laid by Dr. Hutchinson of the Corporation Staff (later Sir Joseph Hutchinson, FRS, who died in January 1988 at the age of 85). Working originally in Trinidad, India and the Sudan, he unravelled the genetics of cotton and established a breeding methodology which persists to this day. He set up and directed the Uganda station at Namulonge in 1945, which became the power-house of cotton production throughout Africa. Half the capital cost came from CD & W funds, which also sustained recurrent expenditure. The corporation evolved into being a development assistance agency rather than an instrument of British commercial policy. It changed its name in 1966 to the Cotton Research Corporation and ultimately donated its stations to the countries in which they were located, as it embraced self-willed extinction, symbolised by the transfer of Namulonge to the Uganda Government in 1971 on its Golden Jubilee.(9)

Subsequent international efforts to recreate a comparable institution have foundered on dissensions among cotton producers and differing assessments of the value of further research. Many African scientists are alumni of the corporation and the agricultural research facilities of Ahmadu Bello University in Nigeria are an outgrowth of the corporation's former station at Samaru. In 1921, the African countries with which the corporation was concerned grew some 100,000 bales of cotton a year. In 1971, production had reached 2.5 million. Today Namulonge is virtually derelict.

Perhaps the greatest British contribution through a domestic institution to the scientific management of the African environment was the work of the Anti-Locust Research Centre (ALRC). The architect of this edifice was Dr. B.P. Uvarov (later Sir Boris Uvarov) who determined in the early years of the century in St. Petersburg that the behaviour of the locust was that of a single

polymorphic species, which in certain circumstances adopted two extreme forms, solitary and gregarious. When Russia became confused, he joined the Imperial (British, not Russian) Bureau of Entomology (later Institute) in London. In a modest way, and under Byzantine institutional arrangements, he founded in 1929 the organisation which became the ALRC.

In 1926, the African Migratory Locust had mustered its armies south of Timbuctu and by 1941 was feeding happily at Cape Town. In Southern Africa it was reinforced by the Red Locust, which swarmed over the whole land-mass south of the equator from 1930 to 1944. The Centre had already initiated biogeographical investigations in Africa. (O.B. Lean, who later established the locust unit in FAO, and B.N. Zolatarevsky were roving pioneers in this field). This research established that the outbreak area of the migratory species was the flood plains of the middle Niger (now Mali) and that of the red species near Lake Rukwa in extreme Southwest Tanganyika. Theory, later vindicated in practice, showed that control measures sustained in those foci could prevent plagues. They have effectively done so ever since. The work of the ALRC in devising, stimulating and servicing international organisations to this end is a triumph of science as well as diplomacy.

The desert locust, which has a range from Mauritania to Pakistan, is not so obliging. It can swarm and create an outbreak area wherever meteorological conditions are favourable. The brilliant work done at the Centre in correlating meteorological observations with locust ecology has been the foundation of its early warning facility, the Desert Locust Information Service. This continues to this day, relating by modern communications with over 50 countries.

In 1948, the Desert Locust Survey (DLS) was set up in Nairobi with CD & W funds, building on techniques of control developed in the war years during the 1941–1947 plague and leading to refined technology in ultra-low volume spraying of insecticides from aircraft. It is convenient that the areas favoured by the locust for mobilisation are generally otherwise highly tolerant of chemical deposits. Responsibility for DLS was transferred to the Desert Locust Control Organisation for Eastern Africa (DELCO) in 1963. With the decline of the last major plague in 1962, a series of regional organisations has evolved to keep this locust in recession. Since for practical control purposes as much is known about the locust as can realistically be applied, the centre has since broadened its interest to other gregarious pests of Africa, such as the army-worm and Quelea birds, and intensified its research on grasshoppers, non-swarming species which can pose a serious problem to agriculture. The story of the London domination of the African locusts (which even escaped into Kensington Gardens but expired, exciting agitated letters to *The Times*) should be properly written up, since it combines deep science, exploitative technology and international sensitivity in a unique way.(10)

There are many other domestic institutions and university departments which illuminated the study of Africa during the colonial period. Volumes could be written on the British contribution to palaeontology and archaeology in Africa, much assisted by the British Academy, which exposed a layer of the past for African scholars to dig into.

Institutional ingenuity can only provide a setting for genius to pursue the elusive truth. After all, Africa remains a mysterious land.

Notes

(1) Sir James Robertson (1979) Cited in *Tales from the Dark Continent* by Charles Allen: Andre Deutsch.

(2) For justification see H.E. Hurst (1952) *The Nile.* London: Constable.

(3) Huxley Julian (1932) *Africa View.* Chatto & Windus.

(4) Lord Hailey (1938) *An African Survey.* New York: Oxford University Press. pp. 1630–1633. (Recommendation on research).

(5) Sir Charles Jeffries (1964) *A Review of Colonial Research 1940–1960.* London: Her Majesty's Stationery Office.

(6) See *History of East Africa* (1976) Vol. 3, Ch. VII. London: Oxford at the Clarendon Press. For classic analysis see Frankel S.H. (1953) *The Economic Impact on Undeveloped Societies.* New York: Oxford University Press.

(7) Professor A.H. Bunting (1988) *Personal communication.*

(8) Ian Maxwell (1980) *Universities in Partnership: the IUC and the Growth of Higher Education in Developing Countries 1946–1970.* Edinburgh: Scottish Academic Press.

(9) For elaboration see the memoir published by the Cotton Research Corporation to celebrate its Golden Jubilee in 1971.

(10) Roffey Jeremy (1970) *The Growth and Development of the Anti-Locust Research Centre, 1945–1970.* London: Ministry of Overseas Development. Also Haskel Professor P.T. (1970) *The Future of Locust and Grasshopper Control.* Outlook on Agriculture, Vol. 6, No. 4.

MY PERCEPTION OF TROPICAL HEALTH RESEARCH: EXPERIECNE AT CUSS AND ELSEWHERE

*Jacob Lifanji Ngu**

Introduction

In preparing the presentation, I have assumed that the background document, *Summary of ICIPE Foundation, Discussion on International Co-operation to Strengthen African Scientific and Technological Institutions*, sent to me sets the tone for this symposium. Before addressing the topic of this paper, it would seem to me appropriate to affirm what perhaps is the obvious, namely: significant strides have indeed been made in promoting science and technology in many African institutions. However, the progress so far made may not justify the finances that have been dispensed, and certainly is not sufficient for the continent to cope with its plethora of problems, particularly health and socioeconomic ones. Thus, a quantum leap is needed in research and development in African institutions for the continent to catch up with the rest of the world.

I have attempted to address the subject of presentation by first reviewing my perception of Tropical Health Research at the University Centre for Health Sciences in the University of Yaoundé and in other research centres of the Ministries of Higher Education and of Health in Cameroon over the past two decades. Second, I have attempted to evaluate what has been done, delineating the many interrelated factors—some of them imponderables—which bear on this multifaceted problem of how to institute cost-effective research on health-related problems in African institutions. I do not, for one, see easy solutions nor consider the problems associated with tropical health research divorced from those associated with research in other areas of science and technology; the commonality of the subjects which form the backbone of these various areas speaks for this view.

Review of Research and Development at the CUSS (University Centre for Health Sciences)

The University Centre for the Health Sciences (University of Yaoundé) was founded in 1968. It is one of a network of innovative schools for the training of health personnel and has a curriculum with the unique feature of community-oriented education and problem solving. Right from its inception, CUSS has had a strong research tradition. The problem-delineation-and-solving-oriented programme entails that the students acquire a significant part of their training within the community environment. Thus, to meet its goals,

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CUSS encourages research. Students are encouraged, and indeed obliged, to undertake a piece of investigative work which is presented in partial fulfillment of the conditions of qualification as a doctor. Since this work has to be supervised, it ensures that most of the staff of CUSS are actively involved in some research. Interestingly, in the early years of the medical school, most of this work involved epidemiology as one tried to establish disease patterns in the community. In retrospect, this was a vital step, as until the problems can be defined, priorities cannot be established. Later work has involved trying to establish aetiological factors in the production of different diseases, and more recently, the research undertaken has been of a more fundamental nature as disease mechanisms have been investigated in the laboratory. As yet, not much effort has been expended on applying the knowledge so obtained.

In the research institute of the Ministry of Higher Education and Scientific Research, the CUSS pattern has interestingly been repeated with regard to human diseases. Most of the work done to date consists of data collation. It is only in the areas of nutrition and medicinal plants that the scientists have attempted to address more fundamental issues. There is no research centre as such in the Ministry of Health. The statistics on which the Ministry relies for defining policies depend heavily on data obtained from hospital records (annual reports). Sometimes, disease trends are computed from reports which at best are anecdotal or heresy.

It is illuminating to note that in many instances when scientifically valid studies have been undertaken on the epidemiology of certain diseases, or their trends by either CUSS or the Medical Research Institute, the results thus obtained are not reflected in health policies defined by the ministry. This underscores one of the main problems related to the discussion of research and development in African institutions, which is to understand the reasons behind the research being undertaken. Reasons for research may include the drive for intellectual satisfaction, for the advancement of the frontiers of sciences, for career advancement, or to solve specific problems. In medicine, all of these reasons may be valid. Perhaps because medicine is an intensely practical subject with a specific aim in view—the treatment of patients—research more often than not is undertaken to solve or investigate a specific problem.

What has not been investigated here so far are the psycho-social aspects of disease—the understanding of how the population perceives disease—and yet, perhaps it is here that we should have started. No matter how well we understand the disease pattern in the community, the infective agents involved, or their mode of transmission, this will be of no practical use in "development" if this knowledge cannot be used to implement changes that will reduce or eliminate the occurrence of the disease in question. Quite clearly, inputs from sociologists and anthropologists, linguists and economists are needed. This then, I feel, illustrates the basic problem in discussing research and development. That is—research may be undertaken for many reasons and at many levels; however, for it to affect development, it must not only be relevant, but also be able to be utilised, and for this, certain other aspects of the communication of knowledge and its application must also be studied.

The second part of this presentation deals with my perception of the difficulties encountered at CUSS in the health sector. Naturally, there are several prerequisites for research to be successfully undertaken. I have sketched below a few pertinent examples:

1. *An inquiring mind.* Also one that is not so preoccupied by other problems that it is unable to concentrate on the work in hand. This is often difficult in the medical school, where in addition to the everyday family and social problems, there is the additional responsibility of patient care. This may be a very real distraction in that there is often no "protection" for the doctor from the general public, who do not understand that research is also work, and feel that a doctor's fulltime activities should consist of seeing patients.
2. *A suitable place to work.* Often the hospital workload is such that it becomes difficult to find time for research. This may be made worse by the lack of any suitable space—except in the hospital—in which to undertake research activities.
3. *Adequate provisions.* This includes not only equipment and reagents but also a reliable electricity supply—without voltage fluctuation which will destroy equipment, nor power cuts that will make experiments impossible—an adequate water supply, etc. One aspect which is often forgotten is the training of personnel to service equipment, and the availability of spare parts. Preferably, these should be "grouped" so that there is no unnecessary duplication of materials, with the additional costs that this involves.

If a comprehensive list is drawn up, among the various discernible patterns is one which for convenience subdivides the list into three groups: major determining factors, moderately determining factors, and imponderables. An example of such a list is appended (Appendix 1). What is important to note is that the list is inevitably longer in institutions in less developed countries such as mine than in institutions in more developed countries, particularly with regard to major determining factors and imponderables. The predictive value (PV) or probability of successfully undertaking a research project of any significant magnitude or for a long period is low in the LDCs. The factors which affect the predictive value of a research project will not all have the same weighting. Some will be more important than others. Also, the weight of individual factors will not be constant, and will vary not only from one place to another, but also with respect to different times in the same place. A member of my "Reflection Group" (Think Tank) who is adept at quantifying problems has provided for me a numerical approach to the problem. No doubt the subject will provide some hours of interesting debate and computation in the mathematics department (Appendix 2).

This is not to cloud the issue. Rather, it is to illustrate the complexity surrounding research and development issues in LDCs. One gets the impression each time a workshop is held on the subject that one has heard it all before.

We have found the approach sketched above as a pragmatic way of tackling the problem of ensuring cost-effective research with high predictive value or probability of success. The University Research Planning and Management Section implements research policies to systematically cut down on the number of major determining factors and imponderables. Thus, scientists working on cell cultures (both plant and animal) from the departments of botany, biology, immunology, and parasitology of three faculties have been regrouped within the same building. They use certain

common facilities. A catalogue of all equipment in the university has been stored in the computer and is made available to all scientists. A water reservoir has been installed in the research centre. Projects submitted by teams with members from several disciplines are treated preferentially with regard to financing. These are examples of our pragmatic approach to improving predictive value/probability of success scores.

Only with time will this theory be validated or disproved. Although not by any means perfect, this does have the advantage of trying to be objective. It will permit funding agencies to arrive at a more rational decision as to the feasibility or infeasibility of a project, in a proscribed area, and within a fixed period of time. It will also allow quantification of the equation relating input (i.e. funds from an agency) to output (success or otherwise) of the proposed research project, so that the "cost-effectiveness" of the project may be assessed, rather than being studied in isolation with no background knowledge of the local facilities, and the sponsoring agency arriving at an arbitrary decision.

Appendix 1

Factors influencing the predictive value of a research project being successfully completed

1. Finance:	*for purchasing sophisticated equipment *for paying personnel
2. Scientists:	*critical mass *sufficient diversification
3. Information:	*ready access to literature *access to information from scientists working on the same topic or in allied fields
4. Acquisition of necessary new expertise	*the ease with which this can be done
5. Reagents	*purchase *storage *preparing one's own reagent
6. Motivation	*career structure *financial gain *recognition within one's own country *publications/exploitation of findings
7. Space	*laboratory space *office, animal house, and storage space
8. Time	*fulltime research vs. part-time research (employment obligations)

(continued)

Factors influencing the predictive value of a research project being successfully completed (continued)

9. Access:	*to research materials *to patients *to communities *to animals *to microbes *to plants, etc
10. Critical analysis of protocol and publications (peer review in one's country or in LDCs).	
11. Number and quality of doctoral students attached to the project.	
12. Number and quality of technical staff (technicians) attached to the project.	
13. Equipment:	*dependability * maintenance, or similar equipment available nearby *tropicalisation *modification or development
14. Multidisciplinary approach:	*availability of collaborators in other disciplines
15. Ability to interest private as well as government sectors	
16. Distraction factor:	*social (cultural) obligations *others, including family, constraints *noisy destructive neighbours
17. Steady sources of electricity and water	
18. Reliable supply of local "research consumables"	
19. Health of the scientist and technical staff	
20. Weather predictability	
21. Road access to communities in the field, access to vehicles and petrol. Extra items needed for field research in LDCs, e.g. special equipment mounted in landrovers, portable refrigerators, etc.	

Appendix 2.

Numerical approach to factors influencing the predictive value of a research project being successfully completed

We prefer to take a systems approach in looking at the impact of any programme on medical institution strengthening. The system has *inputs*. These include human resources, financial resources, infrastructural facilities, etc. Let us denote these by Xi, where "i" distinguishes one type of input from another. The system also has outputs. These could include:

*the number of doctors, nurses, scientists, laboratory technicians, etc. trained in a given period;
*services rendered to the community;
*published books and papers;
*drug trials run; and
*etc.

Let us denote the *outputs* with Yj, where, again, the index distinguishes one output from another.

These two system properties—*inputs* and *outputs*—routinely appear in analyses of this type. That aspect of the system which is often neglected or glossed over, is the set of laws governing the behaviour of the system. These include the set of deterministic (or probabilistic) relationships which link each output to the set of inputs. We express the outputs in terms of the inputs as,

$$Yj = hj\ (Xi),\ j = 1,2,...,M;\ i = 1,2,...,N$$

hj expresses how each input affects output j.

The point here is not so much that we are able to write precise mathematical expressions for these relationships. Rather, the importance of such an approach is:

1. it points out clearly all the various parameters which must be taken into account; and
2. it allows us to see the effect of a specific parameter on the outcome of our project.

If we wish to maximise outputs, we have an idea of how to go about it. We may also take full advantage of "what if"-type scenarios in planning our institution strengthening project.

The approach could be taken one step further. We may chose to emphasise some outputs over others. In this case, we wish to maximise a weighted sum of the outputs:

$$\sum_{j=1}^{M} ajYj.$$

The weighting factors must add up to 1.

So far, we have assumed that our resources are unlimited. This is unrealistic. Not only are resources limited, but the laws which govern the system must include all of

(continued)

the constraints, or limitations, imposed on it. These constraints take into account conditions imposed on the inputs such as limited staff, limited budget, limited facilities, etc.

We account for these mathematically with a set of inequalities:

$$Xi < Gi,\ i = 1,2,...,N$$

The constraints also take into account all other conditions imposed by economic, sociological, environmental, and psychological factors, on the inputs as well as the outputs. Let there be K such factors. We express this as:

$$Xi = fi(xk),\ i = 1,2,...,N;\ k = 1,2,...,K$$

fi expresses how each fact affects input i.

The outputs are now given by

$$Yj = hj\ (Xi, xk);\ j = 1,...,M;\ i = 1,...,N;\ k = 1,...,K$$

They too may be constrained. So we have,

$$Qlj < Yj < Qhj$$

For example, the number of general practitioners produced should not go below a certain minimum and must not exceed a given maximum value—to limit unemployment problems.

The objective now is to maximise a weighted sum of the outputs, as given by the new expressions, with the constraints imposed on the inputs and outputs. Solving constrained optimisation problems is not an easy task. However, even without solving the equation, we have an much better idea of the problem as well as what can result from making a minor adjustment in each parameter.

US ASSISTANCE TO AFRICAN SCIENCE AND TECHNOLOGY: CONTRIBUTIONS AND ISSUES IN INSTITUTION BUILDING

*W. Haven North**

Introduction

The United States, through its foreign economic and technical assistance programme, has had a long-standing interest in the advancement of African science and technology. This interest has been evident from the early days of US development assistance programmes in Africa. The initial impetus was the commitment of President Truman in his 1949 inaugural address to "make the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas" (US Department of State, 1950), and the organisation in 1950 of the Technical Cooperation Administration (TCA), one of the predecessors to the Agency for International Development (AID).

The first programmes in Africa under TCA were in Liberia and Ethiopia beginning in 1950, with agricultural development the priority. It was in Ethiopia that the Point Four concept of technical assistance was first translated into institution building in collaboration with a US university—a pattern that was to evolve in other parts of the world as well, most notably in India. Beginning in 1951, US assistance to Ethiopia concentrated on creating an agricultural education system. An agricultural technical school was established in Jimma in southwest Ethiopia to prepare students for entry into a university programme. The Agricultural College at Alemaya was built and staffed. Both institutions included research programmes on domestic crops.

US assistance to Africa increased rapidly throughout the 1950s, with new programmes in Kenya, Nigeria, Sierra Leone, and Uganda, in addition to those in Ethiopia and Liberia. The basic thrust of these programmes was in agriculture, public health, education, and water resources. By 1959, the Foreign Operations Administration, the International Cooperation Administration, and the Development Loan Fund (successors to TCA and later to be reorganised as AID in 1961) had expended $163 million for these programmes. From these modest beginnings, US assistance has grown both in the number of countries being assisted and in the range of activities covered. AID is now active in development, economic, and food assistance programmes in 42 countries in Sub-Saharan Africa, with a budget in FY 1987 of about $800 million.

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A common thread throughout the past 30 years has been an interest in helping to develop African institutional capabilities in science and technology. I will review in this paper some of the major dimensions of this interest as manifested in the ebb and flow of assistance programmes in the agricultural and health sciences, as well as some related aspects of US assistance to African education. I will also discuss some of the principal recent developments in these fields and lessons learned about the task of institution building.

The Harrar Report

The first major milestone in US assistance to African science and technology was the National Academy of Sciences (NAS) report on "Recommendations for Strengthening Science and Technology in Selected Areas of Africa South of the Sahara," better known as the Harrar Report (NAS 1959).

In 1958, James Smith, Director of the International Cooperation Administration, asked the NAS "to explore ways in which science and technology can best be used to maximize the effectiveness of United States foreign aid in that part of the world" (NAS 1959, i). George Harrar, at that time the Vice President of the Rockefeller Foundation, was selected by the NAS to lead a team of specialists in a review of African science and technology. His report, completed in July 1959, provided "observations and recommendations in the fields of agriculture, medicine and public health, natural resources, engineering and industrial development and general observations in the field of education" (NAS 1959, i). The Harrar group visited 10 African countries, only 3 of which—Ethiopia, Liberia, and Sudan—were independent at that time. (The other seven are today the countries of Ghana, Kenya, Nigeria, Somalia, Tanzania, Uganda and Zimbabwe.)

The dominant theme of the report is the recognition that "Africa's greatest resource. . .is manpower. The rate at which it can be further developed and utilised will establish the tempo of progress." More explicitly:

> Every effort should be made to encourage Africans to engage in private and public enterprises of all dimensions. Local human resources should be developed and utilised to the fullest possible extent in support of national and local enterprise for the exploitation of natural resources, the manufacture of goods, and the development of services. Eventually there will be vast opportunities for entrepreneurial activities by Africans that will create employment and wealth and, at the same time, reduce the outflow of foreign exchange for the purchases of goods and materials that can be produced locally.
>
> None of these developments will be possible, however, without a significant increase in the numbers of Africans qualified to fill positions of national responsibility. . . Nevertheless, with the sympathetic and effective assistance of foreign countries, it can be expected that over a period of years sufficient numbers of trained nationals will become available to satisfy local needs. (NAS 1959, 3)

The report stressed that:

> [T]here must be a definite trend toward general literacy, an expansion of elementary and secondary education and increased emphasis on university and professional education if Africa is to make substantial economic advances within a reasonable period of time. Every other consideration is subordinate to that of education, and it should be a major area for planning and investment. A major consideration should be the strengthening of established institutions dedicated to the improvement of African education at all levels. (NAS 1959, 20–21)

The Harrar Report recommended that US development assistance be guided by this view of the preeminence of education and institution building as a basis for development. The report then elaborated on the "specific fields and disciplines that should be given major consideration by foreign aid agencies." It identified "education, medical and public health services, agriculture, natural resources, engineering, technology and industry. . . The most significant opportunities are to be found primarily in the fields of agriculture and public health." (NAS 1959, 4)

In its support for the advancement of African science and technology, the Harrar Report gave the highest priority to the agricultural sciences. It recommended a ten-year programme with funding of $149 million. It proposed support to agricultural experiment stations, extension services, vocational agricultural schools, agricultural colleges, veterinary education, tsetse fly control, soil surveys, crop inventories, and animal pathology. "The most pressing need is for the greater production of basic food crops to provide an adequate diet for an increasing number of inhabitants." It was optimistic about the "great opportunities for the improvement of maize, sorghum, millet, rice, for significant increases in the production of a variety of leguminous food crops and for the expansion of acreage in citrus and other tropical fruits, oil crops and vegetables." (NAS 1959, 57)

Foreseeing the difficulties of agricultural development, the report spoke of the "bewildering array of agricultural problems which represent both a challenge and a danger to foreign aid efforts. The challenge lies in the multitude of opportunities; the danger is that funds and manpower may be so diluted that too little progress is made on too many fronts." (NAS 1959, 62)

While noting the number of excellent research stations already operating in 1959, the report pointed out the need for supplementary research stations devoted to the food crops and animals that were "most basic to dietary needs and patterns. These stations would deal with land management, soil fertility, rotation patterns, irrigation, disease and pest control, crop and animal breeding, harvesting and processing practices and all aspects of agricultural economics." (NAS 1959, 63)

The report makes an interesting point concerning the transfer of Western technologies that is especially appropriate given recent criticisms of US technical assistance to Africa and reputed attempts to impose Western technology:

> It is not possible to transpose the results obtained in the US experiment station system directly into the African situation. However, the development of a comparable pattern of research centres in sub-Saharan Africa would be one of the greatest contributions which the United States could make to the African people.
>
> Properly organised and developed, these centres would provide a continuing source of information and materials adapted to the areas in which they are to be produced in quantity. They would serve as introduction and testing stations, as sites for varietal improvement through breeding programmes, as locations for studies on soil management and fertility, and as livestock centres for research and experimentation on the management of domestic animals. The role of the proposed experiment stations as training centers for Africans is at least of equal importance to their role as research establishments. Each would provide opportunities for the utilization of significant numbers of African personnel as employees and in-service trainees at sub-professional and professional levels. Eventually some of these individuals would begin to assume full responsibility for the station program and others would be available for assignment elsewhere in response to growing need. (NAS 1959, 63)

The vision in the Harrar Report for US assistance for African agricultural development was of institution building and the development of indigenous capabilities oriented to the local environment and needs.

In discussing the siting of these agricultural experiment stations, the report recommended that they "be associated with an agricultural college so that ultimately the three principal facets of agricultural science would be brought into phase, i.e. education, research and extension." (NAS 1959, 64–65). Subsequent developments have shown how difficult the attainment of this objective was to be.

In public health, the Harrar Report stressed the importance of developing field training at the assistant medical officer and paramedical levels and professional postgraduate training. The report identified institutional development as the main priority and recommended efforts that would build on existing institutions—such as the medical schools in Dakar, Ibadan, Kampala, Kinshasa, and Khartoum. It also identified sub-professional training programmes already underway in Ethiopia, Ghana, Kenya, and Sudan, which could serve as sound bases for expanded programmes.

The report identified several African diseases requiring further research and control efforts. But it cautioned about entering into major control programmes until trained personnel were available and more was known about the incidence of the diseases and the appropriate priorities for their control. Malaria, nutritional disorders, bilharzia, tuberculosis, enteric diseases, trypanosomiasis, and onchocerciasis were given prominence. A major allocation of funds for a West African vaccination programme against smallpox, DPT, and yellow fever was proposed. African education, training, and research on the incidence and characteristics of diseases was the recommended focus for US assistance. (NAS 1959, 22–52)

In its concluding chapter, the report summarises its priorities, as they were viewed by the NAS team 30 years ago:

> [T]he rate of progress of the emerging countries of sub-Saharan Africa will depend completely upon the speed with which manpower becomes available to carry out the multitude of tasks essential to social and economic growth. The political evolution of the African community has moved far more rapidly than the social evolution, and as a consequence the new political entities are generally ill-equipped to handle the technical and scientific responsibilities so fundamental to their sound future development. . . The major emphasis must be placed upon ways and means to educate a very much larger percentage of the African population to the point where they can assume responsibility for the variety of tasks necessary to national well-being. . . Aid to education must be directed toward providing more and more persons trained as teachers, medical doctors, veterinarians, specialists in agriculture and engineers.
>
> Next to education, in order of priority, is agriculture. It is clear that food problems have long been and continue to be a major obstacle to human progress. Along with agricultural development there must be the rational use of renewable and nonrenewable resources including forests, fisheries, wildlife and minerals.
>
> There are great opportunities for improving the general level of public health throughout much of sub-Saharan Africa. The absence of sufficient numbers of qualified medical personnel, the lack of public health organizations and campaigns and the educational and economic levels of rural peoples combine to perpetuate many of the contagious and epidemic diseases which have been stamped out elsewhere.
>
> Investments in the broad fields of technology will provide an essential base for progress in other fields. Emphasis should be placed on those industrial developments which will most rapidly increase national wealth and hence stimulate economic growth (NAS 1959, 104–110).

I have referred to the Harrar Report at some length to convey the flavour of the first broad look by US scientists at African development problems. Also, the report is important because it provided a foundation for subsequent decisions concerning the allocation of US assistance. While the Harrar Report's proposals were not followed as outlined, the philosophy and basic thrust of the report have continued to characterise much of the technical assistance provided by the US since that time.

US assistance and African agricultural sciences and technology

Higher agricultural education

The full range of assistance to African agricultural development is too vast and complex for review in this paper. The heart of the programme, particularly in the early years, and its most successful component has been US technical assistance in support of agricultural education. From the beginnings in the 1950s with the Agricultural College in Ethiopia, US assistance has helped promote the establishment of similar institutions in Ghana, Kenya, Liberia, Malawi, Morocco, Nigeria (three agricultural faculties and a college of veterinary medicine), Sierra Leone, Tanzania, Uganda, and more recently in Botswana, Burkina, Cameroon, and Zimbabwe.

In several of these countries, US assistance helped to create entirely new institutions such as the Hassan II Institute of Agriculture and Veterinary Medicine in Morocco, the University of Nigeria at Nsukka, Bunda Agricultural College in Malawi, the Imperial Ethiopian College of Agriculture and Mechanical Arts at Alemaya, and the University Center at Dshang, Cameroon. In others, US technical assistance helped to establish new faculties or departments of agriculture within existing institutions, such as at Ahmadu Bello University and the University of Ife in Nigeria, or new animal science, soils, and extension programmes, such as at the University of Ghana. In almost every instance, research programmes were closely associated with the teaching programmes, although usually on a modest scale.

AID is now completing a series of impact evaluations of its assistance to agricultural colleges and universities in ten developing countries in Africa, Latin America, and Asia. The African phase has been completed, and the reports are now being published. Five African agricultural institutions were included in the series: the University of Nigeria at Nsukka, the University of Ife, and Ahmadu Bello University in Nigeria, the Hassan II Institute of Agriculture and Veterinary Medicine in Morocco, and Bunda Agricultural College in Malawi. In a preliminary summary of recent findings, Gary Hansen, topic co-ordinator in AID's Center for Development Information and Evaluation, observed for the 20–year period 1965–85 that:

> All five agricultural colleges were newly created in the early 1960s and over the twenty years they have functioned primarily as teaching institutions. Thus, through rapid increases in number of students admitted and graduated, their major impact has been in the production of manpower, primarily at the undergraduate level. In most cases their graduates have been employed in the public sector, where they now fill middle and senior level positions in government agencies involved in agricultural research, extension, teaching, and administration. With few exceptions, college curricula and teaching programs have varied in quality from good to outstanding.
>
> The rapid growth in student enrolments has been paralleled by rapid growth in faculty numbers and an upgrading in faculty training. All the colleges now have a solid core of Ph. D. agricultural scientists.

> Two of the colleges are establishing a significant record of impact in their research programs, whereas agricultural research at the other colleges has been less notable, primarily because of funding constraints, academic compartmentalization and faculty promotion incentives which do not support relevant research. (Hansen 1986, 1)

From the perspective of the conclusion reached in the 1950s that the need for African professional manpower should be a prime concern in African agricultural development, the creation or strengthening of these institutions is a major achievement in US-African collaboration on African scientific and technological development. The task at that time was the education of African agricultural scientists and the development of institutions to sustain that growth. In those countries where there were few, if any, African agricultural scientists during the 1950s and early 1960s and where expatriate specialists predominated, there was a powerful motivation to create indigenous institutions of higher agricultural education. The mission was clear and government commitment strong. As a result, agricultural programmes and related institutions are today staffed and led by African scientists.

The Hansen report, however, identifies a number of "second generation issues" that must be addressed in the coming decades if institutional growth is to continue. Markets for undergraduate generalists are saturated, and new employment opportunities outside public service must be identified. The scarcity of resources for research and outreach is undermining the effectiveness of the agricultural faculties. This is resulting in cutbacks in laboratory and fieldwork and a shortage of locally generated teaching materials and thus in a decline in the quality of academic education. Links to farming communities are limited and weakening; students, not farmers, have been the primary clientele. Agricultural faculties are isolated from new developments in agricultural sciences abroad and from the mainstream of agricultural activity in the home country. Faculties have limited experience with problem-solving and multidisciplinary research relevant to local farming conditions (Hansen 1986, 1–2).

In summary, the report points out that "institutional capacity has been put in place. Now this capacity needs to be strategically positioned to perform more diversified education, research and outreach roles. In the absence of measures to accomplish this objective, the colleges, and previous long term AID [and African] investment therein, will likely wither." (Hansen 1986, 3)

Noting some of the accomplishments at Ahmadu Bello University and the Hassan II Institute of Agriculture and Veterinary Medicine, as well as at other institutions outside Africa, Hansen sees the need to "move from institutional development to a systems development agenda." This systems approach would include an expansion of the college mission to include farmers as a major clientele, a linkage of colleges to rural development programmes sponsored by the government or external donors, the development of exchange programmes with other national and international institutions to help colleges stay informed of advances in the agricultural sciences, and a continuing evaluation of the agricultural environment to ensure the relevance of agricultural programmes to future requirements. (Hansen 1986, 3)

The Hansen report concludes that:

> [t]he first phase on institution building for the agricultural colleges is over—colleges are in place, and in some cases more institution building efforts will be needed in the development of graduate programs. In any case, current capacities frequently remain poorly utilized because the colleges operate in isolation from what is usually a fragmented research, extension and agri-service system. Stronger coordinative linkages are needed in bringing these elements together in a system where resource allocations are driven by a common program agenda.

The report warns that without such collaboration in the agricultural sector there will be further institutional duplication, overbuilding, and a severe shortage of funding for recurrent budgets (Hansen 1986, 4–6)

Agricultural research

In a recent study of US assistance and agricultural development in six African countries, Johnston et al. conclude that the US efforts in building African research programs have clearly not been comparable to its contributions to the building of agricultural colleges:

> Both AID and African governments have failed to take the necessary steps to develop effective national agricultural research systems. . . Many of the research projects that were funded were short-term, fragmented efforts that could not be expected to make a significant contribution to the necessarily long term work of building a national capability for research. (Johnston et al. 1988, 158)

In the early years, research may have been neglected as a consequence of concentrating on educating African agricultural scientists and developing African institutions of agricultural education. Research was certainly a part of the college programmes, but in most instances, its scale was too modest. Educating African agricultural scientists was the first task.

Also, research has not been as politically attractive to African leaders, who were more interested in programmes with early results and impact. As a result, shortages of resources and the lack of recognition for research inhibited faculty members from making greater contributions. In addition, domestic organisational issues, which keep agricultural education and research apart, have impeded collaboration between the best research talents in the universities and the ministries and other agencies with control over resources for research.

According to Johnston et al., US assistance was characterised by "technological optimism" in the early years—in a faith in the efficacy of existing technologies and a belief that new ones could be quickly identified. (Johnston et al. 1987, 157) Subsequently, the basic human needs drive of the 1970s did not support long term research and related institution building.

Despite these adverse influences, by 1980 a majority of African countries were engaged in some form of agricultural research supported by US

assistance. Some of the research was a component of other agricultural production activities related to a particular problem such as dryland cropping research in Kenya or maize and rice production research in Nigeria. In other countries, like Cameroon, Chad, Lesotho, Malawi, Sierra Leone, Somalia, Sudan, and Zaïre, research institution building received more direct attention. Also some significant research work is evident in several of the college programmes. For example, the Hassan II Institute in Morocco has carried out some important work on date palm diseases, dryland agriculture, and dairy livestock. Ahmadu Bello Agricultural College in Nigeria, with its affiliated Institute for Agricultural Research, has undertaken some pioneering work on farming systems research.

In addition to these activities, AID is funding an abundance of research activities in Africa through several centrally funded programmes. The Programme in Science and Technology Co-operation and the US-Israel Co-operative Development Research programme support numerous research projects in Africa, such as studies on food contamination or use of agro-bacterium rhizogenes in Tunisia, tomato production in Somalia, and biochemical aspects unique to the parasite (striga)/host (sorghum) system in Sudan. The Board on Science and Technology for International Development of the NAS has made grants to the University of Nairobi for research on the selection and introduction of grain amaranth for dryland and semiarid climates and to Bunda College in Malawi for research on fast-growing, nitrogen-fixing trees and their effect on crop yields and soil properties. The Historically Black Colleges and Universities are also involved in agricultural research in Africa, such as Lincoln University's project on nutrient analysis of vegetation in Burkina Faso. The AID-funded Collaborative Research Support Programme of the American Land Grant Universities includes several subprojects in Africa, such as on small ruminants, sorghum and millet, peanuts, and tropical soils. These research activities help, to a limited extent, to overcome some of consequences of the shortage of funds available to African institutions for specific studies and may make a small contribution to institution building, although that is not their purpose.

As is evident from the Harrar Report, US assistance to agricultural research in Africa has, from its outset, recognised the importance of national agricultural research systems and the need for significant institution building—at least in principle if not consistently in practice. For example, the concept of a network of ecologically-based experiment stations was recognised in that report. A critically important beginning has been made in this area by the international agricultural research centres—IITA, ILCA, ILRAD, WARDA, ICIPE, and ISNAR—which receive major support from US assistance.

Two milestones in the evolution of African research programmes and US assistance were the 1968 Abidjan Conference on Agricultural Research Priorities for Economic Development in Africa and the 1972 NAS Report on "African Agricultural Research Capabilities" sponsored jointly by the NAS and AID.

The Abidjan Conference provided the first opportunity for African, US, and European scientists to meet and jointly consider the priorities for agricultural research. About 200 delegates from 32 countries participated in reviewing problems and assessing priorities in 11 technical and programme areas: soil and water management, animal health, animal production, cereal crop production, industrial crop production in humid and savanna zones,

economics of agricultural production and marketing, grain legumes and root crop production, education, crop protection and storage, and research institutions. It was at this meeting that the Association for the Advancement of Agricultural Sciences in Africa was formed.

In the discussion on agricultural research institutions, the conference focused on ways to "increase effective research." The participants were particularly interested in ways of determining research priorities, performing the research, and ensuring that the results were applied. "Problem-solving research is not complete until results have been published...and reflected in the welfare of the people." They also stressed the importance of close associations of research organisations and universities—advice that has not been readily followed, as the Hansen report points out. The participants concluded that for the purposes of economy and efficiency, the priorities should be

1. strengthening national programmes;
2. developing national programmes that have unique strengths and extending them to serve additional countries; and
3. strengthening existing regional programmes to meet the needs of different ecological areas.

Some of the participants at the conference focused on the role of universities and schools of agriculture in research and manpower development. Their primary concern was the training in Africa and abroad of African scientists and technicians in programmes that would build their capabilities to work on African agricultural research problems. Research should be "preponderantly such as to contribute to the needs of local agriculture." They also stressed the importance of close associations of university research with similar research in government institutions, other educational institutions, and independent (including commercial and industrial) research organisations. National research authorities "through financial support of research, could assist universities and other institutions to play a fuller part in the agreed program"—advice that continues to be important today. (NAS 1968, 55–57)

Four years later the NAS, at the request of AID, undertook a comprehensive review of African capabilities for agricultural research and laid out a broad range of recommendations for research priorities, including agricultural systems, soil and water management, cereals, grain legumes, roots, tubers and plantains, vegetables, fruits and nuts, sugar, beverages, fibers, oil plants, commercial crops, animal resources, pests and pathogen systems, science policy, communications, institutions for research, and manpower development. Again it pointed out the importance of strengthening existing national research stations and establishing close links with international programmes. "Improving the quality of staff at research stations is of paramount importance. To accomplish this, governments will need to lift constraining civil service regulations, supply better laboratory and housing facilities and develop better communications with university faculties of agriculture and with field service units." (NAS 1972, 253)

The Harrar Report in 1959, the Abidjan Conference in 1968, the NAS study in 1972, and the Hansen summary in 1987 echo each other on the basic issues and themes of the effort to advance African agricultural sciences. Certainly much progress has been made in creating key institutions and

educating highly competent African agricultural scientists. Yet the concerns persist about manpower and funding shortages, weak linkages, and limited impact.

The opening comments on agricultural research point to some of the reasons for the slow growth of support for research in assistance programming and development priorities. Others more expert in the field will have richer insights, but some of the conclusions of AID impact evaluations on agricultural research and agricultural universities worldwide may point the way.

In the fall of 1983, the Center for Development Information and Evaluation in AID completed its Program Evaluation Report, "Strengthening the Agricultural Research Capacity of the Less Developed Countries: Lessons From AID Experience." This report is a comprehensive analysis of existing evaluation documents concerning completed AID projects. Eight projects in Africa, Asia, and Latin America were selected for in-depth field evaluations. Five conclusions stand out from these studies:

1. Host government commitment and support to research is essential. This commitment will determine the sustainability of the research project and the use of research findings. A continuous dialogue among politicians, administrators, and researchers is necessary, along with evidence of the potential benefits from research.
2. Technological solutions alone cannot solve problems which have political, economic, and social dimensions. Agricultural research programmes should be selected within a much broader rural development policy and planning framework.
3. Research should be farmer-oriented. It will be essential to establish, maintain, and use a two-way information system among researchers, extension service agents, and the farmers.
4. Inadequate management of limited resources, especially a high rate of attrition among skilled staff, can undermine the effectiveness and sustainability of an otherwise satisfactory programme. Training skilled researchers has been found to be the most successful component of many research projects, but the training provided should be adapted to the realistic needs and capabilities of the country, in choice of discipline, level of education, and timing of the training. Returning trainees should be assured of satisfactory material and professional incentives, and rewards comparable to those offered to other public servants.
5. Co-ordination among researchers and other development actors, from farmers to politicians, is the key to success. A research system will be most effective if the many actors who influence its success are involved in a network in which their needs are identified and through which the interaction between different sectors of development are as synergistic as possible (Murphy 1983, vi–viii).

Table 9 provides a summary of the conditions that were found to favour the development of the effective research systems reviewed in the evaluation. These conditions reflect many of the essential elements of institution building. Taken together and posed as questions, they provide a guide for assessing effective institution building in agricultural research in Africa.

Table 9. Highlights of conditions found to be favourable to effective research systems

A. Host government	B. AID assistance
1. The host government is committed to providing sufficient human and financial resources for research activities. 2. Pricing mechanisms and other government policies are conductive to expanding production of crops being researched. 3. Complementary services (such as extension, inputs, marketing, credit, roads, irrigation) will be functioning when needed for adoption of research results. The Private sector is allowed to participate in the provision of such services. 4. Research priorities are established as part of a comprehensive development plan. 5. Co-ordination is encouraged among research, extension, services and training institutions.	1. Assistance to agricultural research institutions is designed as a long term activity, preferable 10 years, with option to redesign or extend on the basis of regular evaluations. 2. Assistance is integrated into the entire programme of assistance to the country. 3. The AID in-country mission is capable of providing the required logistic support and problem-solving assistance to the project contractor and the host country and includes staff members with knowledge and understanding of agricultural development and research issues. 4. AID assistance is implemented through a goverment entity which can co-ordinate its activities with those of related institutions and programmes. 5. Training programmes are adapted to future needs and scheduled to complement on-the-job training with foreign technical assistants.
C. Research institution	**D. Research programme**
1. The institution benefits from stability in its research staff (i.e. sufficient presence of competent managers as well as knowledgeable researchers. 2. Funding and research priorities remain assured and stable over the duration of research programme. 3. The research staff forms a multi-disciplinary team including social as well as technical expertise. 4. Linkages are established and maintained with other related in-country, regional, and international research institutions. 5. The research institution exchanges information with the extension services and agricultural training institutions. Excerpt from *AID* 1983	1. The overall research takes into account existing farming conditions and the natural, economic and social conditions that affict change. This does not mean that basic research may not also be necessary. 2. Baseline data on actual farming practices and results are necessary both to establish research priorities and programme design and to verify the results achieved. 3. The expected research results should clearly be worthwhile from the farming household's point of view. 4. The research programme should inclue on-farm testing of results, possibly in co-ordination with the extension service. 5. Correct promotion of reseach results to the farmers should be assured.

Trends in US sssistance to agriculture and current policy

In a functional review of agricultural programmes financed by AID, the Africa Bureau reported on the trends in the allocation of US assistance to agriculture and to various subactivities within the agricultural programme. Overall, from fiscal years 1979 to 1987, the budget for agriculture has increased from $218.7 million to $317.1 million (it peaked at $400.6 million in FY 1985). The agricultural programme share of total US assistance, however, has dropped from 69 percent to 59 percent. From 1979 to 1987, the portion

obligated for agricultural education declined from $36.3 million to $19.6 million, or from 16.6 percent to 6.8 percent of the agricultural budget. For agricultural research (called technology development in the report), the levels increased from $31 million to $46 million, or about 14 percent of the agricultural budget each year.

While there has been some growth in dollar terms for research, the share of total assistance for these two key dimensions of African development is a matter of concern. The primary factor causing these shifts has been the rapid increase in programme and sector assistance, addressing short term policy and balance of payment issues, which has accounted for about 25–35 percent of the agricultural budget (USAID, 1987b, 14–15).

In 1985, AID adopted a *Plan for Supporting Agricultural Research and Faculties of Agriculture in Sub-Saharan Africa*. The two-pronged programme provided for "the strengthening of national agricultural research systems in approximately eight core countries and building strong applied research capacities in neighbouring countries to enable local scientists to screen and borrow technologies and adapt them to local environments." In addition, "long term assistance will be provided initially to four to six faculties of agriculture and other research institutions and programmes." (USAID, 1987b, i).

Drawing on experience with past programmes, the plan identified nine guiding considerations for the implementation of the expanded programme. These include:

1. a concern for more explicit objectives for research;
2. an emphasis on selected countries, commodities, and problems;
3. more support for commodity research;
4. more concentration on food crop research to support income and export growth;
5. improvements in the complementarity among AID's various mechanisms for investment in research and faculties;
6. improvements in management capabilities;
7. finance for recurrent costs;
8. closer co-operation with other donors in planning and carrying out these investments; and
9. the need to make a long term commitment to the development of agricultural research and higher education (USAID, 1985, 1988).

AID's *US Assistance Strategy for Africa—1987–1990*, points out that Africa "faces a serious development crisis. Many African nations are experiencing continuous economic disequilibrium and decline. The recent drought and resulting food emergency have been the most dramatic manifestations of these disturbing trends." The strategy statement also points out that "over the past two decades per capita food production has declined by 16 percent." At the same time, it notes that the medium term prospects for food security on a continent-wide basis are better than for individual countries. While food production has grown at a very slow rate (1.8 percent a year on average over the past decade), "the 1985/1986 bumper harvests estimated at about 54 million metric tons of food grain illustrate the point when compared to estimated total demand of about 57 million metric tons for this year." Yet "meeting the growing demand for food implies a growth in food production of about 4 percent a year. Achieving and sustaining this rate of growth will likely

be very difficult, requiring substantial investment in agriculture and making the most of physical potential." (USAID, 1987b, 2–5)

What this prognosis suggests is that Africa's leadership and the donor community must demonstrate a resurgence of support for agricultural development, focused on improving rural incomes and production through structural reforms that create better incentives, new learning from research and education, and high-quality institutions to sustain the effort.

The agricultural crises of the last ten years have introduced a renewed motivation for strengthening the development of science and technology in Africa. In the 1950s, the mission and the political commitment were clear. Now, in a more complex setting, is the motivation as strong? Are the missions and overall purposes of Africa's agricultural institutions well defined? Are these institutions capable of the dynamic changes and growth required to keep pace with their environments? Are they joining in a co-ordinated attack on priority problems? Or are we seeing a destructive competition for financial and human resources that will undercut effective performance? Are African leaders as committed to the growth and involvement of agricultural institutions as they were to their creation in the 1950s and 1960s?

US assistance and African health sciences and technology

Health sciences

The pattern of US assistance to institution building in public health in Africa has been somewhat ambiguous over the past 30 years. The US commitment to health in the early decades responded to an uncertain trumpet. The importance of health to economic development was heatedly debated by economists and public health specialists, by advocates of capital investment for growth and advocates of investment in social services, and by advocates of clinic-based services and hospitals and advocates of rural health services. Also, there has been a shifting in emphasis between categorical, vertically structured health campaigns and multifaceted, primary health care systems. The impetus for categorical programmes was the opportunity, through direct action, to eradicate or reduce the incidence of specific diseases such as malaria, smallpox, measles, and onchocerciasis. Multi-faceted primary health care programmes emphasised institution building and long term results over a wide range of health services.

In the 1950s, as evident in the Harrar Report, public health was recognised as one of the priorities for US assistance. And in those early years, US assistance supported some significant programmes. One of the most notable was the Public Health Advisory Services project in Ethiopia, the Project Agreement for which was signed in 1953. The agreement provided for a wide range of US assistance including organisational development in the country's health services, extensive logistic and participant training support, establishment of a nursing school in Asmara, and development of the Gondar Public Health College Training Center.

The Gondar project was considered unique at the time for several reasons:

1. It was the first health training institution in Africa in which three donor agencies (AID, the World Health Organization, and UNICEF) engaged collaboratively with the Ministry of Health, in a fully operational role.

2. As part of a team building concept, Gondar's three classes of health trainees (health officers, community nurses, and sanitarians) took classes in certain core curriculum components together.
3. Preventive and curative medicine were recognised as essential components of the health service delivery system, which was to be established in all parts of the country.

In the 1960s, however, US assistance to African health programmes was not encouraged. In Nigeria, during a major programme buildup from 1960 to 1965, AID leadership categorically excluded health from its priorities of institution building in education and agriculture. And as late as the early 1970s, AID resisted new health programme initiatives in Africa. The notable exception was the successful smallpox campaign. The opportunity to eradicate a specific disease caught public attention. Motivated by the technological possibility of eradicating smallpox—an objective of worldwide significance to developing and developed countries alike—the mission was clear. Institution building was not an important consideration of the campaign, although many African scientists and technicians participated in and learned from this unique experience.

As the smallpox programme came to an end (the last case was in Somalia in 1977), it was assumed that there would be no further assistance of this kind. However, there was a residual concern about the need for some longer term institutional development and training and a recognition that measles, which had been included in the smallpox programme, was a continuing problem. These views led to the creation of the Strengthening Health Delivery Services project which began in 1971. This project, which concentrated on West Africa, improved regional disease surveillance and health data systems, national health planning, regional health training centres, and institutional linkages. This was also the time when primary health care programmes, spurred by the 1978 Alma Ata Conference, encouraged greater attention to the creation of primary health care systems. Major primary health care projects were initiated in Botswana, Cameroon, Kenya, Lesotho, Liberia, Niger, Sudan, Tanzania, and Zaïre.

By the 1980s, a compelling international interest in addressing basic health needs brought about a shift in focus to childhood diseases. The Africa Bureau in AID, anticipating this interest, initiated in 1979 the $49 million Combatting Childhood Communicable Disease (CCCD) programme. The programme's goal was to reduce the incidence of morbidity and mortality resulting from malaria, measles, DPT, and diarrheal diseases in 15 to 20 countries. Reinforced by the extraordinary increase of funding for child survival programmes worldwide beginning in 1985, the Africa CCCD programme is being extended to other countries.

While AID health programmes in Africa have reflected the swings between institutional and manpower development and campaign-type programmes, these shifts were never absolute and there were elements of both orientations in the active health programmes. In Ethiopia, the health programme began with the Public Health College and Advisory Services. However, within a few years (in 1955), a major malaria-eradication programme was initiated. In Ghana, the shift was from smallpox/measles campaigns to family health care research, health care planning and management, the introduction of courses on community health in the medical school curriculum,

and the training of public health physicians to serve as district medical officers of health in the 62 districts of the country. In Liberia, the shift was from the construction and operation of the JFK Hospital to outreach health services. And in Zaïre, the initial programmes for maternal and child health services and immunisation campaigns for combatting measles and other childhood diseases have evolved into a broader programme of health care services through private religious organisations and the formation of a public health college.

The question of institution building in the health sciences has been an underlying concern during these decades. In some ways, the period might be characterised as a search for a sustainable approach. The swings from direct campaigns, in which institution building was a subordinate objective, to primary health care systems development, in which it was the dominant goal, reflected the tension between those pressing for immediate attention to critical diseases and those wanting to build permanent capacities to address a wide spectrum of problems of planning and management as well as curative and preventive health issues.

The perceived urgency of the goal of smallpox eradication or, more recently, onchocerciasis control and of the need for rapid immunisation for childhood diseases minimised attention to creating capabilities to carry forward these and similar programmes without external assistance. This does not detract from their extraordinary accomplishments but does raise issues of preserving the progress made and building on it. Yet some important achievements were made during this period in building African capabilities in health care service delivery, from both a medical and a management perspective. The primary health care programmes begun in the 1950s and again in the 1970s in several African countries laid a basis for health care delivery to the rural poor.

It is interesting to observe that in the same year that the World Health Organisation and the international health community were promoting the organization of integrated primary health care and health for all by year 2000, an NAS committee cautioned that there was no "strong evidence that this approach has been demonstrated to be clearly cost-effective and ready for widespread and relatively rapid replication... [T]he development of a system directed toward multiple objectives vastly increases the complexity of the task while sharply reducing its probable successful implementation... In the [NAS] committee's judgment, it may make sense in some situations to develop an operative structure for the execution of one or two functions, gain experience and the trust of the recipients, then add an additional function, and later yet another" (quoted in Buzzard 1987, 45) The NAS committee pushed for categorical programmes. Some of those involved in health care programmes also argued that established health care systems resist the extra burdens of add-on programmes, as was evident when attempts were made to add family planning services to the responsibilities of rural health post staffs.

AID support for primary health care programmes weakened in the face of field experience, which appeared to reflect the NAS committee's conclusions, and the overwhelming attractions of child survival initiatives. AID's current major interest is almost exclusively with child survival programmes. As the programme has developed, however, there has been a growing concern about its sustainability. Unlike the case of smallpox, eradication of childhood disease is not a feasible objective for assistance programmes; permanent national capacities in personnel, organisation, planning, management, and finance must be established. The search for a

sound approach to institutional development in African health sciences and services continues.

Health research

Research on African health problems, and particularly support of health research institutions, has not been a major concern of US assistance programmes. Nonetheless, a number of activities have been supported in both basic and operational research. Examples include primary health care demonstration and evaluation projects in Ethiopia, Senegal, and Zaïre. In addition, AID has for many years supported research activities on schistosomiasis in Cameroon and Sudan and on schistosomiasis and cancer research in Tanzania, and is continuing its support to the development of a malaria vaccine in its worldwide research programme. Meharry Medical College, under an AID grant, is studying the molecular biology of the causative organisms of trypanosomiasis. A major research programme in health and family planning services was carried out in Ghana.

Other significant research has been performed in conjunction with disease control programmes. For example, the Onchocerciasis Control Programme has included research on larvicide development, drug development, a test for detection of early infection, and other technical and socioeconomic studies related to the black fly vector. (Kelly et al. 1986, 5) In the CCCD programme, US Centers for Disease Control epidemiologists have carried out numerous operational research activities, such as on the spread of resistance to chloroquine treatment for malaria and studies on the dosage and uses of oral rehydration solutions for treatment of childhood diarrhea. Many African medical and health specialists received training in these research endeavours. But the creation or strengthening of indigenous research organisations has not been a principal goal.

US assistance and African professional education in the United States

US-funded participant training programmes have been the clearest embodiment of the theme of helping to develop African capabilities in science and technology through African institution building. The term "participant training" reflects the aim of preparing African professionals to carry on the programmes initiated jointly with African governments. The term "scholarship programme" was rarely applied to overseas education because it emphasises personal gain rather than programme capacity building. Participant training has been a standard feature of almost every project AID has undertaken. In all cases, it was understood by everyone involved that the individuals selected for education in the United States would return to the programme and, in most instances, replace the US specialist. Over the years, the evidence shows that well over 90 percent of those who received project-related overseas education returned to the project—at least for a short time.

But in the early years of US assistance, there was also the view that a much more extensive effort was necessary to accelerate the development of African professionals in fields of importance to African development. The numbers of Africans attending US universities and the opportunities in African universities were considered too limited. At the same time, there was concern among some American university leaders, prompted by a few African leaders who had been educated in the United States, that Africans did not consider US

higher education to be comparable to a European education. Members of the African establishment, particularly those in education in the 1950s and 1960s, were still heavily influenced by their colonial heritage and believed in the superiority of the European university system. Thus Africans with undergraduate and graduate degrees from US universities had difficulty competing for positions in government and educational institutions after returning home, or, in some countries with little health infrastructure, even finding positions that could employ their expertise.

Together, these two concerns led to the establishment of several major programmes for African professional education in the United States. One of the most significant was the African Scholarship Program of the American Universities (ASPAU), which began in 1961 and ended in 1975. This was followed in 1963 by the African Graduate Education Program (AFGRAD). Under the ASPAU programme, some 1,600 Africans, many of Africa's best students, received their undergraduate education in leading US universities. Unfortunately, only a small percentage—about 35 percent—of them have returned. Under the AFGRAD programme, more than 200 Africans have received advanced degrees from over 200 participating universities; about 90 percent of AFGRAD students have returned to their home country. (In 1985, the AFGRAD programme began to offer 50 short postgraduate fellowships intended primarily for policy-makers, researchers, and scientists.)

As African universities were established, African leaders began to object to the ASPAU programme because it competed with the local universities for students. In its place, the INTERAF programme was established to provide scholarships for Africans to attend African universities outside their home country in order to pursue degree programmes not available in their home country. From 1975 to 1984, a special programme combining the features of ASPAU, AFGRAD, and INTERAF offered Africans from Portuguese-speaking countries the opportunity to pursue studies in agriculture, education, health, rural development, public administration, and economic planning. About 430 Africans participated in this programme.

In a few instances, individual AID country programmes in Africa had special projects directed to specifically identified groups. One of the most interesting was the Future Agricultural Leaders programme in Nigeria, which sent over 300 Nigerians to US agricultural universities. This programme was intended to complement the work of establishing faculties of agriculture within Nigeria. A similar project was undertaken in southern Africa. In some instances, these country projects focused on specific African institutions. The University General Support project in Ethiopia from 1969 to 1980 was tied to the faculties of agriculture, public health, education, and, to a lesser extent, arts and sciences and to university administration. An even more focused project was carried out between 1978 and 1983 for the National Agronomy Institute of Tunisia to prepare Ph. D.-level faculty in animal, plant, and soil sciences.

Statistics on the number of Africans who have received AID-financed advanced education in the United States are scarce, particularly for the years prior to 1980. But rough estimates suggest that between 1950 and 1986, 25,000–30,000 Africans received undergraduate or graduate education in the United States. A roughly equal number participated in short term (less than 1 year) programmes. Between 1980 and 1987, the number of participants in academic degree programmes of 1 year or longer averaged 2,000 each year (2,179 in 1987). Also during this period, the number of students in graduate programmes increased by 66 percent, while the number in undergraduate

programmes declined. AID-assisted African students in agriculture, education, and health increased by 15 percent. About two-thirds of these students were in graduate programmes; one-third were in engineering, mathematics, computer science, and physical science programs. Based on the statistics for Africans attending US institutions of higher education funded by all sources—public, private, individual—it appears that without the US assistance programme, very few Africans would be attending US universities in agriculture, education, and health.

Unquestionably, participant training programmes have added markedly to African institutional capabilities. Examples abound of individuals in African institutions who obtained their advanced education in science and technology in the United States. But beyond anecdotal evidence, how does one measure the impact of these programmes on African institution building?

First, one has to subtract from the total number trained those who have not returned to Africa (e.g., the 65 percent of the undergraduates in the ASPAU programme) or who have left their countries for positions in international organisations or private business in other countries. Certainly, the lack of suitable well-supported positions in African institutions has diverted many, as have periods of political instability and civil strife. For some countries, like Ethiopia or Uganda, domestic crises have resulted in major setbacks in expanding the institutional capacities that existed in important areas of development activity. Countries like Nigeria and Zimbabwe, however, have conscientiously and successfully worked to induce their professional compatriots to return from abroad after periods of domestic crisis.

For those who have returned and stayed, what have been the opportunities to apply their advanced learning and knowledge of development problems and skills? How have they been able to contribute to their country's economic and social progress? Evaluations of the impact of participant training have generally been limited to attempts to determine what has happened to individual participants and how they have benefited from their participation. We are now experimenting, through our participant training impact studies in Indonesia, Kenya, and Nepal, with an approach that attempts to determine in greater depth what have been the effects of these programmes. Since we do not yet have the results of these studies, however, we continue with the rarely challenged view that the returned participants are playing an important part in African institution building and national development.

Institution building and the sustainability of US investments in African science and technology

What can we conclude from this broad look at US assistance to African science and technology? How has this assistance affected the ability of African institutions to advance African development? What are the factors that have influenced the accomplishments?

In recent reviews of sustainability in development, several categories of factors have repeatedly been associated with the sustainability of investments in development. Although there is no agreed hierarchy of the importance of these factors, they all are evident in varying degrees in each of the programmes discussed in this review. These categories are management and organisation, host government policies, finance, technology, sociocultural setting, environment and ecology, external political and economic circumstances, and programme design and evaluation (DAC, 1988). One study of sustainability as

part of the development process focused on three conditions that encourage sustainability: policy incentives to reinforce long term results, institutions to mobilise continuing support, and management systems to set priorities and adapt activities. (USAID 1987a)

A careful analysis of African programmes in agriculture and health would demonstrate the importance of all these factors to varying degrees. But without attempting a category-by-category review of AID's assistance in agriculture and public health, what are some of the most significant conditions among those cited above that characterised and affected the development of African scientific and technological achievements? I suggest that there are three broad considerations that stand out: commitment and continuity, time dimensions, and leadership.

The commitment and continuity of the political and professional leadership in Africa and the United States stand out as a vital feature of programmes in the agricultural and health sciences. The commitment was not maintained consistently over the 30 years and varied by project and across the board. In the early years, African and US leadership shared a common sense of mission in approaching the challenge that lay before them. The aim of developing African professional and institutional capacities was a highly motivating interest that was shared broadly and in specific projects. A sustained commitment was evident, for instance, in the development of several of the agricultural colleges and faculties, perhaps most distinctively at the Hassan II Institute of Agriculture and Veterinary Medicine in Morocco, where a close collaboration continues after 25 years. While less significant in terms of institution building, an outstanding commitment was evident in the smallpox eradication programme and the current Onchocerciasis Control Program. In these instances, a willingness to maintain an effective programme for an extended period of years overrode counter interests, pressures, and external events.

However, the commitment to institution building in science and technology, evident in the drive of the initial period, was not consistently maintained throughout the 30 years. Several considerations have affected a sustained interest. For one, US interests in development made a fundamental shift in the 1970s, when the concern for addressing basic human needs in programmes with direct and relatively immediate impact became the dominant criterion for resource allocations. In the first years of this view of development assistance, the relevance of long term institution building and even professional graduate education programmes for Africans was challenged. As a consequence, assistance programmes were shifted to rural development schemes directed to specific poor communities and away from building institutional capacities. This shift was evident in most African countries receiving US assistance. For example, in Tanzania, regional development programmes were given precedence over the continuation of assistance to the Agricultural College at Morogoro (now called the Sokoine Agricultural University). The current focus on policy reform and programme assistance—while certainly important—may be having a similarly adverse effect on institutional development.

Second, instability in Africa's political and economic systems has had a profound effect. Internal civil unrest and conflict have deterred long term development activity and have discouraged the return of Africans who are pursuing a professional education abroad. Economic and financial crises and

major periods of drought and famine have diverted attention and resources to short term relief and stabilisation programmes. The common driving interest in the Sahel Development Program was the desire to avoid the repetition of the famine of 1974/1975; programmes to promote rapid increases in food production took priority over institution building efforts.

Third, and perhaps most fundamental, the original consensus on the primary mission of institution building and professional education became less clear and decisive. The Hansen analysis on agricultural higher education raises this issue and points out the need for a redefinition of and a new commitment to the role of agricultural education, research, and extension in African agricultural development—a commitment that must rise above the institutional compartmentalisation that plagues effective development activity. Donor programmes, which can provide the critical margins for continued growth, can either exacerbate this compartmentalisation and the proliferation of institutions to which it leads or promote the effective use and linkage of the institutional capabilities already in place.

Perhaps one benefit of the period of drought and financial crisis—if one can speak of benefits in such a context—has been that it has laid bare some of the fundamental weaknesses in the African condition. There is now a better appreciation of the policy, institutional, and technological circumstances that impinge on Africa's development. The complexity of the ecological environment, the significance of incentive policies, and the need for institutional growth and adaptation all combine to call for a renewal of the shared sense of mission and commitment by assistance programmes and Africa's leadership. Recent developments in the views of African and US leaders suggest movement in this direction, as reflected in the 1986 UN Special Session on African Development and in the reformation by the US Congress of the African assistance programme. But will the preoccupation with the immediate concerns of policy reform again undercut assistance to institution building just as the basic human needs mandate did in the 1970s?

Views on the time dimensions of assistance programmes have been an important determinant of African institutional development. First, the perception of the time it takes to create sustainable institutions—even in the best of circumstances—is commonly underestimated. US assistance has often been cut short for a variety of reasons and often just when institutional maturation was beginning. Ten years is rarely long enough to be confident about the sustainability of a programme that is making a significant impact; yet at the outset, it is difficult for the participants to commit themselves to such an extended relationship. One major exception was the Onchocerciasis Control Program, which was planned from the outset as a 20-year endeavour. Yet even in this programme it is only in the last year or so that attention has been given to the devolution of responsibilities for maintaining surveillance and residual control to national ministries of health. The characteristics and style of the assistance may change over the years, but continued external support for an extended period is important to maintain vital, dynamic institutional growth.

Second, there is an inherent conflict between the need to demonstrate short term results and the need to establish longer term institutional growth. In some instances, such as in health campaigns, institutional growth has not been considered important. Thus, if institutional and management capacities do not exist at the outset of a health campaign programme, they are unlikely to be developed during the life of the programme and the expertise and

organisational capabilities will be largely imported. A clearly formulated strategic plan is required to permit a shift in focus from immediate results and operational issues to organisational development and constituency building.

A third feature of the time dimension is the importance of recognising when "times have changed" and of making appropriate adjustments. As programmes evolve and institutions become established, their long run sustainability is more and more a matter of maintaining relevance. Constant attention to the surrounding environment, whether political, economic, ecological, technological, or cultural, is required in order to adapt institutions to changing circumstances and new opportunities. Concern about programme impact and an interest in influencing the programme's environment, as well as reacting to it, are signs of institutional vitality. This is a key issue for the agricultural colleges and research establishments.

Time and again, reports on successful institution building in science and technology, as in all fields of endeavour, stress the importance of managerial leadership. It is the blend of technical management skills with the talents of leadership that appears to be so essential yet relatively scarce. Competence in organisational development and internal administration is a necessary but not sufficient condition for institutional development—no matter how helpful it may be in the short run. Similarly, pure charisma cannot build or sustain an organization for long. What stands out for successful institutions is a leadership capable of instilling a sense of mission and purpose; of mobilising the support and collaboration of political leaders, complementary organisations, and beneficiaries; and of then following through on a programme. Constituency building is an essential dimension of the institutional development process.

The characteristics of managerial leadership, demonstrated in some of Africa's best institutions and programmes and necessary for the complex and challenging tasks ahead, have been summarised by John W. Gardner, a leader and thinker in US public service. In a recent speech he pointed out what he believes distinguishes the leader/manager from the "general run of managers":

1. They think longer term—beyond the day's crises, beyond the quarterly report, beyond the horizon.
2. They look beyond the unit they are heading and grasp its relationship to larger realities—the larger organisation of which they are part, conditions external to the organisation, global trends.
3. They reach and influence constituents beyond their jurisdictions, beyond boundaries. Thomas Jefferson influenced people all over Europe. Gandhi influenced people all over the world. In an organisation, leaders overflow bureaucratic boundaries— often a distinct advantage in a world too complex and tumultuous to be handled "through channels."
4. They put heavy emphasis on the intangibles of vision, values and motivation and understand intuitively the non-rational and unconscious elements in the leader-constituent interaction.
5. They have the political skill to cope with the conflicting requirements of multiple constituencies.
6. They think in terms of renewal. The routine manager tends to accept the structure and processes as they exist. The leader or leader/manager seeks the revisions of process and structure required by ever-changing reality. (Gardner 1987, 6)

Such characteristics of leadership and management are generally recognised as an important part of development programmes; yet there is rarely a conscious effort to identify and develop them. Where they are evident among leaders of African institutions, they are having a profound effect on the creation of sustainable institutions and programmes.

Conclusion

In this brief review of US assistance to African science and technology over the past 30 years, I have attempted to highlight some of the more significant contributions of US assistance and identify some of the issues that have affected their accomplishments. What seems evident from this experience in collaboration in institution building is the need for a constancy of commitment and a continuing reassessment of progress and problems to enable African and donor leadership alike to adjust programme direction. The crises of the moment, no matter how serious, should not deflect attention from the development and adaptation of the basic institutions and their knowledge of the African environment that are required for growth. For it is these institutions which over time will mitigate the crises and guide the continent's development.

In sum, the test of success in institutional development is a capacity to continue a flow of beneficial impacts on a country's development after major external assistance is terminated; that is, an ability to sustain the valued results of development activities.

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ICIPE: THE TRANSFORMATION OF AN IDEA INTO AN ADVANCED INSTITUTE FOR DEVELOPMENT-ORIENTED RESEARCH

*Thomas R. Odhiambo**

I am tempted to begin from the beginning, to tell the story of the genesis of the International Centre of Insect Physiology and Ecology (ICIPE), from the day in February 1968 when I wrote to Professor Carl Djerassi at Stanford University's Department of Chemistry, actually suggesting the establishment of a centre of excellence in insect science in tropical Africa. But I have resisted this temptation, not because it is not worth relating, but because one such story has only recently been elegantly written by one of the founding fathers of the ICIPE(1) and the present dialogue is much more concerned with the why's and how's of successful institution building in a continent liberally peppered with withered and failed scientific institutions, whether academic or development-related. Victor Rabinowitch ends his story with the words:

> The growing recognition world-wide that science and technology are required for solving critical development problems has created a desire—indeed, a demand—for greater involvement of scientists and engineers from the Third World in the process. Mechanisms are required to develop local capabilities and to organise them effectively so the potential contribution of science and technology to national development can be realized. This is why ICIPE is for many of us such an important model.

And a little further on, he states clearly the specificity of his excitement about this model:

> ICIPE is truly an international success story. . . To those who were skeptical that an international research institute of world standard could be created and thrive in Africa, I can only say ICIPE has proven them wrong. We have survived growing pains and occasional problems of vitamin deficiency (funds, in our case), to become stronger and more vital than before. If lessons are to be drawn from this experience, they are that strength and vitality relate to a clear sense of purpose, a dynamic leadership, an enthusiastic and capable staff, and the recognition world-wide that important contributions are being made.(1)

One may well ask, "What is so unique about the ICIPE model?" Is the original dream satisfied by the institutional reality 18 years later? Is it so singular that it cannot be replicated? Are there other models in development-oriented scientific research which could give pointers to new African efforts in

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institution building in a continent with giant problems of environmental fragility, agricultural unsustainability, and development directionlessness?

This analysis begins with the premise that research and development (R & D) are an essential ingredient for national development. Development decisions arising from R & D cannot simply be imported or copied, at least not insofar as important elements of those decisions are concerned. Nor can the direction that R & D should take be left to outsiders to decide, since there are questions of contextual import and of cultural dimension that need to be considered as well. Development implies the strategic necessity for investment decisions—and these generally concern both human resources and financial and associated resources. Foremost is the necessary condition that the nation (including developing nations) must possess the capacity, first, to ask the essential development question (by identifying the specific developmental problem, assessing the risks and opportunities, set the priorities, and make the required decisions relating to tactics to be adopted in reaching for the solutions); and, second, to answer the development question through R & D. Thus, a developing country needs to make three sets of decisions in some sort of sequence relating to its development plans and practice:(2)

First, it needs to decide on its development path;
Second, it must decide on its science and technology (S & T) policy, which prepares the ground for
Third, R & D most closely fitting into the overall S & T policy.

This is the most effective way in which a well articulated national science-oriented development can be initiated and implemented.

This ideal has yet to be worked out in Africa. The field of insect science is like a surgeon's sharp knife for probing and exploring the R & D environment in Africa, so as to reveal the pathologies within the developing and functioning body, and to suggest new remedies having a chance of success.

The importance of insect science

It is evident from Africa's oral history and folklore—including the rich imagery of its ballads and drama—that insects have traditionally held a tremendous fascination in the region's agrarian pursuits and have wrought a large and sometimes horrendous influence on the course of development among the peoples of Africa—through famine-bringing locust plagues, devastating outbreaks of sleeping sickness, energy-sapping endemic malaria, blinding onchocerciasis, and many insect pests that make the farming households lose more than 30 percent of their crop yields in the field, and another 15 percent in storage. Insects are, therefore, not simply a matter of natural history interest, although they are so indeed (look, for instance, at the story of mimicry which unfolded as the result of intensive studies of this phenomenon among African butterflies beginning from the mid-nineteenth century, or the opening up of a whole new epoch of the study of genetics through the study of the fruit-fly Drosophila melanogaster). The insect world is also important because a very few species of this the largest group of the animal kingdom are pestiferous, and are often regarded as "man's plague". Dethier poses their competitive threat graphically:(3)

> Man and insect compete for the green plant; the green plant struggles against them both. Modern man exploits the plant as never before. He sees the insect as an enemy. In the process of trying to destroy the insect, he is well on the way to destroying his environment and himself.

There is no doubt that insofar as it applies to tropical agriculture, the control of insect pests (as well as plant diseases and weeds) is among the first rank of first priorities in R & D. It is true that wheat and tea, as grown in the tropics, have few pest problems, but the major staple crops in the tropics—cereals, legumes, vegetables, tree crops, roots and tubers, bananas, etc.—show pests as a leading constraint to production. In the Philippines, for example, the Philippine Council for Agriculture and Resources Research and Development firmly regards breeding for resistance to maize borer, and the development of integrated pest management (IPM) for the maize borer, as first among the first-priority R & D programmes in the country. Similar ranking is given to the major legumes, where the development of varieties with stable yield, resistance to insect pests and diseases, take the same ranking as longer seed viability and high nutritive value.(4) Africa, and other tropical regions of the world, should therefore be manifestly interested in the development of pest management technologies that are both effective and sustainable.

The conventional approach, however, has been frontal, without subtlety, buying us time in an extremely expensive manner, without actually winning the pest control war. Indictment against insecticides as the weapon of choice for pest control was waged most damningly by Rachel Carson, especially in her landmark book *Silent Spring*:

> Chemical pest control. . . is at best a stopgap measure bringing no real solution, at worst killing the fishes in the forest streams, bringing on plagues of insects, and destroying the natural controls and those we may be trying to introduce. . . The current vogue for poisons has failed utterly to take into account these most fundamental considerations. As crude a weapon as the cave man's club, the chemical barrage has been hurled against the fabric of life—a fabric on the one hand delicate and destructible, on the other miraculously tough and resilient, and capable of striking back in unexpected ways. . .(5)

Carson went on to characterise insecticides as biocides, as they rendered the planet unfit for all life. She averred that chemical war against pests is never won, and "all life is caught in its violent crossfire," as exemplified by the development of insect resistance to insecticides and the frequent resurgence of these pests after massive chemical treatment. She wondered:

> How could intelligent beings seek to control a few unwanted species by a method that contaminated the entire environment and brought the threat of disease and death even to their own kind?(5)

A quarter of a century later, we are still far from knowing how to use insecticides selectively and delicately, as a fine honed knife. The world is now using 4.5 million metric tonnes of pesticides a year, of which one-third is

deployed in the developing regions of the world.(6) Furthermore, the insecticides are usually laid down as a "protective coat" on susceptible portions of target plants and animals. Yet, the amount of insecticide actually impinging on the target pests is proportionately in infinitessimally minute amounts; for instance, in the case of the application of insecticides at the rate of 1 kg per hectare against *Pieris rapae* caterpillars in collards, a mere 0.003 percent of the insecticide was consumed by the caterpillars.(6) Even so, the problems of environmental pollution are threatening, especially when broad-spectrum, persistent insecticides are used. Even more serious in the long term is the fact that, once selected, genes for insecticidal resistance have virtually permanent persistence in wild populations of the target insect. A dramatic case which should remind us of this danger is the widespread resistance of the cotton whitefly, *Bemisia tabacci*, in the Sudan. The large cotton production enterprise in the Gezira irrigation scheme is now threatened with demise largely because of the high resistance that the cotton whitefly has acquired in the last years of the 1970s as a result of intensive aerial insecticidal spraying, which has made this hitherto minor insect pest emerge as the dominant pest problem of the Sudanese cotton.

The search for more effective and sustainable alternative methods for the control of such tropical pests provided a major impetus for the founding of the ICIPE. Such new approaches required mission-oriented research, much of it of a fundamental kind, because of the lack of a basic corpus of scientific knowledge on which to build a rational technological solution within a tropical environment.

This challenge was made more difficult by the contemporary situation in the tropical developing regions, particularly in Africa, in that the bulk of the target constituencies are made up of resource-poor farmers and the rural poor; therefore, the solutions should be low-cost as well as technologically effective and environmentally sustainable. Such multi-valent solutions can only be reached through high-quality R & D directed towards specific pests in their total agro-ecological context, undertaken by multidisciplinary teams which focus their intellectual resources for a sufficiently long period of time in order to crack the pest problem. Such mission-oriented R & D might well lead to the development of several lines of attack of the particular pest problem, leading to the possibility of an integrated pest management (IPM) system, of which insecticides are merely one component, and in which such IPM systems are designed to balance the goal of pest control with the need for conserving the beneficial organisms in the environment (the parasites, predators and pathogens, which keep the wild populations of the insect pest in check in nature), based on known social, economic and ecological consequences.(7)

We can therefore appreciate the conclusion that IPM not only requires sophisticated R & D, it may also most often not find an enthusiastic patron in the private industrial sector—except where a high volume of pest control products can be manufactured or synthesised on economies of scale, such as chemicals (pesticides, pheromones, attractants, protective vaccines, etc.) and seeds (for instance, seeds of plant cultivars resistant to pests and diseases). Biological control strategies for pest suppression have not found easy implementation by agribusiness for two principal reasons: first, they do not lend themselves to large-scale manufacturing and marketing, and therefore private enterprise does not usually invest in the development expenditures to assure the timely availability of the biological control agents and processes;

and, second, the biological control strategies focus mainly on yield stabilisation rather than on yield maximiaation.(7) Indeed, biological control, once implemented, is oriented towards the prevention of pest outbreaks—by improving the stability of the insect populations within the cropping system—rather than dealing with a flare up of an particular pest emergency. Biological control tactics are consequently very much part of an evolving IPM for any particular pest problem. Yet, as Napompeth says, most IPM programmes being developed in developing countries "are nothing more than modified spray programmes which may or may not be based on sound pest surveillance methods" even though biological control is traditionally rooted in some of the indigenous farming practices in these countries. For instance, the use of ants to control pests of date palms in the Yemen can be traced to 1200 A.D.(8)

Similarly, the reliance of crop varieties that are endowed with resistance to pests is that they give great stability to the crop yield, provided other agronomic practices remain the same. Resistant cultivars are now systematically being screened for by many research institutions and seed companies as part of their breeding programmes; but many crop varieties evolved over a long period of time through traditional plant breeding practices. In either case, we are still far from understanding the bases for such plant resistance or tolerance to pests:

> The secret seems to be that the plants and their pests have coevolved over the years—the plants elaborating natural defensive chemicals, the pests responding genetically to such secondary metabolic products, and hence a dynamic balanced coexistence as a result of this chemical-genetic interplay.(9)

The resource-poor farmer now needs crop varieties that meet his needs (both for subsistence and economic sustenance) by a faster process of synthesising crop varieties that contain a substantial multi-genic element of pest tolerance or resistance, which implies considerable knowledge of the sources of plant resistance and their sustainability.

The people of tropical developing countries need to be relieved of their pest burden, which is even more onerous in tropical Africa. Because of the small body of scientific knowledge available on these major scourges of Africa—on tsetse, livestock ticks, insect vectors of tropical diseases (malaria, filariasis, leishmaniasis, etc.), crop borers, pests of tree crops, and the like—we need to undertake mission-oriented basic research to lay down a firm foundation for the necessary technological development for effective and sustainable pest management systems. This major, long term effort requires a critical mass of scientific talent of a first order, self-motivated, caring, and having a staying power to see through the adoption and implementation of their scientific knowledge and their technological ideas.

Science-led development

There is no doubt that in those problem-areas that need ecosystem-specific and socioeconomic-informed knowledge, such as tropical agriculture and tropical rural health, Africa cannot simply transfer the know-how from other climates and other cultures. As I have had occasion to state recently, "Creation of new human capital for science and technology in Africa is now a

priority of priorities for African agriculture."(10) It is a necessary condition for the sustainable development of productive, stable agriculture, and of uplifting the level of rural health for the preponderant resource-poor rural community in Africa. Dependence on technical assistance, as we have done since political independence, has not resolved this long term socioeconomic circumstance. Indeed, I stated:

> Technical assistance by itself has failed, over the last quarter century, to create this necessary condition for sustainable agriculture in Africa. Time and again, the history of science-oriented transformation of societies has shown that the development of indigenous human capital, dedicated to the long term tasks of the national development goals and motivated by incentives to reach the highest levels of excellence and relevance, has proved a pivotal factor in sustaining such transformation.(10)

Our requirement then is for technical assistance and a well articulated international co-operation to create an innovative, development-conscious, African human capital for science-driven transformation of Africa. The late Harrison Brown, who had spent a distinguished period as the Foreign Secretary of the US National Academy of Sciences, summarised this enlightened strategy at about the time the ICIPE was being born. In a Pugwash Symposium on Science and Development convened in Stanford University in September 1970, he pleaded that technical assistance of a different kind, targeted on producing the human capital of developing countries to address their technoloy-led development problems, was a matter of urgency and required massive support from the USA and other industrialised nations, and went on to state that:

> Massive technical-assistance programmes should be created, of far greater magnitude than any such program attempted before. These programs should be aimed at producing decision-makers, problem-solvers, managers and other technical persons, at developing the organisation framework within which such persons can operate effectively, and also of devising innovative solutions to specific development problems and bottlenecks.(11)

It is the creation and sustaining of a critical mass of this national human capital (in terms of the discoverers of new problem-solving scientific knowledge, and of fashioning this knowledge innovatively into new products and services required by that particular society), of establishing and nurturing an environment conducive to such scientific discovery and technological innovation, and of developing a value sense and an organisational system for selecting and recognising intellectual property. It is with respect to these crucial factors of institution building for science-driven development that the notion of "centres of excellence" such as the ICIPE is such a powerful concept.(10)

The existence of a critical mass of high-performance, motivated scientists—even in agriculture, which is regarded as "the dominant engine for future economic growth and employment" in Africa(12)—is lacking in Africa.

The annual rate of turnover of research scientists is too high, at 7 percent (almost twice the rate acceptable in the industrialised countries); perhaps this is due to the low compensation of scientific staff in relation to other types of employees, a poor working environment precipitated by limited operational funding and research facilities, and the poor management of the research effort by scientists who have been catapulted into managerial or supervisory roles without intuitive talent for such a function and in the absence of even elementary exposure to effective management tools. The nurturing of an enabling environment for R & D requires, at the very least, training at the highest levels (both doctoral and postdoctoral) in an intellectual climate in which scientific prowess is recognised and rewarded; in which knowledge services (in the form of libraries, newsletters, and other documentation services, as well as the provision of external contacts—through seminars and personal visits to other laboratories, etc.) are part and parcel of the research enterprise; and in which entrepreneurship—that is the ability to articulate hypotheses, develop relevant research programmes to test these hypotheses, and mobilise the necessary resources to undertake this experimental work (12)—is stimulated and wholeheartedly supported. While Asia and Latin America already exercise proprietary rights, Africa has still to engage itself seriously in re-examining its intellectual property rights, in terms of these rights being a commodity for international co-operation and exchange in the world market-place, and in terms of their forming part of the incentive package for the upcoming African scientific community.

Already, the question of germplasm collections which are being assembled by several international agricultural research centres in Africa (and other tropical developing regions of the world), and the interest evinced in these collections quite evidently by multinational seed companies, has raised the spectre of this world heritage being cornered by the private sector, and therefore becoming inaccessible—except at great cost—to the farming cultures in the tropical regions where most of the original domestication, germplasm selection and crop breeding was undertaken over millenia of time. Plant breeders' rights and farmers' rights are therefore at issue; so is the question of country-of-origin royalty. These issues need to be addressed by the national science policy organs in Africa, and to extend this re-examination to the problems of patents, copyrights, and trademarks as they impinge specifically on Africa.(13)

Even though the recent record of Africa's S & T institution building has been abysmal, there are some outstanding successes. For instance, the Tea Research Foundation of Central Africa in Malawi, and the Coffee Research Foundation in Kenya, have done an outstanding R & D work which has put the tea and coffee industries in these two countries in a leading position worldwide. Similarly, sugar-cane production, based on research and agro-industrial development undertaken as a leading economic sector in Mauritius, has put that island nation in a commanding position for this commodity internationally. Finally, the Agricultural Research Corporation in the Sudan has established a good example in its management of the research enterprise in one of the poorest of the poor countries of Africa.

What inspiration can we derive from the "centres of excellence" model, which would make S & T institution building in Africa a more frequent expectation and occurrence? Perhaps, the starting point should be the criterion

that Djerassi so succinctly enunciated when he set out his own ideas as to how to establish a centre of excellence in a developing country or region:

> From the standpoint of scientific development, a "developing" country becomes a "developed" one when original research emanates from it. The eventual consequence of such research is the creation of technological innovations, which may then be utilized in many other countries that have the manpower to accept such innovation. . .(14)

Such a level of S & T sophistication can be reached by countries that have not yet reached a self-sustaining S & T capability, through the kind of institutional building model he promulgated based on his new experience of building a first-rate chemical R & D capacity in Mexico almost from scratch in less than two decades.

His model, first unfolded at the Pugwash Conference held in Sweden in 1968, embodied three critical features:

1. An international cadre of postdoctoral research fellows, based at the institution for a short period of time, as the core group undertaking the necessary R & D, together with Ph. D. students from the host country.
2. Scientific direction being provided by a group of part-time directors derived from major universities in the industrial regions of the world.
3. Selection of research areas having intrinsic fundamental interest as well as possible ultimate economic pay-off and having a multiplier factor: steroid chemistry was such an area in Mexico of the late 1940s.

Replication of successful institution building in Africa

It is not surprising then that the ICIPE, which was founded only three years after the Djerassi paper, contained these three innovative features. Addressing the US Congress Panel on Science and Technology, held in Washington, D.C., in January 1971, barely nine months after the legal instruments for the establishment of the ICIPE had been signed, I considered the following five characteristics of the organisation of the ICIPE as singular features that would characterise the ICIPE as "one of the finest examples of international co-operation"(15)

1. Its main research workers consist of a pool of young talented postdoctoral research fellows specialising in many fields of insect science (insect ecology, genetics, natural products chemistry, biochemistry, biophysics, physiology, endocrinology, and insect pathology) from many lands (both developed and developing), working at the Centre for 2 to 3 years.
2. The research workers perform their missions under the guidance of outstanding world scientists, who visit the ICIPE two or three times a year as non-resident Visiting Directors of Research.
3. The individual support of the ICIPE comes from over 100 scientists, policy-makers and other distinguished public personalities from Africa and around the world, and who formed themselves into a non-profit organisation (the ICIPE Company).

4. The Centre's policy-making is done by a governing body with an international composition.
5. The intellectual support and the scientific quality control is provided by an International Committee (later coming to be known as the "ICIPE Foundation"), comprising representatives of leading academies of science having a substantial interest in insect science and institution building, with the specific charge of guaranteeing the high quality of the R & D work performed at the ICIPE.
6. The institution of an African Advisory Committee, whose main objective was to ensure that the research priorities drawn up by the ICIPE management were truly relevant to Africa's abiding needs, and that the Centre implemented its work programme in a manner that would enhance substantially Africa's indigenous scientific capacity.

The first two elements of this package of innovations in institution building in Africa, which directly emanated from Djerassi's experience, as well as the idea of the ICIPE Foundation and that of the African Advisory Committee, were all truly singular features of the management architecture of the ICIPE. This constellation of innovative features inspired an unexpectedly strong spirit of commitment and a sense of exhilaration that we were all partners in a novel international experiment, which would eventually help Africa to manifest its scientific talent in the service of its own development.

The experiment continues. It has had a considerable measure of success: it has established itself in the minds of the African leaders, intellectual as well as geopolitical, as an advanced centre of development-oriented research centre that authentically addresses its major pest problems and scientific capacity-enhancing potentials. African governments recently played a pioneering role in negotiating an international charter to affirm the international character of the ICIPE, and to confer on it benefits and facilities which would further its pan-tropical mandate. A charter was signed in November 1986 which has eight adherents from three continents but which guarantees the functional autonomy of the institution. In February 1988, the Organization of African Unity approved a co-operation agreement with the ICIPE, which would permit across-border pan-African collaboration in research and training.

We are now at a field pilot testing stage of tsetse control methodology, exemplifying a community-based trapping technique, which is low-cost and simple to use, but founded on a tremendous body of knowledge on tsetse population ecology, tsetse sensory physiology and behaviour, chemical ecology and reproductive biology, and the epidemiological relationships of tsetse and its host animals gathered over an intensive period of research in ICIPE laboratories and field sites over the last decade and a half.

We have established a special programme of training for scientific leadership in Africa—the African Regional Postgraduate Programme in Insect Science (ARPPIS)—which is being undertaken with a consortium of 14 universities in Sub-Saharan Africa. Started 6 years ago, it is now graduating about 8 Ph. D. insect scientists a year. In this zone of Africa, it is estimated that there are at present only about 50 Ph. D.-level insect scientists; it is clear then that the ARPPIS contribution to the pool of national insect scientists will soon prove a substantial element.

This relative success has brought with it new insights in this dynamic situation. As the institute has grown into adolescence in the late 1970s, and later asserted youthful maturity in the mid-1980s, it has continued to keep a prudent dynamism in its functional growth and productive efficiency—as has been related so well by Rabinowitch in his ICIPE Guest Lecture given in April 1985.(1) Perhaps the most change-bearing notions are the following four which have evolved through experience:

1. The idea of making a research institute, such as the ICIPE, a centre for postgraduate training, in partnership with a consortium of universities monitoring the academic content and quality of the course and project work, while the institute provides the supervisory skills, the research facilities, and a creative environment for such a joint endeavour. It is an exciting new development, pregnant with possibilities for the future. ARPPIS is a resounding success, and the ICIPE has more requests for graduate training of motivated and good quality students, already committed to the profession, than it can handle.
2. The development of a loose consortium of donors, the Sponsoring Group for the ICIPE (SGI), with its secretariat at the World Bank, which meets twice a year to consider ICIPE's biennial programme and budget, and considers the required resources to undertake the programme of work already approved by the ICIPE Governing Council. Although this mechanism does not guarantee funding, nor act as the donor group of last resort, it gives legitimacy to the ICIPE as an international project, and gives some confidence to the donor community that the ICIPE is a worthwhile project to support. A helpful instrument in this regard, which was pioneered by the ICIPE Foundation, is the periodic appointment of external evaluation teams, which carry out in-depth review of the ICIPE programme activities, management, and mandate. The SGI organises such evaluations on a triennial basis, and this has become a vital measure for scientific quality and management efficiency of the institute every so often.
3. The establishment of an interactive R & D network—the African Regional Pest Management R & D Network (PESTNET) in October 1986—for the development of locale-specific, ecosystem-sensitive IPM strategies for target pests in concert with national scientific institutions who adhere to PESTNET. PESTNET secretariat is based at the ICIPE, headed by a full-time co-ordinator. The network already has as its members 11 countries in Eastern and Southern Africa, and will be extending its reach to West Africa shortly. It runs a quarterly bulletin. It convenes methodology workshops. It sets R & D priorities, agrees on annual work programmes, and evaluates progress made each year. PESTNET has begun its R & D work by concentrating on crop borers of cereals (mainly maize and sorghum) and grain legumes (principally cowpeas), aspects on which the ICIPE has considerable information already, and where ICIPE's agro-ecological work is reaching the farmers' field testing stage. Consequently, the ICIPE can productively interact with the national research systems in this field. Already, the ICIPE will be, within the next three months, basing a small resident team in two member countries with contrasting agro-ecological situations (namely, Zambia and Somalia), and at the same time initiating an accelerated programme of

training of graduate-level insect scientists to enhance the interaction at the working level.

4. The establishment of a Social Science Interface Research Unit (SSIRU) at the ICIPE, now that some of our research is approaching the stage of technology development. It is concerned primarily with two issues: the consideration and understanding of the traditional knowledge base on pest management by the resource-poor rural community in the context of rural household food security, and the development of IPM technologies within the contextual social realities of the target constituency. This research unit therefore works intimately with the natural scientists at the ICIPE in developing a transdisciplinary scientific understanding of the process of ecosystem-sensitive, agronomically-feasible and socially informed pest management technologies which would therefore have a high potential for sustainability. This notion, as embodied in the SSIRU, goes beyond the conventional farming system approach, or simply a social science approach.

We have endeavoured to make ICIPE's strategies more immediately answerable to the pest management needs and competence-enhancement priorities of the national research systems without in any way jettisoning our mission-oriented fundamental research approach. The latter approach is vital for building up the basic bricks on which new pest management challenges of the future might be erected. Thus, the ICIPE is now putting considerable effort in building up expertise in molecular sciences (molecular biology, molecular biochemistry, and molecular immunology) across the board. Similarly, over the last two years insect population modeling is coming into its own in at least two of ICIPE's core programmes.

So far, we have said little about building of physical structures and installation of equipment. It is ICIPE's philosophy that the most critical resource for institution building is people. We have, therefore, concentrated on the selection of people to cater the various programmes and management functions of the Centre first, and in creating, maintaining and enabling environment. Buildings, although important, are only now following after the establishment of a tradition of excellence and relevance, and the installation of a culture for the full and productive participation of the indigenous African people in R & D as well as in institutional management.

It would be presumptuous to state categorically that there are no other S & T institutions in Africa that have the hallmarks for excellence and relevance, or those that are competence-enhancing. Four have already been mentioned. There are also the R & D institutions funded and managed under the umbrella of the Consultative Group on International Agricultural Research (CGIAR), those located in Africa being the International Institute of Tropical Agriculture (IITA), established three years before the ICIPE; the International Laboratory for Research on Animal Diseases (ILRAD), founded at about the same time as the ICIPE; the International Livestock Centre for Africa (ILCA), established some five years later; and the West Africa Rice Development Association (WARDA), an older institution. They are all massively supported through the CGIAR, which guarantees funding for an agreed programme of work. This guarantee has greatly released management efforts for other institute concerns. The CGIAR is really a loose, "non-organisation" forum for mobilising resources, although it has now grown into a vast operation. The SGI

took the essence of the CGIAR notion as a pragmatic notion for resource mobilisation. Indeed, the CGIAR is perhaps the most innovative element of the system of international centres for the downstream end of R & D.(16) It is perhaps because of this latter orientation that the CGIAR has yet to chalk up in Africa the sort of successes that have attended the green revolution in Asia and, to some extent, in Latin America.

We have come a long way, but the problems in Africa which might be solved with scientific and technological approaches still remain largely intact. We cannot let the models of success of institution building in the past become ossified in our thinking or operation. While the old problems of institutional productivity remain in Africa, the development challenges become larger. It behooves us therefore to heed the aphorism of one of the ICIPE pioneers, Victor Rabinowitch, when he stated in April 1985:

> Finally, as good chefs well know, a good recipe gets better as experience demonstrates that certain ingredients can be added, subtracted, or otherwise modified as new or better ones are incorporated. So it has been with ICIPE, whose "chef", together with the owners and managers of ICIPE, have modified the structure, operation, and indeed the substance of the research program to respond to evolving needs, and, even more important, to emerging opportunities.(1)

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A FOUNDATION PERSPECTIVE ON AFRICAN SCIENCE

*Francis X. Sutton**

The development of the sciences and technologies is always dependent on a multiplicity of conditions and on the consequences of policies contrived for purposes other than their advancement. A similarly vague but useful observation can be made about the programmes of philanthropic foundations, and certainly about the Ford Foundation. When Ford decided in 1957 to extend its overseas development programmes into Africa, it did not have science or technology very prominently on its agenda. From the beginning of its national and international programmes in 1950, it had chosen to focus on problems, not disciplines, proclaiming in its public documents that it was guided by a "problem orientation". A concern with the preservation of democracy in India led the foundation into a major engagement with the community development programme there, and started a general interest in rural development which became part of its African program from 1958. Similarly education and public administration were manifest "problems" for developing countries and assumed major places in the African programme, as they did elsewhere. An interest in economic and social research was present in the foundation's programmes at home and was pursued overseas, beginning in the Middle East and in India from 1952 onward. The initial judgement of the 1948 Study Group that laid down the policies and programmes the foundation was to follow in its first years was that support of the natural sciences and medicine could be left to the federal government and others. Such interest in science and technology (other than in the social sciences) which might arise in the overseas development programmes would thus have been derivative from other programme interests rather than from a direct interest in advancing science and technology. By 1960, the foundation had taken up direct interests in science and engineering at home in the United States and was manifesting strong interests in them abroad, but still within the frames set by development programmes.

When Lord Hailey in his gargantuan "African Survey—1956" assessed the future of research in Africa he thought it was "likely to receive its chief support from international sources rather than from the former colonial territories themselves, or the powers which are interested in them".(1) Hailey apparently saw the future in this form because he thought the prime possibilities for fruitful research lay in matters that were not limited to particular countries and required a general scientific approach (he cites the conquest of yellow fever as a model case). But at the time Hailey was writing, the general patterns of development co-operation and technical assistance were following a different course. Development meant the progress of newly independent countries; national governments were the prime agents and

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ultimate authority on what development programmes should be undertaken in their countries. Governments and international agencies that engaged in development assistance were constrained to respect these principles. It was not obvious that a private foundation need do so. The Rockefeller Foundation had for many years proceeded rather differently in the applied science paradigm Lord Hailey had before him. But Ford with its "problem orientation" initially accepted the principle that development meant country-by-country development, and that it should work closely with each sovereign government, respecting the priorities and needs that government defined.

By the time Ford started in Africa it had had a striking and exciting success with this strategy. Paul Hoffman, Ford's first president, visited India in August, 1951, met Prime Minister Nehru and agreed to fund pilot community development schemes. The man Hoffman recruited to run this and other Ford programs in India was a rural sociologist and extension expert from Missouri, not the obvious kind of man to get around Nehru's dislike of Americans. But Doug Ensminger became perhaps the most influential American in India in Nehru's time as Prime Minister, and built up the largest programme Ford had in any country overseas.

The way the Ford Foundation's programmes in Africa developed showed both imitation of and reaction against the Indian programme. On the Indian model the foundation looked for a key country and had an obvious candidate in Nigeria. But the multiplicity of small African states made regional strategies obvious and essential, despite past discouragement with regional programmes in the Middle East. They were developed mostly as common themes among projects based in individual countries, though where regional institutions (like the University of East Africa) looked promising they were eagerly supported. The projects and institutions the foundation funded were thus nationally-based and selected for their contributions to the development of the nation in question. Against this dominant pattern, the funding of the International Institute of Tropical Agriculture by the foundation appears as a striking deviation; indeed it was, for reasons and in ways that will engage our attention.

The investment of approximately $22 million in IITA by the Ford Foundation was largely the result of one man's convictions. Forrest F. (Frosty) Hill came to the Ford Foundation as vice-president in charge of its overseas development programmes in late 1955. He was a farmboy who became agricultural economist, New Deal administrator, provost at Cornell, member of the board of the New York Federal Reserve Bank, and much else. He was an enthusiastic but cautious man, garrulous but shrewd. When he came to Ford, India was the foundation's crowning glory overseas, and community development the jewel in the crown, but from his first trip, Hill disliked and distrusted what he saw in India. He was a little ahead of the general disillusionment with community development that was then rising. He thought it unlikely to bring the increases in agricultural production that India obviously needed and he was already brooding on strategies for such increases. Frosty Hill was not a man for confrontations, but he had a hard time avoiding them with Doug Ensminger. Ensminger's sweeping enthusiasms for Ford's role as a partner to Nehru's government in preserving democracy in India seemed in Hill's view to lead to wastefully large and diverse expenditures. Ensminger, on his side, thought Hill lacked overseas experience and was interested only in agriculture.(2)

Ensminger was a powerful satrap, but Hill had the upper hand in planning the overseas development programmes at headquarters in New York. The decision to open programmes in Africa came not long after Hill took charge. In his economist's language, Hill opined that there could be larger marginal returns from Ford grants in Africa than like amounts would bring, used where the foundation was already working. The initial idea that useful programmes in Africa could be mounted on a smaller scale than the existing programmes in Asia and the Middle East, and overseen from New York without representatives in the field, did not originate with Hill. It was there when he came to the foundation, but he did not dispute it and indeed at first looked with favour on small grants in public administration, education, social and economic research. He was remarkably cautious on grants in agriculture and rural development. Of course, there was to be no engagement in community development programmes (which were then prominent in many parts of Africa), and proposals for agricultural training brought him to rambling disquisitions on the high cost of doing it well. By 1958 when Ford's regular programmes in Africa south of the Sahara started, there was as yet no trace of effects from Hill's celebrated discussions on the Scarsdale commuter train with George Harrar of Rockefeller that were to lead to the International Rice Research Institute by 1962, and other institutes thereafter. Whatever else there was to be said about international institutes, they were clearly expensive and long term investments, while Africa was new territory for Ford where modestly scaled programmes were to be the starting norm.

Ford thus began its African development programmes working with individual African governments (both independent and still colonial) in the familiar patterns of the time. It was quickly caught up in the excitements of the independence movement and the success of the new African nations became its overriding interest, rather the way the preservation of democracy in India had been for Hoffman and Ensminger. At the approach to 1960 there was an unusual opportunity for an organisation that was (at least plausibly) politically neutral to enter into the crucial but delicate business of "Africanising" the public services. The foundation was invited to provide expert advisors, which it happily did, and thereby commenced a long and heavy engagement with public administration in Sub-Saharan Africa. In the appended table on the foundation's African commitments, it will be seen that "Development Planning and Management" is overtopped only by "Education and Research" in the categories of expenditure. In this very general interest, concerns with the staffing of scientific and technical services entered as a special subject, derivative from the broader interest.

Education has always been a central interest of the Ford Foundation. Under the presidency of Henry Heald from 1956 to 1966 it was so dominant that Heald liked to characterise Ford as an "educational" foundation. And if there was a soft side to Frosty Hill, it was in his loving and reverential regard for education—it had been his ladder out of the wheat fields of Saskatchewan to the stars, and he brought an educator, F. Champion Ward, back from India to head the Middle East and African programmes. Everyone was sure in those years that the "key" to development lay in education (or "investment in human capital" as those deferential to economists put it), that Africa was gravely short of "high level manpower" and that urgent efforts were needed to remedy the dearths. The foundation flung itself enthusiastically into a broad spectrum of

educational projects, from manpower planning to improved primary education, but mostly centred on universities.

The early years of the Ford Foundation's African programmes coincided with an extraordinary increase in the foundation's assets. By 1960, its endowment had reached nearly $3 billion, a sum which amounted to more than half the total endowment of all American colleges and universities. Its annual budgets rose more or less correspondingly and by 1960 Ford's expenditures were greater than the regular budgets of the UN and all its specialised agencies.(3) Needless to detail, Ford's annual expenditures were bigger than those of many African governments and the fraction of Ford's budget that could be allocated to Sub-Saharan Africa made it look to one African official as a "middle-sized power". In such circumstances, high ambitions and expensive projects could be and were contemplated. Expenditures rose rapidly in the 1960s, though not always in the fields Ford thought most important. Frosty Hill believed the critical subjects for development were food, population, and education.(4) The appended table shows that, despite the foundation's major concern with population, it did almost nothing there until 1966 and relatively little thereafter. The rise in agriculture expenditures was sharp and sustained after the founding of IITA, but began slowly for reasons already indicated.

This setting of Ford's engagement with scientific and technical competences in Africa in the larger context of its development programmes may be a useful reminder of the way governments and international agencies approach these subjects through broader and apparently more urgent concerns. It has often been remarked that international assistance to universities under development programmes has been far from an ideal context for university development. Something similar might be said about scientific institutions and services generally. But development has in fact had the fattest budgets in international assistance and it will certainly remain so for the foreseeable future in Africa. It thus may be instructive to review what Ford did and did not do for the advancement of the sciences in Africa, starting as it did from a broad development motivation.

Public scientific and technical services

In the very modest state of development of African countries before independence, with industry and higher education limited or embryonic, most existing scientific and technical capacity was to be found in public services. There were, indeed, some examples of commercial agriculture supporting private research activities. But for the most part, the dependence was on public services, either directly linked to secretariats and ministries or organised as separate units, and sometimes, as in East Africa or French Africa, on a regional basis. In the vast revue-ménage brought by the transfer of sovereignty, these services and centres were inconspicuous particulars. As in most other parts of the public establishment, it was thought that "the machinery should be kept functioning" at least until more urgent business could be disposed of and the new authorities had time to consider what in their heritage they wanted to keep or discard. The retiring colonial powers and the new African authorities certainly thought scientific competence important to future development, but what was presently to be done about it was enmeshed in general policies of transition and Africanisation. So it also was with the Ford Foundation.

As an American organisation, the Ford Foundation entered Africa with a freight of American associations and ample self-confidence. There was confidence in American managerial capacities and technical strengths which was shared both by Africans and (often grudgingly) by colonial administrators. While the foundation became active in the then Belgian Congo and a little later in the French African territories, it was in fact only in the anglophone countries that this mutual confidence lead to important projects in the Africanisation of public services. But in several such countries it did, with a heavy input of technical assistance as staff development advisors, job analysts, manpower planners, and trainers of various sorts. All of this was cast in a neutral, technical style bolstered by the then undisturbed faith that there was such a thing as a science of administration.

In fact, Ford's (and other's) technical assistance was often a quasi-political mediation in an agitated process where careers were being made and broken, prizes won and lost. Though the moral imperative of African sovereignty had been accepted, there remained critical questions of pace and preparation. These were no mere technical questions but lay in the heart of the political process. It is, of course, well-remembered that the Africanisation of governments proceeded much more rapidly than was anticipated on the European side (and less rapidly than some of the more exuberant Africans wanted). The light-hearted good spirit in which the transfer of power was celebrated by many Europeans was in part based on conviction of their long term indispensability; one remembers Lord Mountbatten predicting 25 years for the full Africanisation of the Tanzanian armed forces, this being the normal time for a subaltern to rise to general rank. A realistic projection of the pace of change—and consequently preparation for it—was almost impossible to achieve between European civil servants, proud of their competences and fastidious about the qualifications for replacements, and Africans used to fighting their way over barriers they saw as walls of prejudice. As in many walks of life, outside mediators had a role to play, as the foundation discovered in the regional and federal governments of Nigeria, in Tanganyika (where Governor Richard Turnbull saw the need to hurry before independence), and later in Kenya, Zambia, and Botswana.

Much of what was in fact done was of a counting and tabulating sort. It was the task of technical advisors to assess supplies of indigenous talent, training needs, and possibilities of technical assistance from all sources, to devise reorganisation of services to adjust to different levels of trained competence, etc. Manpower planning of this sort became influential and popular, and Africans were trained to carry it on as a regular part of national planning. If it was an indispensable basis of policy it was in itself no sure guide, as its later detractors have loudly proclaimed. In particular, it was obvious that some sort of difference existed in the problems of changing administrative and technical personnel; the common and easy view was that expatriate administrators could and should be replaced first and expatriate professionals and technicians held for longer periods until local replacements were available. If veteran technical staff from the colonial heritage departed before indigenous replacements were ready, they would have to be replaced by international recruitment. The rather atomistic view of staffing problems was quite unrealistic in its neglect of social and institutional factors, and in its underestimation of the difficulties of fresh international recruitment. As the foundation discovered in such ventures as the reorganisation of the Tanzanian

ministry of works, the technical staff inherited from the colonial era were a social group, not easily reassured about the future and liable to take flight in flocks. And despite the fact that Africa has long had the lion's share of international technical assistance, the international response to needs of national technical services has typically been slow and inadequate both in quantity and quality.(5) The result has commonly been chaotic periods of turnover or persistent collapse of technical services.

Something of the sort evidently was occurring in the mid-1960s in the scientific services of East Africa as the testimony of Mohammed Hyder, then secretary of the East African Academy, declares (1966):

> Probably nowhere else in the world is the "half-life" of expatriate staff shorter than in East Africa today, and this situation applies more critically to research scientists than to any other category of personnel. One would hope that, with increasing East Africanisation a stable backbone of research scientists could be created. But for two reasons this expectation will not be fulfilled for some time to come. One is that few East African scientists are available in East Africa today. The other is that there is, in any case, a serious dearth of that admittedly rare creature anywhere in the world—the research scientist. But even the few that have come through the "pipe line" have invariably been promoted to administrative positions and invariably lost for good to research.(6)

Hyder was an academic and had a much livelier appreciation of the special qualities of research scientists than was typical of political leaders and governmental planners. There was little disposition on the African side to treat research centres and research scientists as special cases requirlng different sorts of Africanisation policies than were being followed elsewhere; one indeed heard much resentful talk in those years of "expatriate enclaves" and there was a natural but hazardous disposition to Africanise the administration while attempting to maintain expatriate scientific staff until African replacements were ready. While there was some disposition at the time to develop specialised civil service cadres—the Ford Foundation had much experience in efforts to develop economic cadres—one recalls no such planning for research cadres.(7)

The striking difference between the devolutions on the French and British sides suggests that different British policies in support of African services and maintenance of careers of then serving research officers could have led to less turbulent changes than Hyder depicted. The practice on the French side of maintaining scientific research cadres based in France avoided familiar difficulties on the anglophone side, at the expense of more sluggish Africanisation. By 1971, when Hill made a review of agricultural research in French-speaking Africa, he was greatly impressed: "The French program of agricultural research in French-speaking Africa is excellent. Taking into account both quality and coverage, I know of no other program that is in the same league."(8) He was well aware of the weakness of national research services that have continued to be perturbing on the anglophone side, but knew it to be beyond Ford's resources to make a major difference there in the short-run.

In retrospect, the transition from colonial to independent governments in Africa looks far less controlled or controllable than those earnestly engaged in managing it thought it might be. Much was changed fundamentally and in ways not wished or foreseen by Africans or outsiders, and some things did not change as rapidly as expected or wished. The history and present state of national research services suggest that they have proven to be either fragile, or sluggishly Africanising, parts of the colonial heritage in which the policies of the former colonial powers remain more important than other sources of international aid. It is a fair question to ask if international aid, and the Ford Foundation in particular, might have done better. Given the general policies and motivations which underlay its overseas development programmes, and lacking specific scientific traditions and competencies such as Rockefeller had, it is probably unrealistic to suppose that Ford might have focused more heavily on the maintenance and development of national research services. Preoccupied as it was with the general tasks of building effective African governments, it could give only limited attention to their technical and scientific services. What it was able to try to do in support of research and scientific competencies came through its commitment to education and in the promotion of new organisations for agricultural research.

African higher education: policies, programmes and problems

African independence coincided with a great flowering of higher education all around the world. The 1960s were years of unprecedented expansion and enthusiasm for higher education in the United States as in other countries. The American foundations have had a particular vocation to higher education—until quite recently grants to institutions of higher education have always taken the largest share of the largesse of the major foundations. Ford's largest domestic programmes in the 1960s were in higher education as they were overseas. Like other foundations, it had close relations with university presidents and faculty, and felt itself more at home in universities overseas than the officials of organisations like USAID were. On any Ford mission overseas, universities were regular ports of call.

The fledgling universities established in Africa in later years of the colonial era naturally became prime objects of attention for the foundation. Indeed it became policy that, while the multiplicity of African countries required geographical limits for other foundation programmes, universities were eligible for attention everywhere. Like the colonial authorities that established them, Ford felt that a university was a necessary attribute of a competent modern state, even for quite small ones. Grants for overseas training were evidently important but no substitute for the development of national universities. The functions of the universities were evidently multiple—in training, research, service, and as nuclei for the intellectual and cultural life of the new nations. Guiding principles for university development were needed and by the 1960s, in the heyday of manpower planning, the provision of "high-level manpower" for development was the dominant theme. UNESCO conferences in Addis Ababa and Tananarive at the beginning of the decade had declared that 60 percent of university places should be in science-based fields, and the development motivations of external donors gave particular emphasis to applied fields.

Despite this emphasis on the sciences in African universities, Ford did not specifically focus on them. It was not reluctant to do so in other settings—in Latin America in that decade its largest investments in universities were in building science, engineering and agriculture faculties. In Africa it followed a different course, emphasising general university development and the social sciences, pure and applied. A conscious division of labour with the Rockefeller Foundation, which was also heavily involved in African higher education, was in part responsible. There was also an awareness of other donors' interest in agriculture, veterinary science, and other applied fields. There was nevertheless a guiding conviction that African universities had a major role in research, so all sorts of grants to that end were made—for Africanisation, for facilities for visiting researchers (the "Ford flats"), and for general university development at Ibadan, Khartoum, the University of East Africa, and elsewhere.

The foundation was relatively free of the common disposition of Americans to want to replace what the British, French, and Belgians had established by more "practical" American models. With one notable exception in Zaïre where it was the principal donor in the founding of the Ecole Nationale de Droit et d'Administration, the foundation worked within existing institutions, seeking their development in ways it thought they needed. There was early awareness of the extremely expensive character of higher education in Africa. The familiar calculations that for one African student, it costs 30 units of their per capita gross domestic product per year to attend a local university, while it costs an American or European only one unit of their respective per capita GDP to attend theirs were much contemplated. The foundation was also familiar with places like India or Egypt where vast expansion of public universities threatened the quality of what they could do. If Africa was to build universities of superior quality capable of graduate study and research, it could hardly sustain them everywhere. Selected "centers of excellence" around the world was an ambition of the foundation in those years, from Delhi, to the University of the Philippines, and the University of Chile. Africa was thought to need such centres too, and Ibadan and the University of East Africa became the choice for major investments by both Ford and Rockefeller. A considerable part of this investment was specifically in the development of research capacities, mostly in the social sciences and in African studies for the Ford Foundation.

The research functions of African universities were less readily definable and quantifiable than their training functions, bolstered as these latter were with the arithmetic of manpower planning. In the happy early years this arithmetic called for expansion, and from an economic point of view there was a case to be made for the development of African universities as primarily institutions teaching for first degrees. The costly university functions in research and graduate training might, from this point of view, be put upon the rich countries, their universities and aid programmes. This course of economic prudence was, however, quite unacceptable both to Africans and outsiders. A typical assertion was that of Y.K. Lule, then principal of Makerere University College at the 1967 Conference of the University of East Africa: ". . . we have no doubt that Makerere must decidedly thrust ahead with programs of post-graduate study and research. . ." and he had a long list of concrete proposals toward this end.(9) An attachment to research was a natural disposition of faculty both African and expatriate, anxious to advance their own careers, and

it was reinforced by leaders' visions of national dignity through respected universities. There was, of course, much sensible consideration of what sorts of research were most appropriate and promising in African universities, but the basic aspiration was that there be some sort of research and advancement of learning at standards which would win international respect. African universities were founded as a start toward African participation in the general human effort in the advancement of knowledge, and as a means of guiding their own countries' destinies. To start was an assertion of intellectual independence. It was a moral imperative, accepted by the Ford Foundation, as it was by others. Ford was not devoid of ideas on research it thought appropriate but recognised that the agenda of university research is always in large measure indeterminate, dependent as it is on the interests and talents of the available staff, and on the uncertain links between basic research and its uses.

There is neither the scope nor the need here for a recall of the contentions that have surrounded efforts to define appropriate research roles for African universities. Academic freedom has had to be reconciled with service of the nations, and international research standard with pertinence to local needs. The evident need to relate the research functions of universities to other research services has led, with much international encouragement, to the development of national research councils, but it has not been easy to make these organisations into wise and effective guides to national research strategy. The Ford Foundation had no significant role in these efforts, other than indirectly through its heavy engagement with national planning agencies. But it was conscious of the need for national strategies and sought to help through international resources like the Science Policy Research Unit at Sussex, which could develop expert knowledge of the problems in a broad array of countries.

The support of research activities in African universities was affected in later years by three broad developments:

1. the turning-away in the 1970s of the foundations and other agencies from university development;
2. a related fresh emphasis on "basic needs" and direct assaults on poverty; and
3. the growing financial pressures on African governments and hence on their support of universities.

All of these changes seem to have adversely affected research capacities and performance in African universities. They can be viewed here, not in the full generality they deserve, but from the limited perspective of Ford Foundation history.

Both domestically and internationally the Ford Foundation showed a major decline in its support of higher education from heights of the mid-1960s to a low at the end of the 1970s. This great change came about primarily because of a drastic decline in the size of foundation resources relative to university needs, but also because of diminished enthusiasm for higher education relative to other needs. It is perhaps not generally appreciated how much foundation resources were diminished by the inflation and adverse capital markets in the 1970s. The Ford Foundation's assets reached their maximum size at a little over $4 billion in 1964; by the mid-1970s its assets had fallen under $2 billion. Its maximum annual expenditures were at $362 million

in 1966; they slumped to a low of $107 million in 1979 in inflated dollars; in constant dollars they amounted to about a sixth of peak expenditures in the 1960s. In the late 1960s the foundation withdrew from major programmes of assistance to American universities and by the early 1970s it terminated large university development programmes overseas. It was not only that the foundation's own resources were diminished; the scale of universities and their costs kept growing, and what had seemed feasible in the 1960s was no longer so.

Like other international agencies engaged in development, the foundation responded to the heightened concerns with basic needs in the early 1970s. As budgets declined, it sought to maintain its programmes concerned with food and population. Educational programmes were affected by the tide of economists' criticism of low rates of return in higher education relative to primary and secondary education. The largest parts of Ford's educational expenditures shifted to capacity building for educational planning and research, and away from broad university development. Grants to universities of course continued but with more specialised objectives, notably for training and research in the social sciences and agriculture. There was also a substantial engagement in efforts to develop international strategy for education through a series of Bellagio conferences in the early and mid-1970s; these explored the then popular side of the "developmental university" but brought forth no substantial new foundation programmes in that mode. The intimacy of engagements with the general problems of African universities which had been so pronounced in the 1960s fell away and much that was happening in them was lost from sight.

This declining interest in university development was not peculiar to the Ford Foundation. It was shared widely in other organisations as they refocused their efforts toward new directions and basic needs, although the Rockefeller Foundation held on until 1978 with its university development programme.

It was perhaps natural that there should have been a falling away after the excitements of beginnings. Moreover, the doctrines of development assistance were that responsibilities should shift to the developing nations themselves, and as the African universities became Africanised in administration and staffing, the role of external agencies was diminished. But it might still be wondered that foundations with their traditional commitments to higher education and research did not hold on more vigorously. A sense of relative impotence was a discouraging influence overseas as it was at home. Universities continued to grow even when it was not apparent that "higher-level manpower" needs of countries were compelling. By the late 1960s the Ford Foundation had the experience of providing manpower surveys which showed that certain categories of university graduates were in early prospect of oversupply, only to have such conclusions indignantly rejected. There was, moreover, discouraging evidence that universities were not serving as sensitive screens for talent, recruitments to the public services being on less than discriminating criteria.

It seemed apparent that African countries were becoming as responsive to the pressures for expanded opportunities in higher education as other parts of the world were, and they were beginning to suffer some of the overburdening political intrusions and internal turbulence that afflicted universities elsewhere. The vision of universities as quiet settings for research and scholarship became clouded and in some cases the tensions between

governments and universities made recourse to them for research and policy guidance less promising.

Even with these daunting challenges to effective university development, the Ford Foundation might have persisted more determinedly had it not been responsive to the strong emphasis on direct concerns with equity and the poor that came with the 1970s. The emphasis it put on food and population exemplify these concerns. And it began to feel the declining confidence in governments and national planning that was to lead toward more support of local initiatives and private agencies. There is normally a tension between the claims of "action" and "research" in foundation programmes and the mood that arose in the late 1960s favoured "action" over against "studies for the shelf". Research and capacity-building programs could not in fact be neglected, and foundation representatives who were determined to "get to the grass roots" commonly found that they were dealing more with universities than they had expected to. But the recourse to universities had its motivations elsewhere than in a general concern with the functioning of universities.

What may follow this period of reduced or specialised interest in African universities and their research capacities is uncertain. The strong continuing interest of the foundation in Africa is not in doubt and many interests lead to grants to universities. A sense of concern for past relationships and investments typically motivates foundations and promises lasting interest in the health of African universities. It was always recognised that their building was a long term undertaking, and as conceptions of development priorities shift there may again be periods of focused concern with them. Special attention to the social sciences seems more likely than to the natural sciences. But it may be remembered that there was, in the 1960s, a broad interest in science education in Africa from the primary school onward and reaching to concerns for the supply of well-prepared science students for the universities. An account of these efforts cannot be included in this paper, but they may perhaps stimulate imitation or revival in the future.

The International Institute of Tropical Agriculture and other research institutions

While, as we have seen, Ford's interests in scientific and technical competencies in sub-Saharan Africa were principally derivative from wider interests in the development of governments and universities, there was one major direct interest and a variety of smaller ones. The International Institute of Tropical Agriculture near Ibadan in Nigeria became the largest grantee the foundation has had in Africa and as such it deserves particular attention in this paper. A fuller account of the foundation's programmes would have to survey a number of smaller efforts and actions to relate other international institutes to African needs, but these can only receive passing attention here.

The commonalities of nature have long made it evident that knowledge and research to meet the problems of developing countries did not all have to be gained in these countries. The Rockefeller Foundation had classically established the International Health Commission and supported its work with the Rockefeller Institute of Medical Research. The colonial powers had supported research in metropolitan institutions on tropical medicine, agriculture and other fields. The overwhelming predominance of the industrial countries in scientific research facilities and trained scientists has continued to

make their resources of continuing and sometime critical importance in the assault on a great range of the problems of developing countries.

In the early years of the development era (Point IV), there was excited expectation of fruits from the transfer and application of the knowledge and technique that had made the industrial countries rich and prosperous. But it became apparent fairly quickly that effective transfer demanded research and local adaptation, and problems were sometimes encountered that pushed research back into quite basic scientific questions. An example of the latter arose when the interest of the Ford Foundation in population brought it (by the end of the 1950s) into support of research for better contraceptives. This work led to a concentration on reproductive biology that went on for two decades and became the largest part of the foundation's population expenditures. The largest part of this work was carried on in First World laboratories, although there were substantial efforts to build capacities in the Third World, with increasing scientific contributions therefrom.(10) In many other fields, from development economics (in which Ford was active) to antibiotics (in which it was not) there have been great activity and consequential results from research in the advanced countries.

It was not in keeping with the aspirations of the developing countries that they should be "derivative cultures", passively enjoying the benefits of knowledge from elsewhere. As Indira Gandhi told the AAAS in 1982, "India is just too vast to be bailed out by any country or group of countries. . . for India, science is essential for development and no less for the intellectual self-reliance and creativity of our people."(11)

Countries much smaller were hardly less determined to build their own scientific resources (as we have seen for the African universities) and wanted to participate in the world endeavour in the advancement of scientific knowledge. Development thus required the building of indigenous capacities as well as the advancement of knowledge. Respect for sovereignty and national particularities made development programmes overwhelmingly national programmes, a pattern in which we have seen the Ford Foundation enthusiastically joining. There were however, evident commonalities of need that respected no bounds of sovereignty. Warren Weaver and George Harrar of the Rockefeller Foundation asserted, following Asian visits in 1952 and 1953 that "many of the fundamental physiological, biochemical and genetic problems are essentially independent of geography, and they are certainly independent of political boundaries."(12) They thought an international institute the most promising way to attack such problems, but were disappointed in the response they got from the relevant countries in Asia.

The idea did not die, however, and for the next two decades the Ford and Rockefeller foundations explored many possibilities of international institutes, not only in agriculture, but in various other fields as well. In a period when their resources were burgeoning, they were undeterred by the reluctance of developing countries to support international institutes outside their own territories. The foundations were ready to go ahead alone, and they did.

The establishment of the first international agricultural research institutes was a kind of heresy in the doctrines of development co-operation. They did not respond directly to the development plans of particular developing nations and ultimate control was kept insulated from any one of them. They came into being because leaders of the Rockefeller and Ford foundations saw an opportunity to produce a major leap in agricultural

productivity through such institutions that they thought would not otherwise happen as quickly.

When Frosty Hill put his mind to guiding the Ford Foundation's overseas development programmes, he did so not simply as the senior responsible executive. He had devoted most of his professional life to agriculture and he began to act as the foundation's principal agricultural specialist. As we have seen, he was very skeptical of the promise of the efforts he found the foundation making when he became vice-president in charge of the overseas development programs in 1955. He talked endlessly to his colleagues about the history and conditions of increases in agricultural productivity, rode back and forth from suburban Scarsdale talking with George Harrar on the same theme, and set his own hand to writing papers. He was wonderfully obsessed with the subject, tirelessly instructing his colleagues on the achievements of the Rockefeller programmes on wheat and maize in Mexico and the possibility of a similar breakthrough in rice productivity. As he loved to recite, the basic science and technology for a major improvement in rice was known but yet unapplied to the varieties of rice grown in tropical areas. In a paper modestly entitled "Notes on Agricultural Development" (13), he surveyed the many requisites for such development, argued that not all factors were equally limiting and stressed the need for improved production technology. The key to substantial yield increases was improved technology which would not come about quickly without special institutions devoted to finding them. International institutes should be a "supplement and not a substitute for research institutions and experiment stations in the developing countries"; their attraction was that they could speed things up and perhaps save as much as 15 to 25 years. By 1958 there was agreement with Rockefeller to move ahead to the establishment of the International Rice Research Institute (IRRI) which came about in 1960, Ford supplying the capital, Rockefeller much of the scientific staff and recurrent costs.

IRRI was an institution of sharply defined purpose, devoted to a single crop and established on a scale that was known to be necessary if results were to be attained in a finite time. Peter Jennings, one of those present at the creation, has protested about the "overtones of magic or miracles" that many heard in the "Green Revolution". What in fact happened, he has argued, was simply "the modification and application of accumulated information developed over past decades in North America, Europe, and Japan to cereal production in the developing countries".(14) There was in fact little confidence that useful results would be achieved as rapidly as they came from IRRI. Frosty Hill liked to warn his colleagues and trustees that the foundation had started something that it would have to be with for a long pull—three cycles of seven years, for a total of 21 years was his usual formula. But the confidence that the international institute pattern was the right one to follow did not await happy results from IRRI. Before its success was assured, there was planning for other institutes in different regions of the world, including the transformation of the Rockefeller Mexican programme into the Centro Internacional de Majoramiento de Maíz y Trigo (CIMMYT).

The International Institute of Tropical Agriculture (IITA) was to be the African institute in this array. It was first proposed to the Ford Foundation's trustees in 1963 following much staff discussion in the two foundations and a visit by Hill, Will Myers and Richard Bradfield to Nigeria.(15) Its initial conception, in contrast to IRRI, was remarkably broad. In a letter to the Ford

Foundation representative in Nigeria, Hill wrote, "I would think of it as the kind of institution that would be qualified to tackle almost any agricultural research problem, whether basic or applied."(16) But there was a special emphasis put on the need for better systems of managing tropical soils, seeking replacement of the system of shifting cultivation that was becoming more and more inadequate as population pressure on the land grew. In a set of notes for discussions with the Rockefeller staff, Hill put this research subject first, but also included plant protection, plant breeding, agricultural economics, and even work on commercial crops "on important problems if financed from non-Rockefeller Foundaton or Ford Foundation sources." The Institute was also to engage in graduate training and extension, and to act as a "regional catalyst and clearing house."

A research focus on the management of tropical soils was a very different mission from the crop research that had been successful in Mexico and looked ready for successes at IRRI. If successes in rice research were fruits ripe to be plucked, it was by no means obvious that early successes in better management of tropical soils were possible. Indeed, Hill thought that "relatively little reliable information" was available on the subject (17) and this was hardly comparable with the fund of knowledge brought to the establishment of IRRI. The fact that the foundations went ahead, with the Ford Foundation ultimately committing about $17 million to the capital costs of the IITA—more than twice the amount it had committed to IRRI—evidently represented faith in the general vision of international institutes, and the need for an African member in the network.

It took most of the decade of the 1960s to bring IITA into being at Ibadan in Nigeria. With delays, caused in part by the civil war, the research programme began in 1970 and construction was completed in 1972. At an early point it had been decided to extend the research agenda into research on grain legumes and root and tuber crops and to make the institute serve as a regional relay station for IRRI and CIMMYT on cereals, work that has continued to the present along with research on soil management and farming systems.

The location of IITA at Ibadan has been much criticised, on scientific and other grounds. It was a choice strongly influenced by the foundations' concern for proximity to a leading African university. Both Ford and Rockefeller were heavily engaged at the time in the development of the University of Ibadan, as we have noted. While they were basically concerned that IITA have autonomy in its research programme and staffing, they also wanted it to serve for the development of African capacities and to become effectively related to national research and extension programmes. The importance of these interests was such that from original conception IITA was to be "a quasi-independent institute within the University" (the University of Ibadan) (18) and no alternative site was seriously considered.

The initial concerns with training and relations with national research systems have persisted. As IITA came into operation, a new Ford Foundation representative for West Africa, fresh from successes with the Green Revolution in Pakistan, vigorously promoted programmes of outreach and training, in actions which have been extended in later years to other parts of the continent. After the initial expenditures, it is fair to say that Ford was as much concerned with these outreach and training activities as with the development of IITA itself.

This is not the author nor the place for a serious assessment of IITA's accomplishments. The initial vision of better management of Africa's soils has proven hard to realise, as one of IITA's own staffers has recently written:

> With regard to land and water management, improved systems in the humid tropics—light clearing, *in situ* burning, and intensive use of surface mulch in combination with herbicides and minimum or zero tillage—which are being developed by IITA have yet to prove effective in on-farm testing. Moreover, chemical weed control methods and small scale equipment for use in low tillage systems poses more immediate research problems.(19)

In crop research, there has certainly been progress in finding improved varieties amid complex disease and other problems and achieving dissemination of some of these, but the merits of IITA's establishment are perhaps less fairly judged by its slow progress amid the notorious difficulties of African agriculture than in significance this institute (along with the rest of the CGIAR network in Africa) have come to have over the weakness of the national research systems in the continent. It is hard to believe that comparable investments in national research systems would have brought us farther. IITA and its sister institutes have been shielded from the economic and other difficulties that have beset national institutions. They continue through the present crisis to preserve germ plasm and to pursue their research.

The history of the efforts of the Ford and Rockefeller foundations to cope with the problems of African agriculture through international institutes may thus be seen as grounded in a faith in the institutional conception, a faith perhaps more rewarded by unanticipated benefits than by their concrete research results thus far. IITA's history shows that single-minded pursuit of research results was by no means its sole purpose; the early emphases on its roles in training and in relations to national systems of research stand out in the records. The balancing of these purposes always presents problems and they may have been particularly difficult for the Ford Foundation, given the general character of its overseas development programmes.

Ford's commitment to the international institutes came in the course of internal debates that reached a bitter climax in a conference in Mexico City in 1964, where the advocates of "extension" were pitted against the advocates of "research". Hill's paper for that meeting was carefully crafted to advance the case for research while honoring the arguments of the opposition. Most of the foundation's overseas staff at the time were earnestly engaged in building national capacities, with Ensminger, as usual, in the lead with a $10 million Intensive Agricultural Districts Program in India. Hill had the support of the foundation's president, Henry Heald, who thought the foundation had gotten hold of the wrong end of the stick and should have devoted itself, like Rockefeller, more to research than to getting itself enmeshed in the morasses of application.(20) Headquarters prevailed and there was increasing attention to research for better production technology, but the concern with building national competencies remained and it seems evident that the conceptions for IITA as a pivot for training and extension were influenced by it. Critics of IITA's Ibadan location would say that it was excessively influenced by these concerns through the desire to be linked to the University of Ibadan.

The shape of Ford's internal debate between "extension" and "research" focused strongly on the prospects of marginal gains versus quantum leaps in agricultural productivity. The advocates of research at Mexico City leaning heavily on some of David Hopper's research in India, thought it bootless to seek large improvements from steady marginal gains through "extension"; technological breakthroughs such as those that IRRI was producing were needed. This point of view was common at the time, a forceful expression of it being given by Peter Jennings in the address already cited:

> Once a breeding team has accepted increased yield potential as the prime objective, it is imperative that it set high goals. Gains in productivity of 100 percent are reasonable for all food crops in the tropics. We must seek quantum jumps in productivity and not be content with a cumulative series of minor improvements. . .There is no more prospect of moving agriculture in marginal areas with 10 percent gains in productivity than there is for favored areas.(21)

Even allowing for the inflated optimism that marks new beginnings, one might fairly ask if such criteria had been rigorously followed, would IITA and some other of the CGIAR institutes have been established? In fact, the course of their development was less determined by hard-headed assessments of promise of early results than by identification of fundamental problems and faith in an institutional pattern. The successes in the Green Revolution bolstered faith in the pattern, and there has been recurrent perception that "something must be done" about even apparently intractable problems. One reads, for example, in the World Bank's "Toward Sustained Development in Sub-Saharan Africa":

> More attention is needed to the whole system of farming and to the sustainability of the land itself . . . the adaptation of existing technology will not by itself be enough, especially in the dry areas. Major research is needed on new crop varieties, techniques for soil moisture conservation, land use, livestock diseases and systems, and agroforestry. . .(22)

This nearly two decades after IITA (and others in the CGIAR system) were established. One must assume, then as now, the evident need for better technologies leads to efforts, whether or not the existing state of knowledge promises early results. The faith that a quantum leap in productivity was needed and that it could only come through research was enough to persuade Ford and Rockefeller to tackle the management of tropical soils through IITA. IRRI and CIMMYT were not in fact models closely imitated by IITA, as an early reviewer regretted.(23) It became a rather different sort of venture and the last that the foundations took on alone.

The two foundations had in fact hoped that they could persuade USAID to undertake the capital costs of IITA and they made unsuccessful overtures to that end. Both were facing the serious reduction in resources described earlier for the Ford Foundation. Both had large and experienced international staffs in the 1960s which they reduced quite sharply (and painfully) in the 1970s and early 1980s. Conscious that they could no longer go it alone in the building of major international institutions, the foundations sought to use their

professional expertise and non-political neutrality in the mobilisation of other resources.

Foundation staff regularly served on the boards of the CGIAR institutes (Hill was, at different times, IITA's and IRRI's chairman), while Hill, David Bell, and Lowell Hardin played very active roles in the meetings of CGIAR and the development of its policies. There was much discussion of the appropriateness of these roles when Ford was bringing "smaller and smaller piles of chips to the table". As its resources diminished in the 1970s, Ford felt compelled to reduce its staff in reasonably close proportion to the budget reductions it had had to make, but it sought to maintain its capacities for participation in these international councils. A determination to keep as much as possible of its work in food and agriculture eased decline in these subjects, however, and Ford's own programes and its role in CGIAR affairs did not suffer as much as in fields like university development.

Conclusion

In current discussions of the state of African institutions, one frequently hears regrets that the 1970s brought a lapse in the institution building efforts of international assistance. The then prevailing emphases on basic needs and new directions are frequently blamed, with some justification. But as for the foundations, the relative diminution of their resources was a powerful influence. Even in the sanguine years of their strength in the first half of the 1960s when institution building was the dominant interest, there was consciousness of limitations. When IITA was first put to Ford's trustees in December 1963, the discussion paper stated firmly:

> "It is clear that the less-developed countries will have to establish, staff, and finance their own agricultural education, research and extension organizations. The job is much too big to be done from the outside even if this were desirable and politically feasible".(24)

Later, erosion of resources brought even more modesty. The attractions of international institutes remained strong well beyond the agricultural fields where they have had their great flowering. Several explorations were made during the 1970s of possible institutes in such fields as international economics, human rights and refugee problems, but with growing caution. The revival of foundation resources in the bull markets of the 1980s has given hopes of revived ambitions for coping with the expensive and demanding efforts of institution-building—national and international. With the rising concerns over the state of African universities and research services, one may hope that they may attract renewed attention.

Notes

(1) Lord Hailey (1957) *An African Survey*. Oxford University Press, pp. 1614.

(2) Account based on oral histories of both men in the Ford Foundation Archives and on personal observation.

(3) (1973) Figures from Ford Foundation annual reports, the Statistical Abstract of the United States, and Mahdi Elmanjra, *The United Nations System: An Analysis*: London (Faber and Faber) 1973, pp. 228–229.

(4) Cf. *Hill's Oral History*; Ford Foundation Archives.

(5) Cf. I.M.D. Little (1964) *Aid to Africa/An Appraisal of U.K. Policy for Aid to Africa South of the Sahara*, London and New York (Pergamon and Macmillan). Address by Prof. E.O. Edwards (1967) *Kenya Ministry of Economic Planning and Development*, pp. 54–62 in *Report/Conference on the University of East Africa*, Nairobi, October 23–26, where Edwards points to the need to increase Kenya's overseas supply of engineers, architects, agronomists, accountants and physicians. As to trained Kenyans, he points out projections of surplus in people trained in pure science and shortages in medicine and engineering. In a parallel report for Uganda, Nicholas Bennett noted a projected surplus of 100 agronomists, 370 scientists, and shortages of 70 doctors and 40 surveyors by 1976 (ibid pp. 67 and table pp. 71)

(6) *(1966) Research Services in East Africa*. Compiled for the East African Academy, Nairobi (East African Publishing House), pp. 8.

(7) Cf. Hailey, op. cit. p. 1603.

(8) Hill to Bell David E. and Hardin Lowell S. (1971) *Agricultural Research in French Speaking Africa*, Sept. 27. Report No. 009608, Ford Foundation Archives.

(9) Report cited in note 5, at pp. 42-43.

(10) Cf. Greep Roy O., et al., (1976) *Reproduction and Human Welfare/A Challenge to Research*, Cambridge, Mass (MIT Press).

(11) *Science*. (1982) v. 217, 10 September, pp. 1088.

(12) Cited in CGIAR 1985 *Annual Report*, (1985) pp. 2, in a summary of Warren Baum's Partners Against Hunger (The World Bank) 1986, where the quotation appears at p. 13.

(13) Hill, (1964) *Notes on Agricultural Development*, Report No. 002850, Ford Foundation Archives: this version for the Mexico City conference, Sept. 4–9.

(14) Science, (1974) 20 December, v. 186, pp. 1085.

(15) Hill to Heaps, August 1, (1963) *Discussion Notes, Institute of Tropical Agriculture* in Ford Foundation. Hill papers, Box 6833, Ford Foundation Archives. Cf. also (1963) *Discussion Paper: Overseas Development Program: Proposal for an International Institute of Tropical Agriculture Located in Africa*, December. Report No. 002859.

(16) Hill to Heaps, loc. cit.

(17) Hill's *Discussion Notes*.

(18) Hill to Heaps.

(19) Dunstan S.C. Spencer in Berg Robert J. and Whitaker Jennifer Seymour , eds., *Strategies for African Development*, Berkeley (University of California) pp. 223.

(20) Heald *Henry Oral History*. Ford Foundation Archives.

(21) Jennings, op. cit, pp. 1088.

(22) World Bank, (1984), pp. 32.

(23) Ruttan Vernon (1971) in *Nigerian Trip Report*. Cf. Hardin to Bell, 23 August 1971, transmitting July 22, 1971 Ruttan letter and report. In grant file, 68–797, Ford Foundation Archives.

(24) Discussion paper cited in note above, pp. 5.

SUSTAINABLE AGRICULTURE: AN ETHIOPIAN VIEW

*Haile Lul Tebicke**

It has been argued that the current food crisis in Ethiopia is only a foretaste of far more catastrophic ones that lie ahead. Although the devastating famine was occasioned by very poor rainfall in successive crop seasons during 1982–1984, drought is only one of the factors that have contributed to an alarming downward spiral in Ethiopian agricultural productivity, just at a time when the country's agricultural output must drastically increase if its population is to survive.

The prolonged droughts of the current period repeat a pattern last seen during 1972–1973, in which drought was followed by shortfalls in domestic food production, with tragic consequences for people and livestock. But the falling levels of average annual rainfall have combined with rapidly expanding land degradation to quicken the decrease in agricultural productivity. To avert even more disastrous shortfalls in the future, Ethiopian agriculture must pass through a rapid transition, arresting and reversing such degradation while raising productivity toward a sustainable mode.

This is a formidable, though not impossible, task. In its report, *Guideline on the Economic and Social Development of Ethiopia* (1984/1985–1993/1994), the Ethiopian government expressed its commitment to many of the principles necessary to achieve such a turnaround.(1)

Agriculture has always been the mainstay of Ethiopia's society and economy, and all projects indicate that it will retain this dominance in the foreseeable future. Until recently, Ethiopian agriculture met all the food needs of the population—albeit at a subsistence level. Agriculture provides very nearly half of the gross domestic product and almost all export earnings. Almost 90 percent of the population, revealed by the 1984 census at 42 million (20 percent more than estimated), lives in rural areas, wresting a precarious livelihood from crop cultivation and/or keeping livestock. Livestock are a dominant feature of both crop cultivation and pastoral agriculture, as well as the principal rural means of acquiring and holding wealth. Pack animals are the main means of rural transport.

In the early 1970s, ecologist Leslie H. Brown categorised the land resources of Ethiopia's 1.2 million square kilometers in the following way:

- Lowlands receiving less than the 700 millimeters of annual rainfall deemed necessary for crop cultivation constituted 48 percent of the land area. These lands were suited only for keeping livestock, and many of them only marginally.

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- Five percent of the land has high mountains, cliffs, or gorges, mainly in the north. Some of this land, though fertile, was already densely inhabited and overused.
- Steep, eroded slopes in need of reforestation constitute 15.8 percent of the territory.
- Brown classified 31.2 percent of the land, the gently rolling plateaus, as potentially good crop land. Presumably included in this category, however, was the small area of existing natural forest; the actual area under crops at the time totaled only 7.8 percent.(2)

A decade later, in 1984, a UN Food and Agriculture Organization (FAO)-assisted survey of land use, using satellite imagery and ground checks, reported patterns of land use roughly conforming to Brown's earlier analysis:

- 51 percent is being used for livestock grazing.
- 14.7 percent is under rain-fed crop cultivation, with about half actually under crops at any one time, while the rest is fallow.
- 11.7 percent is under woody vegetation, of which about one-third is natural forest.
- 3.8 percent, though potential fertile, is unproductive.
- 18.67 percent is unusable.(3)

Added to the constraints of available land resources is the problem of rainfall, which varies widely from year to year, especially in the semi-arid lowlands. Studies over the past three decades show a drop in average annual rainfall in some locations of as much as 50 percent in the mid-1970s. A rising rainfall trend in the late 1970s was interrupted by the drought of 1983–1984. Prolonged drought is thus a recurrent but unpredictable hazard. Technologies which have proved effective in mitigating the effects of drought have yet to be extensively applied in Ethiopia, although the frequency and severity of drought have been rapidly increasing during the past few decades.

By far the most alarming problem for Ethiopian agriculture, however, is the rapid spread of wind and water erosion, from which no part of the country is safe. Topsoil from the barren surfaces of over-grazed pastures and farm fields is easily blown away by whirlwinds common in the dry season, and the damage is compounded by the heavy rainfalls which end the dry season. In these downpours, large raindrops pit the barren ground surface, loosening topsoil and carrying it down the slopes. In March 1981, for instance, the long dry spell was ended at Alemaya by a deluge of 39.4 millimeters of rain during a 10-hour period. In that single rainstorm, land with a slope of 3 to 6 percent lost 3 to 3.5 centimeters of topsoil. This represents about 500 tons of topsoil per hectare, or 40 times the maximum tolerable soil loss rate per year.

This high erosion rate is ruining the agricultural base. Lester R. Brown cites a late 1970s estimate that over one billion tons of topsoil flow from Ethiopia's highlands each year. The cost of fertiliser to replace the soil nutrients eroded away in one crop season alone would exceed $1 billion. (4)

The most important factor in preventing soil erosion is the infiltration of precipitation into soil. The fibrous root systems of grasses hold soil intact, while the upper parts of the plants protect the soil surface from the impact of falling raindrops or drippings from trees. This is evident in the hilly pasturelands in parts of Bale and Sidamo in the south and southwest, where

rainfall is high but good and adequate year-round grass cover protects the land from erosion.

Soil conservation measures are now being extensively promoted in north and east Ethiopia, where severe erosion has turned once-fertile plateaus into wastelands of deep gorges and boulder-strewn hillsides, interspersed with remnants of good farmland. There is little evidence of soil conservation practices in other parts of the country, where erosion damage has not yet reached catastrophic levels.

The FAO-assisted land use planning report concludes that over-grazing by excessive livestock populations is a primary cause of land degradation and warns that unless grazing is controlled and vegetation is permitted to regenerate periodically to cover the ground surface, it would be impossible to arrest land degradation.

Ethiopia is said to have the largest number of livestock in Africa, although it ranks ninth in territorial size. There are believed to be 27 million cattle, 42 million sheep and goats, seven million equines, a million camels, and over 50 million poultry. Most of these livestock are to be found in the cultivated highlands, though this represents only about a quarter of the area utilized for livestock rearing. The highlands are heavily populated with both livestock and humans—peasants who are carrying out subsistence production primarily to meet their own immediate needs.

These farmers use oxen to cultivate land and thresh crops and pack animals for transport. Meat and products such as milk and butter are a source of cash income, and livestock serve as a hedge against destitution during drought, since animals survive longer than crops when rains fail, and they may be driven to areas where pasture and water are available. Furthermore, livestock enable their owners to derive private benefit from communally owned grazing lands.

The livestock offtake rate in Ethiopia, at 7.5 percent, is low compared to 11 percent for Africa as a whole and 42 percent for Australia, since the majority of cattle are kept long beyond their productive age. Livestock density is high in relation to feed resources; consequently, the competition for land is keen between livestock and crops, especially in the valley bottoms—prime croplands which are often reserved as the most dependable grazing sites in the long dry seasons.

Another FAO study indicates that Ethiopia will be able to feed only 36 percent of its population by the year 2000 if current agricultural practices—using traditional crop varieties and cropping patterns, without fertilisers, pesticides, or long term conservation measures—are continued.(5) This estimate should be revised downward to at most 25 percent, since the study was based on population projections before the 1984 census, in line with which the year 2000 projections should be raised 20 percent.

In other respects, the estimate is based on ideal, and in some ways impossible, conditions. It does not take into account the possibility of drought, and its assumes that all potentially cultivable land would be used to grow nothing but food crops. Land under food crops would therefore need to be expanded at a steady rate of 1 percent, or 1.25 million hectares, per year. Not only is such an unprecedented rate of expansion of questionable feasibility, but it would also mean that the 11.7 percent of total land now under woody vegetation, including the residual area under natural forest, would have to be cleared to grow food crops.

Even now peasants are presumably expanding the land they plow in order to meet their own increasing needs. This is done by decreasing the proportion of land left fallow to recuperate fertility, and by plowing terrain which formerly had been left uncultivated because of its steep slope, poor soil quality, or inadequate rainfall.

These traditional ways of expanding cropland eventually become counterproductive, however, as the land brought into use is likely to be at the lower end of the yield range, and the fertility of existing land is depleted by overuse. Erosion on such land is likely to be severe, with even further lowering of the yield, lading into a vicious downward spiral as more land is plowed, with lower yield per hectare, and faster soil erosion.

Moreover, some cultivable areas must be set aside for crops other than food grains, such as vegetables, fruits, fibre, and forestry as well as for export crops to earn foreign exchange. Such crops now account for more than a quarter of the harvested area, and their share is rising.

These discouraging projections, however, are based on current practices. An alternative strategy which the FAO examined would call for the intermediate level of inputs, in the form of fertilisers, chemicals, and improved seeds, with simple conservation measures that would cut land degradation by half. The FAO recommends continuing present crop mixes on one half of the land, and using the most productive crop mix on the other half. With these measures, the FAO study predicts that Ethiopia could meet all its food needs by the year 2000.(6) Some formidable technical obstacles, however, need to be overcome to meet this goal.

Ethiopia now has no domestic sources of chemical fertilisers or biocides. The cost of either importing three million tons of fertiliser or building the plants to manufacture it would have to be met out of foreign exchange earned from the export of agricultural commodities or processed agricultural products. In the latter case, adequate domestic supplies of raw materials and energy would also have to be assured. Distribution of these chemicals would occasion further costs.

To help the peasants make optimal use of yield-increasing measures, an efficient agricultural extension network, backed by an research system, must be capable of delivering well-tested, site-specific recommendations.
Until recently, the extension system had a field work force of only 2,400; even at the now standard rate of one extension worker per 150 square kilometers of land area accessible by all-weather road, the work force should number 6,700 to cover the productively utilisable land area.

Even this may not be enough. Leslie H. Brown had indicted that an extension worker could keep visiting 100 rural families "often enough in a year to maintain their interest" and teach them the basic steps of soil conservation and yield increase. Assuming the 90 percent of the 37.25 million rural inhabitants are crop cultivators, and extension work force of about 70,000 would be needed to meet this standard.

The link between the extension network and the agricultural research system has long been weak. The emphasis in agricultural research at present is largely on genetic and soil fertility improvements, both of which require measures that are technology and capital intensive. Little work is being done in labor-intensive, low-capital technologies such as improved agronomic practices and moisture conservation techniques, which are much more critical than plant nutrients in medium to low rainfall agriculture. The FAO-assisted land use

study points out, for instance, that fertiliser application of more than 60 kilogrammes per hectare had not increased yields where rainfall was less than 600 millimeters annually.

The present emphasis on plant genetics is likely to pay dividends ultimately and deserves sustained support. The generation of an uninterrupted succession of improved crop varieties over time can be assured only from an adequately supported research capacity, the building of which requires a long lead time.

The more urgent requirement, however, is for technologies to support the transition to sustainable agriculture. Topsoil depletion, now rampant almost everywhere in Ethiopia, is a primary threat to agricultural productivity and is destroying the life-supporting potential of the environment in the foreseeable future. Unquestionably, the highest priority should be the rapid reduction of the rate of soil erosion everywhere, but most urgently where erosion damage has not yet reached catastrophic proportions.

This change would pay immediate dividends in increased agricultural productivity. Reducing erosion overall would reduce the pressure on the peasants to increase crop yields by plowing marginal lands and allowing less land to lie fallow—practices which bring short-term increases but contribute to the erosion cycle.

No-tillage crop cultivation is one intermediate technique that has yet to be given serious consideration and adaptation trials in Ethiopia. Bede N. Okigbo, at the International Institute of Tropical Agriculture in Nigeria, reports no-tillage cultivation to be a very suitable method of erosion prevention in the highly erodible alfisols of southern Nigera.(7)

Leaving residues from the preceding crop on the fields protects the soil, especially in the early period after seeding, when the crop canopy is still developing. According to Okigbo, this practice also "reduces energy requirements, enhances timely planting and flexibility of operations, reduces investment in machinery, enhances water infiltration and effectiveness, and encourages microbial activities with favorable effects on soil aggregate formation." Only four to six tons of plant residue per hectare are required, and crops can be grown on slopes of up to 15 percent without any significant erosion risk. An eight-year study reports crop yields as good as, or better than, with conventional tillage—and with significantly lower runoff and erosion.

As well as improving conservation, and important side benefit of the adoption of no-tillage farming techniques in steep gradient farmlands would be the reduction of the number of oxen needed to work the land. This could trigger a chain reaction of mutually reinforcing benefits:

- Cattle would not be kept to the advanced age typical of those used in tillage, with a consequent improvement in cattle products such as meat and hides and in their market value.
- Fewer cattle would mean less overgrazing in the dry season.
- Fertile bottomlands now traditionally reserved for pasture could be available for crops, and steeper gradient uplands could revert to pasture.
- A final benefit would be the capacity to plant crops immediately at the onset of the rainy season, without costly mechanisation. When tillage depends on cattle that are debilitated by poor fodder and lack of water during the long dry season, the animals need time to recover strength for plowing at the beginning of the rainy season.

All these would be greatly beneficial to Ethiopia, especially where steep gradient land is being extensively cultivated. But, as Okigbo stresses, conservation practices and productivity increase would be further enhanced by the development and adaptation of site-specific, scale-neutral technologies involving mechanical, chemical, and biological resources which peasants can afford to own or hire, use, and repair themselves. Ethiopian research capacity in farming systems engineering is, however, still at a very early stage of development.

Further gains may also be derived from applied forestry research. Reforestation is currently being promoted largely by the customary method of raising tree seedlings in nurseries and transplanting them in the rainy season. The scarcity of water during the dry season means, however, that nurseries must be located near the few streams that have year-round water flow. The seedlings must them be transported appreciable distance to the reforestation sites, with commensurate risk of deterioration, and the transplanting must take place when rural families are busiest with other planting.(8) Forestry research, therefore, should be directed to finding alternative methods of reforestation that would not require seedlings.

A successful reforestation program would enhance the pace of restoring plant cover in vast areas that are now severely eroded and would make possible the extension of soil and water conservation to these now terminally deteriorating areas. At the same time, it would add to the rapidly dwindling stocks from which fuelwood, timber, and other wood products are currently being drawn. If effective alternatives to the costly and slow process of reforestation via seedlings are not adopted, there can be no doubt that even residual forests will disappear entirely before the end of the century, with disastrous consequences for the environment and Ethiopian people.

The transition form the prevalent pattern of low-productivity agricultural practices must be set in motion with the greatest urgency. While only a few measures needed to effect the transition to long-term sustainable agriculture have been mentioned above, the benefits to be derived from the adoption of such measures are immense and would be immediately discernible.

The Ethiopian government, in its guidelines for development, has expressed its commitment to explore, develop, rationally utilise, and conserve the country's natural resources. Such a commitment must be sustained over the coming years in order to arrest the downward spiral of agricultural productivity now seen in peasant attempts to expand local agricultural output with current practices and patterns. There is no rational substitute for conservation as a strategy for national survival.

Notes

(1) Workers Party of Ethiopia (1984) *Guideline on the Economic and Social Development of Ethiopia* (1984/1985–1993/1994). Addis Ababa: Workers Party of Ethiopia.

(2) Brown Leslie H. (1973) *Conservation for Survival, Ethiopia's Choice.* Addis Ababa: HSIU Press.

(3) Nair K.N.N.S. (1984) *Economic Analysis of Land Use.* Assistance to Land Use Planning, Ethiopia. Rome: UNDP/FAO.

(4) Brown Lester R. (1981) *Building a Sustainable Society.* New York: W.M. Norton and Co., pp. 20.

(5) Harrison P. (1984) *Land and People: a New Framework for the Food Security Equation.* CERES, vol. 17, no. 2, (March-April 1984) pp. 25.

(6) *Ibid.*

(7) Okigbo B.N. (1981) *Alternatives to Shifting Cultivation.* CERES, vol. 14, no. 6, (Novemeber–December 1981). pp. 41.

(8) Mrema G.C. (1985) *Utilization of Bioenergy Resources: A Case Study of Tanzania.* Paper presented at the World Resources Institute/Rockefeller Brothers Fund Symposium on Biomass Energy Systems, Airlie, Virginia, 1985.

SUB-SAHARAN AGRICULTURAL RESEARCH

*Montague Yudelman**

As the agrarian crisis in sub-Saharan Africa becomes clear to the rest of the world, so do the urgent needs to identify their causes and to search for agricultural improvements. The magnitude and pervasiveness of the problems have overwhelmed many African countries. Their persistence and intractability have demanded more attention for the development community. And the depth of human suffering has been appalling both in Africa and abroad.

No existing analogies describe these conditions, no adequate perspectives or mental constructs help us to understand them, and no current development theories offer apparent solutions. Indeed, solving the problems demands far more than the substantial financial resources now pouring into the African continent through a wide range of assistance projects and programs.

Four measures of economic performance in sub-Saharan Africa, drawn from recent World Bank publications, reveal the magnitude of the crises—in real terms, in comparison to other developing regions, and in comparison to its own recent past:

- Per capita food production in that region is declining; in 1983, it was only 79 percent of the 1961-1965 average. Per capita gross national product in 1984 was 11 percent below the 1980 level.(1)
- Food imports are increasing. In 1982,the region imported 9.25 million tons of food—enough to feed one-fifth of the population (or all urban dwellers); this is up from four million tons in 1972.
- Population growth continues unabated. Today, the growth rate is 3.1 percent, up from 2.3 percent in 1963.
- Infant mortality is 50 percent higher in sub-Saharan Africa than elsewhere in the developing world.

The search for viable development initiatives and activities has spawned a prodigious amount of studies and analyses—by concerned African, bilateral, and international organizations. While all studies suffer froma seriously inadequate knowledge base, they tend to agree on a number of research areas that need strengthening.to be sure, not all studies and institutions rank the cause of the current agricultural crises the same: negative international economic trends and deteriorating terms-of-trade for agricultural exports are emphasized as important causal factors by the Organization of African Unity.(2) The World Bank reports criticize domestic governments for failing to

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provide adequate incentives for increasing agricultural production and to manage the agricultural sector adequately.(3)

The International Food Policy Research Institute (IFPRI) argues that massive investment in rural infrastructure and rural institutions must accompany policy reform before agricultural development can succeed. Others point to additional issues inhibiting development, among them the urban bias in African development and development assistance, the failure to transfer agricultural technology from abroad, and the lack of attention to women as producers.

Although their analyses of root causes differ, most experts agree that African agriculture must become more productive. They also agree that this can happen only if there is substantial technological change in the continent's current traditional systems of production—systems that now give the lowest yield per acre and per person among all regions of the world.

Sub-Saharan Africa, more than twice the size of the United States, has a population of around 350 million people. About 70 percent live in rural areas where agriculture is the main source of livelihood. The region is as diverse as any on earth. Ecological systems range from the hot, humid rain forest in the Congo River Basin, to the cool highlands in Kenya and Uganda, to the tall and short grass savannas which grade into the Sahara to the north and the Kalahari and Namib deserts to the southwest. Much of the region has fragile soil and low, infrequent rainfall.

While population density is low—half that of Asia—large areas of land are not suitable for human settlement because of tsetse flies, river blindness, rock outcroppings, and other problems. Nevertheless, there is much potential, which can be realized through research that will enable agriculture to shift from traditional systems to systems based on application of scientific procedures.

The prevailing system of production in much of the region uses very few chemical fertilisers, herbicides, tractors, improved seeds, or other purchased inputs. This system is based on different forms of shifting cultivation; some land is left fallow while crops are rotated from one cultivated area of the next. The fallow period serves many purposes: it restores the land's fertility, limits the potential damage from pests and soil-borne diseases, and provides grazing for livestock. The whole system of shifting cultivation depends on a plentiful supply of land, enabling each family to produce a low level of output. Unfortunately, the very rapid increase in population is reducing the readily usable land available per family. With less land to farm, families are forced to shorten the alternating fallow and production periods, and to move crops into more "hostile" areas. As a consequence, agricultural increase is very low, and degradation of the region's natural resource base is considerable.

In other parts of the world—notably Asia—increasing pressure on the land has been offset by increasing yields through the use of purchased inputs. Asian yields have risen by more than 20 percent in the past decade, as a result of introducing high-yield varieties of seed, an upsurge in fertilizer use, increased reliance on herbicides and pesticides, an ambitious expansion in irrigation, and—as important as all these changes—a variety of more attractive pricing policies.

It was once thought that the Asian technology would be easily transferred to Africa, but it is now clear that this will not happen. The Asian technology relies heavily on irrigation, but Africa is the least irrigated

continent in the world. (Only 3 percent of sub-Saharan production comes from irrigated land.) Also, the high-yield seed varieties were primarily wheat and rice, but the major African crops are maize, sorghum, and millets in the drier areas, and tubers (such as yams and cassava) in the wetter areas. Nonetheless, the success in Asia, stemming as it did from applied agricultural research, is leading to a major effort in agricultural research to generate technologies that can reverse Africa's dismal trends.

Agricultural research in sub-Saharan Africa has been—and continues to be—influenced by the region's colonial heritage. Before World War II, when nearly all the area was in colonial hands, policies and programmes related to agriculture, including research, were formulated by the colonial powers: British, French, Portuguese, Germans, and Belgians. The governing powers generally assumed that there was no need to be unduly concerned about food crops. There was land enough to sustain a slowly increasing populations engaged in traditional subsistence production.

Pressure built, however, for the colonies to increase their exports, to produce low-cost raw materials for the metropolitan powers and to contribute resources toward defraying the costs of colonial administrations. Consequently, the relatively modest efforts that were undertaken in agricultural research focused chiefly on such export crops as coffee, oil palms, and cotton.

After World War II, but before independence, the United Kingdom, France, Belgium, and Portugal wanted to increase the supply of food and export products in their colonies, and to this end they stepped up agricultural research. These four colonial powers established effective regional (multi-country) agricultural programmes—among them, the East African Agriculture and Forestry Research Organization (EAFFRO) based in Muguga in Kenya, the Agricultural Research Council of Central Africa at Salisbury in Southern Rhodesia (Zimbabwe), l'Institut de Recherche Agronomique Tropicale (IRAT) at Bambey, Senegal, and the large national center (INEAC) at Yangambi in the Congo (Zaïre).

These programmes produced useful basic research information on crop agronomy, plant nutrition, and genetic material, information which has since become an essential part of national and international plant-breeding programmes in Africa and elsewhere. For example, millet germ plasm from the EAFFRO program has been used extensively in Africa, and material from Nigeria formed the basis for disease-resistant millet lines released recently by the Indian national programme.

With national independence, many of the regional programmes were discontinued, leaving much weaker overall national efforts in such key areas as food crops. Nevertheless, because many bilateral donors—among them the United States, France, Netherlands, the United Kingdom, and Germany—continued to assist, there was some improvement in food production research, and bodies such as l'Institut de Recherches pour les Huiles et Oléagineux (IRHO) and the Cotton Research Corporation (CRC) continued to support successful research on commercial crops. Most of this research, however, was done by expatriate Europeans. Very few indigenous Africans were involved, though many were being trained under a number of national and local programmes.

The postcolonial period has seen the emergence of more than 40 sovereign countries in sub-Saharan Africa. In some, where the transition to

independence was violent, as in Zaïre and the Portuguese colonies, the local research systems simply collapsed. In others, where the transition was harmonious, the colonial powers provided considerable support for the national systems. Exemplary in this way was the work of the French in aid of their former colonies, such as the Ivory Coast and Cameroon.

Now, however, research efforts throughout sub-Saharan Africa are fragmented; three-quarters of the region's countries, with populations below 10 million, each have their own national systems. Still, over the past 20 years the sustained efforts of national governments and donors to train African agricultural scientists have generated a relatively large supply.

Most of these scientists, however, are inexperienced, and by all accounts the "payoff" from the national programmes has been less than satisfactory. A generally poor research environment and a lack of staff continuity are partly to blame, and many of the national programmes suffer from a lack of cohesion and direction.

It will be some years before the national programmes will be able to make a major contribution to resolving the region's problems, unless they have considerably more technical support and strong leadership. Fortunately, an international effort is afoot to promote agricultural research and thus help resolve some of the region's technical problems, at least during the interim.

Sub-Saharan Africa stands to gain considerably from the most significant and far-reaching postwar program in tropical agricultural research, the International Agricultural Research Center (IARC). Begun by the Rockefeller and Ford Foundations, this programme has profoundly affected agricultural production in Asia. The foundations developed the concept, under which teams of qualified, mostly expatriate scientists would be stationed at centers in Mexico and the Philippines to do agricultural research toward the improvement of varieties of wheat, corn, and rice. These centeres have provided an attractive working environment; they are free of the problems common among developing country bureaucracies, but fulfill the essential requirement that applied agricultural research be carried out where it will be used.

In effect, the two foundations created enclaves where expatriates could work on problems of tropical agriculture with scientific support from the research communities of the United States and Europe. The highly motivated and mission-oriented research in these enclaves produced brilliant results. Researchers such as Norman Borlaug, who received the Nobel Peace Prize for his efforts, were able to draw on intellectual and financial resources that were simply not available to researchers in local national programmes.

The new varieties of wheat and rice produced in these centres are vastly superior to the traditional varieties when used with regulated water supplies and agrochemicals—especially fertilisers. They tend to be photoinsensitive, less susceptible to disease, and unlike traditional varieties, have short, stiff stalks, which prevent them from "lodging", that is, toppling over when carrying a full head of grain. These improvements provided the basis for the "Green Revolution," which helped greatly to allay fears that a Malthusian population crisis would strike Asia during the 1970s.

The initial success of the expatriate enclaves in developing agricultural technologies led to predictable pressures to expand the number of enclaves and to cover other products and agroclimatic zones, including those in Africa. Faced with this challenge, the foundations sought new partners. In 1972, a new

organisation, the Consultative Group for International Agricultural Research (CGIAR) was created under the aegis of the World Bank, (with strong leadership from its president Robert S. McNamara), the Food and Agriculture Organization, and the United Nations Development Program. Managed by the World Bank and supported by 23 governmental and nongovernmental donors, CGIAR now has an annual budget of $180 million. CGIAR supports 13 entities, with the largest contribution—25 percent—coming from the United States, followed by close to 15 percent from the World Bank.

In recent years, pressure within CGIAR has been increasing to do more to address and resolve the growing problems in sub-Saharan Africa. To meet this pressure, CGIAR has been shifting its resources to expand work already underway in Africa. Three of its centres, the International Institute of Tropical Agriculture (IITA), the International Livestock Center for Africa (ILCA), and the International Laboratory for Research on Animal Diseases (ILRAD), plus the West African Rice Development Association (WARDA), a regional programme, are located in Africa while the fifth, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has a comprehensive crop and systems-based co-operative programme closely associated with national systems in the Sahel and Central Africa.

The centres in Kenya and Ethiopia both deal with livestock problems. The former concentrates mainly on field and laboratory work to resolve the debilitating diseases of East Coast fever and animal trypanosomiasis, which keep large parts of otherwise agriculturally fertile areas out of use. ILCA is working on animal nutrition, range management, and sociocultural issues related to livestock production in Africa. WARDA, which conducts rice research in several West African countries, is modeled on a regional concept focusing particularly on rice farming in the varied ecosystems of West Africa.

There are other substantial co-operative efforts between IARCs and national systems. The largest is that mounted by ICRISAT, which seeks to improve the genetic potential of sorghum and millet crops, two important staples in semi-arid Africa, and their management systems. Several other centres, utilising funds from bilateral sources, are mounting efforts on crops as diverse as maize and beans. In total, close to 40 percent of the 700 scientists in the CGIAR system are currently working on Africa-related issues. Future plans call for even greater efforts, with creation of subregional programmes in the semi-arid and subtropical zones. These programmes will focus on improving varieties of drought-resistant crops and food legumes.

Without strong, confident, and efficient national systems, sustained agricultural research progress in Africa will be limited. This is particularly true for the current efforts of the IARCs, where weak national programmes impede the testing and dissemination of technologies. Although many donors, including the World Bank, have attempted to help strengthen national programmes, efforts have been piecemeal and fragmented, often bearing little or no connection to an overall national strategy or plan. While this situation exists, little of lasting value can be done. Furthermore, the problems of institution building require long term commitment by both donor organisations and host countries.

Arguably, however, CGIAR should be more involved while African research institutions are maturing. Such a strategy would be two-pronged: on the one hand, linkages between the national and the international centres would continue to develop. In particular, greater co-operation and exchange

would strengthen the national centres. On the other, given the region's pressing needs, it is important for expatriate scientists in the CGIAR system to be more involved in problem-solving.

To this end, more subregional centres in different climatic zones and many more outreach programmes or networks dealing with particular commodities throughout the region should be created. Thus, the two-pronged approach would call for CGIAR to increase national research capacity—a slow process—while international scientists redouble efforts to modernise African agriculture. Under such an approach, CGIAR would have to develop an "African strategy", and African governments and donors would have to back it.

Notes

(1) World Bank (1981) *Accelerated Development in Sub-Saharan Africa* (Washington, D.C.: World Bank); World Bank (1984) *Toward Sustained Development in Sub-Saharan Africa* (Washington, D.C.: World Bank).

(2) Organization of African Unity (1981) *Lagos Plan of Action for the Economic Development of Africa 1980–2000* (Addis Ababa: Organisation of African Unity).

(3) World Bank, Op, cit.

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