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> Modern science has thus, raised moral issues of profound importance, but it has not, and could not have, made any contributions towards solving them. The most important questions that man must answer are questions on which science has nothing to say.[1]

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[1]Arnold J. Toynbee, A Study of History, (as abridged by D.C. Sommvell) (New York: Dell, 1965), Vol. I, p. 116.

CHAPTER ONE

Science for Development --
A Problem in Search of a Policy

What can United States science aid offer African states confronting the problem of material underdevelopment? Do we understand which elements of the development problem science can best address? Does science offer special answers to the difficult development questions of "how to?" and "which way?" and "with what?" Does the United States possess the capabilities for transferring scientific and research resources to the developing countries of Africa?

For some policy makers the answers to these questions are obvious. For this writer they are not. Science aid is a troubled policy area but one that deserves more attention than it is currently being given within the American aid community. Basic issues of how much we know, what we can do, and what should be done have been ignored in the face of institutional competition and ignorance of our own national interest in this policy area.

Africa is faced with a staggering number of serious development problems. As a continent, material underdevelopment is greater than in any other part of the globe. We cannot, however, begin to meet that situation until we have our own house in order and our priorities straight. Investments in science and research, if they are to reap any benefits for the people of Africa, will need to be of a long term

nature. Science aid can make no impact at all in isolated two year projects, conceptualized and implemented in an ad hoc fashion. More so, than any other development policy area, science requires commitment because it requires time.

A. Science as Knowledge and Science as Public Policy

Americans generally believe themselves to be at the forefront of scientific innovation and technological development. Despite empirical evidence to the contrary, this belief has led to the articulation of the theory that science and technology can solve all serious socio-economic problems, provided that the will and capital exist to apply it. The concept of will is a tricky one. Science itself is not imbued with purpose. In fact according to one respected source, science

> . . . has sought to purge itself of a concern for purpose and values . . . in order to deal more reliably with the study of material phenomena and their causes and effects.
>
> Science has advanced by getting rid of the idea of purpose, except to abstract purposes of advancing truth and knowledge.[2]

Will does not reside in science but rather in the institutions which put it to work. Political leadership in our own era, has chosen to pursue certain scientific goals and not others. And, in the process, to support the development of certain truths over others. In a technical respect, we know better how to destroy populations and the cities they live in than we know how to harness the energy of the sun.

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[2]Don Price, The Scientific Estate, (Cambridge; Harvard University Press, 1965), p. 122 and p. 133.

In the transfer of the theory of the power of science and technology to solve socio-economic problems from America to Third World countries, we often forget to indicate the importance of commitment -- and that which follows -- capital and organization.

The United States did not engage in national science policy making and funding until the Second World War. The development of the atomic weapon is generally regarded to be a watershed in the articulation of science policy. However, not until the conclusion of the war, was a legislative act written and accepted which included the definition of a scientific problem as a matter of public policy. This law, the Atomic Energy Act, states that it is the task of the Atomic Energy Agency to study the forces acting between the particles within the atom's nuclei in order to increase the understanding of them and for the benefit of national security and well being.

By 1975, thirty years later, the majority of committees in the House of Representatives and the Senate deal with matters of science policy and R&D as a routine part of their work.[3] While a good deal of research is of course undertaken by private industry, government policy often encourages investment in research at universities and other research institutions which is of no priority to the industrial science establishment. Public monies fund research which the government judges to be of importance to national security or national welfare. Among industrial countries in general, it has become a matter of course for governments to play a dominant role in the initiating of a major

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[3]Steven Dedijer, "Research Policy and Politics" in Lars Dencik Scientific Research and Politics, (Lund Sweden; Student literature 1969), pp. 84-86.

portion of scientific research. Since industrial countries in turn make up 95 percent of the world's resources invested in scientific research, the direction of global scientific work is in some fashion or other channelled and managed as a part of the public policy of industrial states.

Several important consequences flow from this circumstance. First, and most obvious, the overwhelming control over R&D is lodged in the industrial world. Second, this control is exercised as much by governments as independent corporations or institutes. Third, insofar as LDC's require science for their own development, they are very much dependent upon the public policy decisions of the more developed world. Thus, decisions of political as well as scientific import, guide the research which is available to less developed countries and these political decisions are made in terms of variety of interest groups and objectives reflecting the nature of industrial societies.

Thus, it becomes clear, that in terms of the concept of will, in the first instance, it is the will of the industrial countries which does or does not make scientific resources available to the developing world. There are important obstacles to the application of science to development internal to the societies of Africa but there are much more immediate obstacles to the accomplishment of this task internal to the structure of public policy in the United States.

Without a redirection of public policy and thus capital, science cannot on its own contribute much to development. In spite of the hundreds of books written on the subject, the thousands of studies undertaken, and the millions of dollars spent we basically don't under-

stand how to produce development. We know how to build roads, hospitals, factories. In some instances, we know what to advise and what not to advise concerning specific aspects of the problem of development. Yet, in terms of the overall change in society and the improved economic well being of the population that we generally associate with development, we do not have sufficient understanding of the total process to know which resources, in which quantities, aid human beings in their efforts to improve their lot. South Korea, Taiwan and China stand out as remarkable examples of societies which have made rapid economic progress. But, these countries have not taught us to induce similar progress in dissimilar countries. The knowledge base which exists, in terms of the achievements of science in the Third World, is a part of this context of uncertainty and imperfect data. What answers science might offer to developing countries in Africa is in part a complete mystery. The role it might play as a critical catalyst to development is again an unknown, simply because of the level of material underdevelopment and the consequently low expenditures on R&D.

We know that there is not a direct relationship between political commitment, capital R&D and the benefits which accrue to society. Despite incredible investments in scientific man years and public funds, America is without a cure for cancer. Despite a general increase in public welfare as a result of R&D, we are plagued by the unintended effects of chemical preservatives. Many of our workplaces are unsafe and malnutrition continues to be an important social problem. Still, while we know that science is no god-head and that there is no quick technical fix for the problem of development, the acquisition of basic

knowledge about the natural and human world has greatly aided the development of the U.S. and other industrial states. We do not have an equation for the incorporation of science into African development, but we believe that by the end of this century science and technology could have a significant impact on African development. This will come about when and if industrial countries come to terms with science for development policy as an extension of their own national interest.

B. Random Objectives, Policy, and the National Interest

We have not had in the past, nor do we have in the present, a U.S. science policy related to development issues in LDC's. There is no doubt that the United States is engaged in and supportive of a wide range of activities that concern themselves with science and that these may have an impact on the development of the Third World. However, calling these desperate activities a policy is stretching that word beyond the bounds of common parlance.

A policy, according to a somewhat common but nevertheless illuminating source, is

> a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions.[4]

A policy is, in short, something more than an enumeration of activities one happens to be engaged in. It is in fact a conscious selection process which requires that one have a set of reasons as to why objective X is pursued rather than objective Y. For example, the United

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[4]Webster's Seventh New Collegiate Dictionary.

States clearly has a defense policy. There may be periodic debate on what aspects are more and less important, on the amount of funding particular projects deserve, and so on, but there is no doubt that a definition of what constitutes good policy guides these debates. It is not a bundle of amorphously related activities which for convenience sake are aggregated and called a policy.

The force which has galvanized defense policy and forged a common perspective on the problems it addresses is that overworked concept of the national interest. In the case of foreign policy, the national interest is among other things a shorthanded expression for policy which is important enough to the state that common objectives can be agreed upon. Because the national interests at issue are clearer in the case of national security and defense, policy is more coherent than in a myriad of economic development policies which the United States pursues in the international environment. It is difficult to clarify and justify American national interest in something which does not appear to directly link into American well-being. It may not be immediately apparent why research in Zaire on tropical insects or a training program in Upper Volta on cattle diseases is important to the United States. It is difficult to justify policy when it concerns more directly the welfare in far removed and exotic parts of the world. It is difficult to justify policy when returns whatever they might be are not immediate. These are the problems a policy of science for development presents.

While defense policy is the best example of foreign policy which is clearly coordinated and coherent, and which clearly addresses the national interest, most other types of foreign policy fall somewhere in between that type of coherence and the confusion and ambiguous nature of science for

development policy. In foreign affairs the distinctive difference between a policy which helps shape and determine action and a set of ad hoc activities lies in the manner in which a policy relates to the national interest. In many cases this is a matter of competing interests settling upon such an understanding. The consequences in terms of public policy and funding are serious. When a policy on a given subject has been explained according to some understanding of the national interest, it provides a basis for purposeful government action, the mobilization of private and public resources.

If one agrees that the need for knowledge as it pertains to the development of Africa is both vast and urgent, then the mobilization of American science also becomes urgent. The precondition for such a mobilization appears to be a redefinition of national interest so as to be inclusive of such a commitment. We need now to discuss how the existing patchwork of private and public activities currently going on in the area of science and development can be rationalized and reorganized according to such a redefinition.

A coherent and well organized science for development policy is in the American national interest for a number of reasons. It would allow us to encourage the growth of international science, to open and maintain markets, to secure access to raw materials, to anticipate serious global resource and environmental crises, to participate in the creation of greater global welfare, and to assure a stable international system. Thus, while a science for development policy would without a doubt contribute, over time, to the creation of the foundations of self-sustaining development in the Third World, it would also aid in the creation of the international foundations for our own continued economic growth and national security.

Scientific knowledge, research, and information management is already to a considerable extent internationalized. Our own scientific capabilities have been directly supported by the growth of science in other parts of the globe. It has been in the past in the interest of the United States to promote international competition and cooperation in science because it is productive of creative science and in the long run, of increases in our own national scientific capabilities. Countries such as Sweden and Canada have for the past decade directed larger portions of their aid programs to investments in scientific research in developing countries than the U.S. If the United States and its scientific establishment wish to remain at the forefront of this scientific endeavor, they need also to begin to perceive the Third World as a place where pioneering efforts in research and development will reap real gains in the advancement of science itself.

Scientific research which addresses the economic development problems of less developed countries and in the process helps to create the basis for self-sustaining growth in these countries is also in the economic interests of the United States. The U.S. economy is dependent upon the accelerated availability of overseas markets and stable international trade for its own ongoing growth and development. Markets for U.S. goods and services in less developed countries will only increase at a reasonable rate if the overall development of LDC's moves into sustained growth in the decades to come. While it is demonstrably true that in 1978 most U.S. trade is with other industrialized countries, it is also the case that most economists believe that new markets in LDC's will become increasingly important to our growth in the years to come.

Furthermore, predictability in international trade and production patterns is linked in a fundamental respect to the overall economic development of both industrial and nonindustrial states. Stagnating Third World economies will not assure the United States of the trade relations it needs to maintain its own standard of national welfare. Science for development constitutes a long-term investment policy for the development of an international economic structure which is supportive of the continued stability and growth of the U.S. economy.

Research into the problems of energy resources and the frugal use of nonrenewable raw materials is also central to U.S. national interests. The development of new sources of energy and raw materials, their equitable distribution, and conservation of their use is a part of the U.S. national interest because it assures the United States of continued long-term access to these resources. The less developed world is in possession of many of the basic resources which are the source of the strength of industrial economies. LDC's are at the same time unable to develop many of those resources without scientific and technological advances. The short-term option to exploit Third World energy and raw materials immediately is compelling in an era of national inflation and resource uncertainty. However, scientific research into these questions will only be postponed with the pursuit of such a policy and the U.S. will through the use of force or hegemonic control only sell out its long-term interest in a stable national and international economic system for short-term economic gains.

Each of the arguments made thus far concern the national interests of the United States in terms of the internal maintenance of scientific

and economic capabilities. The following discussion will address more directly the issue of national security and global stability.

The food problem, the environmental problem, the population problem, and the energy problem -- each of these has emerged over the last decade as a global problem which has the potential to upset the balance of power amongst states. These staggering problems are in the main development problems, problems which will change shape and take on new meaning as science unravels their complexity. The United States cannot afford to ignore these problems and it therefore cannot afford to ignore their solution. It is in the United States' national interest to be at the forefront of issues which will not only dominate the agenda of scientific research around the world, but which will continue to dominate many international policy making fora The developing world will become more not less important as the twentieth century draws to an end and it will continue to contribute highly destabilizing factors to world peace as long as food shortages or energy shortages or the like are characteristics which a majority of nations share.

Increasingly, questions of basic needs, of the economic welfare of people in the Third World, cannot be seen in purely national terms. Poverty and disease abroad, the inability of millions of people to meet their food, energy and shelter needs cannot be ignored by a powerful state characterized by widespread affluence and well-being. Even if one wishes to argue that a fortress America is viable, and most would argue that it is not, the quality of life in the United States is or will be affected by the quality of life for the rest of mankind. This is true in terms of food, nutrition and health. This is also true in regard to

the management of mankind's commons -- the sea, air, and natural resources. An American investment in scientific research in these areas will not merely have long range benefits for developing countries but will increasingly become central to the physical and economic well-being of American citizens. In short, American investment now in terms of Third World welfare should not be perceived as American altruism but as an insurance policy for the economic and political future of the United States itself.

The United States as a world power defines its own national security in terms of the stability of the international economic and political system. Stability is unlikely to be fostered in a situation where the North/South welfare gap continues to widen or in which raw material shortages, food shortages, and population pressures become so intolerable that the majority of states are unable to participate in the international system at all. The internal political machinations of many states should be of no serious concern to U.S. security policy. Whether there are a "socialist" or "semi-socialist" coups is of less importance than whether food wars, resource wars, and general international economic panic threaten to engulf the politics of these states. Science will not produce democracy but it can through the gradual solution of these problems enhance our own national security.

To conclude, the responsible exercise of U.S. power suggests that our relative advantages -- our national science capabilities -- be employed in ways which are supportive of the breadth and scope of their reach. Noninterference in the affairs of others should not become the alibi for policies which define national interest in a narrow and parochial fashion. Scientific research is not a quick fix for

development problems nor is it a quick fix for the dilemmas of international policy. It is a long range strategy for insuring our continued role as a pioneer in scientific research, for establishing the foundations for a high quality of life for American citizens in a changing world, and for assuring global stability and the capability for other governments to assure their own populations of basic needs. Investing in science for development should not be seen merely as foreign aid but as a core component of our forging a self-interested national and international development policy.

CHAPTER TWO

African Material Underdevelopment and Scientific Capabilities

Development policy requires a very particular and careful assessment of the actual circumstances of the state or group of states at issue. This report is concerned with African states which do not always correspond in terms of development circumstances with the general category: Third World States. Latin America, because of the relatively advanced circumstances of many countries, because of the outlook of Latin American technocrats, and the relationship of Latin American technocracy to policy making and planning is frequently taken as the hypothetical model for the identification of development problems and scientific cures. Much of our understanding regarding the organization for and the utilization of planning for development has come from an examination of the Latin American context. Africa is quite different and not simply in terms of culture, language and history but more importantly in the context of science and development in terms of material underdevelopment. It becomes particularly important therefore to consider some of the particularities of the African context in order to indicate in a future chapter how and why appropriate policy for aiding Africa needs to be carefully and especially tailored according to some important African characteristics.

In terms of comparative global indicators of development Africa has more states categorized by the UN as least developed than any other continent. Of the 50 states of Africa, 18 were determined to be among the world's 29 least developed states.[5] These countries are:

Botswana	Guinea	Uganda
Burundi	Lesotho	Tanzania
Central African Empire	Malawi	Upper Volta
Chad	Mali	
Dahomey	Niger	
Ethiopia	Rwanda	
Gambia	Somalia	
	Sudan	

Africa also has a high ratio of landlocked countries. The African region accounts for 14 of a total of 19 landlocked LDC's. These include:

Botswana	Lesotho	Swaziland
Burundi	Malawi	Uganda
Central African Empire	Mali	Upper Volta
Chad	Niger	Zambia
	Rwanda	Zimbabwe

In addition, most if not all African countries suffer from:

1. Poor communication and transport links between countries.

2. Inadequate institutional machinery and manpower for development administration.

3. Substantial enclaves of foreign economic activity amidst vast areas of rural backwardness.

4. An absence of pacemaker countries with development experience to offer the region (such as Japan in the Far East, or Brazil in Latin America).

5. Small national markets -- only two African countries have populations over 30 million.

Another important indicator of levels of development is education. This indicator is of particular importance in any assessment of scientific

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[5] GA Res 262 XXV of 24 Oct 1970.

capabilities. There are on the average, 480 students in higher education per one million inhabitants in Africa, excluding Egypt. This represents one-fifth the ratio for Asia (excluding Japan and China), one-tenth that of Latin America and one-twentieth of Europe. Over half the students studying at national African institutions of higher education are enrolled in faculties dealing with the humanities, education, fine arts, law and the social sciences. Engineering and agriculture attract the fewest students: on the average 5.3 percent and 4.1 percent respectively. The absolute numbers of those studying abroad is small and the ratio of fields of study is similar to those studying at home. For some African countries -- Central African Empire, Dahomey, Gabon, Mauritius, and Upper Volta -- the number of students abroad exceeds the number at national institutions. However, the overall number of Africans studying abroad was by 1974 circa 36,000 vs 126,000 enrolled in African institutions. A ratio of 1 to 3.5.

Thus in relationship to overall population not very many Africans are receiving higher degrees or diplomas. For every 100,000 inhabitants only 5 to 10 students graduated annually in twelve African countries surveyed by UNESCO. In only five of these countries did the ratio reach 20 by the mid 1970's. Thus, given the low ratio of graduates in relationship to overall population and the small number who are trained in the sciences, it is not difficult to see the capability problem facing African science development. On top of this the brain drain deprives Africa of some proportion of the few who are trained in the sciences. Hence while overseas study does augment the number of Africans trained

in the sciences given migration North the impact is small whether you evaluate it in terms of absolute or comparative figures.[6]

If we look at comparative figures for African and European countries, the situation in Africa appears even more stark. Studies done in the early seventies concerning the ratio of R&D scientists and engineers per million inhabitants (including the fields of economics and other social sciences) are the basis for this comparison.[7] In Italy there were in 1970, 380 scientists for every one million people; in Sweden, 830; in Belgium, 940; in Bulgaria, 1,330; in the USA, 2,600. In Africa four countries had from 6-10 scientists per million people; thirteen countries had 11-13 scientists per million people; twelve, 31-60; six, 61-90; one, 121-137. It is of course the case that during the decade of the 1970's, the number of African scientists has increased. However, more up-to-date figures even when one takes into account the unreliability of the data, reflect the simple and undeniable fact that there are few individuals in Africa trained and able to engage in scientific research.

The problem of making this determination is in itself a problem and indicative of the circumstances of material underdevelopment which one wishes to measure. UNESCO has been at the forefront of this effort and has found their inquiries are not carried out properly because governments themselves do not have the information and/or lack the resources to gather the information. The international community has

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[6]UNESCO, National Science Policies in Africa, No. 37, 1974, pp. 22-23.

[7]UNESCO, Science and Technology in Africa, No. 35, 1974, p. 123. and UNESCO, National Science Policies in Europe, No. 17, p.45.

believed for some time that a general human and material inventory of African science capacity is a precondition for future policy. Yet, the very measurement of this capacity or rather the obstacles to such measurement is itself symptomatic of the development constraints that most African states confront. It is not that governments remain recalcitrant in the face of international inquiries but that they themselves do not have a handle on exactly what exists, what doesn't, what is operational, and what isn't. Such problems have become quite acute in relationship to the preparations of national papers for the 1979 UNCSTD conference. Descriptive materials regarding a country's infrastructure and capacity are frequently found to be either nonexistent, outdated or based on guesswork. In countries in which national research councils, bureaus of statistics, or other ministries have at one time or another attempted to assess the situation, frequently there has been little intragovernmental coordination and the resultant figures are not systematic or utilizable. The consequence of this state of disarray is that planning takes place without an accurate or useable information base.

The ability to carry out research is mainly based on the training and experience of the individual scientist. However, technical backstopping and infrastructure are also important. The scientists' ability to carry out research thus depends not only on himself but on his ability to harness trained technicians in the lab and in the field and on the availability of necessary laboratory and testing equipment. Much of the R&D attempted in Africa breaks down because of a shortage of technically trained supporting manpower and because equipment is nonexistent or in a state of disrepair. African scientists are faced with problems to

solve and no supportive services to rely upon. We know of horror stories concerning American research efforts which have been set back due to a power failure or a laboratory accident. Those stories can be multiplied by the thousands in Africa where scientists work in almost nightmarish conditions.

The obvious conclusion to this chapter is that current scientific capacity in Africa; whether measured by number of scientists, supportive personnel, working conditions, or general infrastructure; whether compared on a country-by-country basis, in comparison with industrial states, according to relative or absolute figures; does not allow for the scope or intensity of research which African underdevelopment calls for.

CHAPTER THREE

Scientific Institutional Infrastructure: American, International and African

There are a range of research institutions and facilities which address the R&D needs of African states. There are institutes in industrial countries which address development issues, international centers of excellence, African regional institutions, and national organizations. There is no one center of authority within this institutional context. African states are not able to rationalize the diverse research outputs of these various actors neither are they able to impose a research direction upon them which serves their own development interests. As a result Africa's development in science both at the regional and the national level has so far proceeded in a random fashion. The interests and priorities of colonial powers, international development fashions, and the talents of individual African scientists have charted the direction and determined the quality of science for development in Africa. In some cases this has served development; in many cases, it has not.

A. Industrial Countries

It is difficult to measure either directly or indirectly what proportion of scientific research undertaken within the universities

and research institutes of industrial countries relates to African development. We do know in general however that it is very small.

Former colonial powers such as France and Britain continue to have special research institutions devoted to the problems of their colonies -- schools of tropical medicine, institutes of tropical soils and the like. These efforts have been proportionally greater than those of industrial countries with no colonies in Africa, but have nevertheless proven to be of limited value. There are two reasons for this. First, in relationship to the overall research needs of the African countries themselves, they were very small operations. Second, many of the research efforts were limited to issues of special concern to the colonizer. For example, research on export crops was emphasized at the expense of research related to African domestic food consumption.

In industrial countries like the United States with no remnant colonial structure of research institutes, activities relating to African research problems have been much more limited and disorganized until recently. Pertinent research activities have been left to the vagaries of individual scientists and research institutions and yet, U.S. government and foundation support have increasingly been channelling funds to increase U.S. activities and capacities in this field.

The important development field of the agricultural sciences can help to illustrate the pattern of U.S. aid and the strengths and weaknesses of its program. United States universities have been a key to the U.S. effort in this area. The reason for this is based on the model of the land grant college, the agent of U.S. agricultural development, and the assumption that the model might be transferred to LDC's.

Beginning in the 1950's the USDA drew upon U.S. land grant colleges for help in its overseas program. By and large, during the 1950's the few projects which were supported used U.S. institutional capacity for the purposes of technical assistance and some training. American foundations also supported such efforts. According to the 1958 publication International Programs of American Universities twenty-six universities were engaged in international agricultural activities. Almost all of this was technical assistance and educational exchange. Of the 31 programs only a tiny fraction were concerned with Africa.[8]

By the 1960's things began to change somewhat. In 1966, 43 American universities had agricultural development programs and of the 90 programs which they sponsored USAID supported 48. Technical assistance continued to be of predominant importance but training programs were also stepped up. The dominant type of assistance was the rural development project funded by the U.S. government, carried out by a land grant institution, providing U.S. technical expertise and opportunities for study in the United States. By 1966 there were 2,360 training participants under AID rural development contracts. Africa contributed only 179 to this number.[9]

During this same period research carried out at U.S. institutions relating to development and agriculture continued to be ill directed and unsupported by any special government funding or financing. However, the problem was recognized and some institutions sought to

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[8]Robert Morgan, The Role of US Universities in Science and Technology for Development, (Washington University St. Louis Mo. Center for Development Technology 1978), p. 126.

[9]Ibid., p. 134.

combine their resources in order to maximize their capabilities to meet the problem of providing aid to LDC's. For example, the Midwest University Consortium for International Activities, Inc. (MUCIA) established in 1964 addressed itself to university cooperation in agriculture.

USAID funded agricultural R&D programs peaked in the early 1970's but most recently the entire question of development, agriculture, and science has been given new impetus in the passing of the Title XII legislation. Title XII gives the government an even more specific mandate than it had in the past to transfer the American model of land grant institutions and an integrated system of research, extension, and education from the United States to less developed countries. At the same time, it calls for increased research within the United States on questions of development which agricultural scientists here might address. In 1977 in a survey of 144 universities, 41 reported that their faculties of agriculture and natural resources dealt with foreign regions. Thirty-four percent of these were concerned with Africa. Thus, Title XII which was passed in 1976 cannot be taken as an indicator of a cumulative growth in U.S. capabilities in the agricultural sciences as they pertain to developing countries but it is perhaps an indicator of a fundamental change in thinking about development which is currently affecting the bilateral aid programs of many industrial countries.

The importance of research in comparison with technical assistance has received new life as a result of the successes of the Consultative Group and the international research centers it sponsors. Title XII

will move U.S. universities in the direction of these centers. It will support an increase in their capabilities in food and nutrition; in their research in agricultural science as it pertains to developing countries; and in their role within the community of organizations and states which see research as a key to agricultural and general economic development in the Third World. American universities may cooperate with the international centers. They may host international efforts such as the International Soybean Program (INSTOY) located at the University of Illinois. They may serve as catalysts for research networks such as that which has been created amongst Purdue University, Texas A&M, and the University of Puerto Rico on sorghum. Realistically speaking, we are only at the beginning of such efforts. The capacity building both within U.S. universities and amongst the programs they sponsor may initiate a new era in the assistance the United States is able to offer Africa in agricultural research.

A good deal of research also takes place in industrial countries within private corporations. Research agendas here are focused on the economic needs of the industrial states they serve. The market orientation of private industry is not however completely independent of government policy and influence. While public policy in this area is more directly related to aid institutions and universities, policy priorities for research on development issues of public health, nutrition, agriculture, and the like do have an effect on private research. First, the research climate itself is changed. Second, the government can offer incentives to private institutions to follow its policy lead. Third, as publicly sponsored research reaps its rewards a market is created to which private institutes respond.

So far, Africa has not benefitted very much from the research capabilities of industrial countries. African R&D simply has not been a very great priority in the Western assistance community. This is beginning to change in agriculture where the creation and diffusion of new knowledge has had far reaching impacts on Asia. It will have similar effects on Africa if such R&D efforts continue to be supported.

B. International Research Centers

Centers of research excellence which are internationally supported and which make the results of their research available to all states exist in many scientifc fields. A unique occurrence in the international organization of the agricultural sciences has recently drawn our attention to the role such institutions can play. The International Research Center when it has the enthusiastic support of the international community can mobilize research resources so that development problems are addressed within a continuous and coherent program of research. This stands in stark contrast to the ad hoc contributions of industrial countries.

The Consultative Group on International Agricultural Research was formed in the early seventies following three decades of work in Mexico and a decade of research in the Philippines, and the spectacular results of the diffusion of their work in the Green Revolution. Co-sponsored by the Food and Agriculture Organization and the World Bank, the Consultative Group brought together a wide array of donors in order to launch a network of research organizations addressed to the needs of farmers in various agroclimatic conditions. The food crop orientation

of these centers has reversed the colonial bias of agricultural research of the first half of this century and has assured it relevance to individual cultivators. Germ plasm banks have been established which will continue over this century and perhaps into the next to fuel the genetic research which will over time provide more technological breakthroughs to farmers throughout the Third World. A global system of testing and evaluation has been established as a part of the work of most centers, as have programs of training for Third World technicians and scientists.

The Group now includes centers which address questions of cereal crops and livestock; the problems of semiarid environments and tropical soils; and the special issue of farming systems and research for the small holder. The mandate of the Centers to take responsibility for the diffusion of their research is ambiguous and while some centers like CIMMYT support active and aggressive national programs of technology diffusion others do not. Furthermore, the Centers have been included in the criticism of the Green Revolution technology as not being relevant to the poorest farmers. The issue of research impact has not been solved institutionally or in terms of research orientation by the Centers but both questions are under discussion within the Consultative Group. The major point of controversy is how much responsibility the Group and the Centers it sponsors can take for research delivery systems and how much traditional bilateral aid programs should pick up.

The International Center is potentially an extremely attractive resource for African governments' attempts to put science to work for

development. However, if knowledge transfers are actually going to take place in Africa, the questions of organization, accessibility, and assistance are as important as the research results themselves.[10]

C. African Regional Institutions

In general African regional institutional capacity in science is minimal. However, remnants of the colonial structure which fostered interstate research facilities do remain. They are basically of two types. On the one hand, institutions exist which address continental problems and which are organized around functional issue areas. On the other hand, institutions have been created which address the problems of a particular territory or group of states which have come together to cooperate as a territorial entity.

In terms of broad functional cooperation the former French colonies continue to be part of a French structure of research. Close links have been maintained with the parent research facility in France and the Office de la Recherche Scientifique et Technique Outre-Mer (OSTROM) continues to play a coordinating role. The French applied research institutes also maintain branches in post colonial Africa. These include IRAT which addresses problems of tropical agriculture; IFCC which is concerned with coffee and cocoa; IRHO which is concerned with the issue of palm oil; CTFT which addresses the problems of tropical forests; and IFAC which is concerned with tropical fruits. Two facts stand out as the most

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[10]Consultative Group, International Research in Agriculture, NY 1974, See also, Lowell S. Hardin and Norman R. Collins, "International Agricultural Research: Organizing Themes and Issues" in Agricultural Administration (1), 1974, pp. 13-22. See also Appendix 35 & 36.

relevant indicators of the importance of these institutions. First, they are devoted as are their home facilities in France to research on export crops. Second, local involvement of the African varies widely but is on the whole limited. In short, while these research facilities are located in Africa they are not African and they do not address the important issue of research capacity building in Africa.

Another network of functional research institutes which are also a holdover from colonial times are the various bureaus, councils, and institutes associated with the CCTA and which are now a part of the Organization of African Unity under the supervision of its Scientific Technical and Research Commission (STRC). In the under financed and otherwise limited STRC these institutions such as the Inter-African Phyto-Sanitary Council and the African Animal Husbandry Bureau still carry out work, but they cannot be perceived by any stretch of the imagination as significant inter-African research facilities.

The East African Community is perhaps the most prominent territorial unit of research cooperation which exists on the continent. It embraces research institutes in agriculture, forestry, fisheries, veterinary problems, pests and diseases, animal and human health problems as pertain to East African environment. They constituted at independence a promising beginning for regional science. However, as the Community began to collapse these institutions were absorbed into the individual states in which they were located and in most cases suffered the consequences both of reduced funding and reduced manpower capacity. In short, these regional efforts not only ceased to be a nucleus for a regional

institutional capability but deteriorated to such an extent that they do not even service the states of which they are now a part.

In West Africa the efforts of such states as Ghana, Nigeria, and Sierra Leone to sustain regionally based research stations in export crops -- again inherited from colonial times -- have met with uneven success. Post colonial regional organizations such as OCAM, UDEAC, and ECOWAS have not as yet found themselves able to establish research centers to meet the needs of member states. Indeed the activities that do succeed are a result of the talents of individual scientists who are able to mobilize regional support and energy rather than to the ongoing institutional infrastructure. At this writing West African enthusiasm and support for interstate science efforts are central to the political rhetoric and the institutional blueprints for the region but they have not so far been translated from rhetoric into reality.

The Southern part of Africa also inherited territorially based research structures which due to the political conflicts and power relationships amongst states do not operate to the best interests of the members. The research associations which were a part of the Federation of Rhodesia and Nyasaland -- now Malawi, Zambia, and Zimbabwe -- have for post colonial political reasons completely deteriorated. The states of Botswana, Lesotho, and Swaziland are tied into the South African research system and to some extent continue to be so related.

The regional research capabilities which are a legacy of colonial rule in Africa whether they were continental and functional in nature or defined around the problems of a particular group of states were

fundamentally an extension of the institutional capabilities of the colonial powers. Both in terms of institutional structure and the content of research they reflected the interests of those states. The decolonization process as well as the political process in the post colonial period have tended to lead to the disestablishment or deterioration of these interstate efforts. Post colonial efforts to establish new interstate connections have by and large not as yet developed interstate institutional capacities in science.

Finally, the UN Regional Commission for Africa has sought throughout its twenty year history to encourage African interstate cooperation and institution building. It must be reported, however, that its success in the field of science has to date been insignificant and the attention the ECA has devoted to science has until very recently also been limited judged by both manpower and overall budget allocations.[11] However, the ECA has offered its administrative structure and good offices for the convening of conferences related to interstate science institution building and for the making of policy. It is very much involved in the African regional effort to articulate clearly and forcefully African demands at the 1979 UNCSTD conference to be held in Vienna. In this sense the ECA has and continues to play some role in interstate science policy making.

It must therefore be concluded that African interstate science capacity is small and that the African interstate science institutional base is weak. There has been much African rhetoric in support of strengthening such institutions but neither the financial or human resources have been made available to implement professed commitment.

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[11]Less than 4 percent of ECA's budget has been allocated to science and technology, see IV Gruhn "regionalism.....

D. African States

As the research carried on in industrial states and at international research centers is increasingly oriented towards African states it will become of greater importance for national research programs and institutions to be able to translate research into viable national programs. In agriculture for example, location specific research is required to identify and test innovations suitable for farmers of particular localities.[12] It should be obvious given our discussion thus far that in the area of national capabilities African states suffer from extremely serious disabilities. Not only is there a shortage of trained scientists in all fields but the institutional infrastructure and support mechanisms for doing science are very limited for those scientists who do exist. By and large African scientists are ill funded and are equally poorly supported lacking auxiliary or middle-range technicians essential for the operations of many scientific enterprises, lacking equipment and the means to repair that which does exist. In addition to these disabilities are several others. Because there are so few scientists in Africa many of the most able are overtaxed in their duties to teaching and government service. The average teaching load at an African university leaves relatively little time for research. Furthermore, many scientists, whether or not they have the training or interest, are asked by their governments to participate in government activities at home and abroad. All these necessary and desirable activities generally cut into research time and eat away at the quantity and

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[12]World Bank, World Development Report 1978, p. 54.

quality of research. African scientists who for whatever reason manage to stay clear of these obligations and make the time for themselves to do research run into other problems. They are isolated from the work which is being done in their own fields. It is not only that they lack colleagues at home with similar training and interests but that they do not have proper access to information and contacts around the world. The extent of this problem of doing up-to-date and creative work in a given field cannot be underrated. Keeping up with one's own field can prove to be very difficult in Africa where access to even professional journals and hence up-to-date papers on related research may be delayed for months or even years.

Thus isolated from the scientific community, lack of technical back-up support, and poor funding prove to be monumental obstacles for doing science in Africa. On top of this many scientists find that teaching and government burdens side track their research efforts. A continental shortage of scientists is magnified by weak institutions and accompanied by the erosion of research time.

As mentioned in an earlier chapter, in spite of concerted efforts in recent years, it is next to impossible to define on a country-by-country basis the precise science capacity of each African state. The United Nations Economic and Social Council's Advisory Committee on the Application of Science and Technology to Development (UNACAST) asked UNESCO to proceed with a country-by-country world survey of scientific capabilities. These surveys are to include an analysis to determine the scientific and technological requirements of each nation; an analysis of the scientific and technological capabilities of each nation; and the

delineation of the science and technology institutions demanding priority consideration. Accordingly, UNESCO developed a methodology and a questionnaire for the accomplishment of this task. However, for Africa the results are thus far meagre and unreliable.

UNESCO's efforts to gather the desired data in Ghana will illustrate some of the problems associated with implementing such a program in Africa. Local staff for the implementation of the study did not have proper training; essential Ghanaian experts were unavailable for questioning; participants from the scientific community who were available had been insufficiently briefed and were unable to supply the needed information. Given all these obstacles a five-week survey proved inappropriate and while a multi-month study might have come up with some information, that would have entailed a broadened mandate for UNESCO. At best the study may provide some cautious indicators of Ghanaian capabilities; at worst it proves useless for making any such judgment.[13]

It should be pointed out that amongst African states the difficulty of obtaining an accurate perception of national capacity should be relatively easier in Ghana than in many other states. In short, while some national facts and figures are currently available and a concerted international effort is currently underway to gather and provide more hard information, we simply do not know about the national capacities of individual African states. In certain instances like that of Ghana it is also difficult to know to what extent the absence of proper science management and policy obscures rather than highlights available national science capabilities. Thus, a number of useful scientific activities

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[13]UNESCO, Restricted Technical Report (RP/175-76/ 2.121.2) Ghana.

and institutional capacities may well be in progress while national governments and international agencies are not able to account for them. In spite of the general absence of national capacity data and the on-going obstacles in Africa to collecting such data, one can nevertheless put forth some facts and figures which will bring to light the variations amongst states while at the same time placing the overall situation in a comparative perspective.

There are only three sub-Saharan countries where the number of scientific R&D workers exceeds 1,000. These are Ghana, Nigeria and Kenya. The number of scientific researchers in other countries varies from 28 (in Mauritania) to 995 (in the Sudan). It also appears that the number of part-time researchers is high and that most are also connected with higher education. Natural sciences appear to constitute the largest sector of activity, accounting on an average for 37 percent of the total R&D sector. Agriculture accounts for 33 percent; medical sciences 17 percent; and engineering 9 percent. These figures were only approximations when published in 1974 and require updating though the ratio has probably remained largely unchanged.

A breakdown in the relative weight of the percentage distribution by field of science of total scientists engaged in R&D also gives some useful insights.[14]

Natural Sciences

Lesotho	88	Somalia	62
Congo	77	Sierra Leone	60
Gabon	73	Ivory Coast	53
Mali	71	Niger	52
Guinea	65	Sudan	52
Zaire	64	Liberia	51

The following countries show figures of less than 20 percent -- Kenya, Mauritius, Togo and Upper Volta.

Agriculture

Mauritania	72	Burundi	57
Mauritius	71	Kenya	57
Tanzania	65	Cameroon	50
Central African Empire	60		

The following countries show less than 12 percent -- Congo, Guinea, Lesotho and Zaire.

Medical Sciences

Percentage of more than 20 percent.

Upper Volta	61
Senegal	37
Uganda	27

In 12 countries there appeared not to be a single scientist engaged in R&D work in the field of medical sciences.

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[14] UNESCO, National Science Policy in Africa, Science Policy Studies and Documents No. 31, (1974).

It is not difficult to see that most countries are not equipped to undertake research work -- basic or adaptive -- in areas of fundamental concern. The distribution of capacity is also frequently based on inherited colonial emphasis or happenstance rather than the logic of a country's economy or of the direction of its development strategy. The almost uniform paucity of capacity in the medical sciences is notable. Similarly, only 24 countries -- one-half of the continent -- have a relative emphasis on agriculture when all are predominantly agricultural societies.

Another way in which to judge both ongoing and potential capacity is to examine current expenditure for research and development (see Appendices 2, 3, 4, 5, 6, 7, 8).

Once again figures are both outdated and unreliable, but they do give an overview and dispel some fictions. It does appear that many African states are moving to or exceeding the target of 0.5 percent of GNP invested in research which had been recommended by the UNCAST World Plan of Action.[15] While none of the statistics give the necessary information to assess in any meaningful way the relationship between basic and applied research or between productive sector and other sector research, the evidence is sufficient to dispel the notion that has become fashionable in international aid circles that African R&D expenditures are predominantly in the universities.

In most African countries government funds constitute the main source of R&D financing but data show that productive enterprise funds

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[15]UNCAST, Plan of Action, p. 56.

are relatively important in Kenya and Mauritius.[16] Also for many countries foreign funds constitute an important addition to government support. Out of a total R&D expenditure foreign funds account for 19.3 percent in the Central African Empire; 55.13 percent in the Ivory Coast; 37 percent for Malawi; and 78 percent for Upper Volta. Conversely for Maurituis and Nigeria this source of funds is less than 5 percent of total funds. Diverse structures of funding for science and different levels of dependency on foreign funds characterize the African situation.

We know that African national science capacities are small but we do not have the data which would allow us to gain an accurate overview of the problem. This is one reason why underdevelopment constitutes something of a vicious circle. It is difficult to plan for and execute change through conscious policy formation and management techniques in the absence of governmental capacity to produce the essential information required for such planning and development. These national incapacities are further magnified when international assistance is based upon national data.

With the close of this decade of development the general view that African countries require an institutional capability to make science policy prior to the establishment of national R&D capability is taking hold. With a good deal of encouragement from UNESCO and equivalent institutions in industrial states, African countries have increasingly developed national academies of science and research councils. The role, function, and viability of these institutions varies

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[16] SC/CASAFRICA/3 Ref. 1, Statistics on Research and Experimental Development in African Countries, Analytical Report, Dakar, (January 1974), pp. 21-31.

from country to country but in most all cases they are still new and in the process of defining their own direction. It can be expected that the development of organized networks of scientists, peer reviews for research grants and the like will help support science in Africa at the same time that it will promote links with similar bodies elsewhere and ease the isolation of African science from the rest of the world. However, academies of science and research councils are not THE solution to this very complex problem. They will mirror the circumstances of African societies and should not be expected to offer more than a small additional capability in the overall development of science.

E. Some Concluding Comments on Institutions

Science in Africa is supported by many different levels of institutions. The difficult problem for the external actor desirous of choosing the linchpin and investing there is that there is no linchpin, no institutional level which will catalyze the others. Institutional capabilities need to be strengthened within the R&D community within industrial countries, at the international level of international centers of excellence, at the African regional and at the African national level. Science has become internationalized and science in Africa will not, in this century at least, take place apart from the work which goes on elsewhere. By the same token local science -- both basic and applied research -- is essential for national development to take place.

The success of the Consultative Group may very well prove to be the institutional model for international research in other disciplines.

It might also prove to be the center for the dissemination of a certain understanding of what constitutes good agricultural research the world over. Beyond this effort the attempts in more recent years at both the national and international level to identify priority R&D goals and policies has not progressed very far. The very uncertainty of relating science to development; the low-levels of manpower; the low-levels of funding; the underdevelopment of institutions and other infrastructure in Africa make this process of goal setting and policy choice very torturous.

CHAPTER FOUR

Policy Recommendations:

Strengthening U.S. Capabilities

The policy recommendations which will be made in the following two chapters address two separate issues of institutional development: American institutional development and African institutional development. Both chapters are concerned with the common problem of reorienting American policy and commitment to a better utilization and expansion of U.S. capital resources invested in R&D related to African development.

In 1979 the United States plans to spend $27.9 billion on research and development. Of this, $13.8 billion will be concerned with defense, $3.4 billion for space, and $10.7 billion with civilian R&D.[17] The AID budget for research for 1979 totals $76 million. While the AID figure represents a 53.5 percent increase over the previous year, it is only 0.272 percent of the total U.S. R&D while defense is 49.5 percent.

The United States will support scientific research at its universities to the tune of $3.566 billion. Of this figure 1.49 percent of the total will be provided by AID for the purposes of research applicable to LDC's.[18]

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[17] Intersociety Preliminary Analysis of Selected R&D in FY 1979 Budget, (Washington, D.C., Feb. 1978).

[18] See Appendix 26,27,28.

The National Science Foundation budget for 1979 calls for $10.6 million for International Cooperative Scientific Activities. The majority of these funds, 58 percent to be exact, will be spent on cooperative science programs with developed states or the most developed Third World countries. Another 31 percent of that budget will go to Scientific Organizations and Resources, an NSF program which is largely concerned with funding the International Institute for Applied Systems Analysis, a joint US-USSR undertaking. Neither of these efforts will meet African or least developed country needs.[19]

It is not difficult to determine given the figures cited above that the funding of science for development whether it is to increase U.S. R&D capabilities or those of less developed countries commands very little attention. Defense and space research combined together command 61.7 percent of the budget. The money going to AID is miniscule in comparison. Similarly the National Science Foundation, founded in 1950 as an agency of the Federal Government to promote and advance scientific programs in the United States, is still little concerned with the developing world. As a key policy making mechanism in the area of science policy the program emphasis of the NSF is an important indicator of where our own priorities lie and where our own capabilities are being developed.

This report is recommending that a new era of science policy be initiated, that the American national interest embrace the support of science for development, and that in turn, such a reorganization of policy be followed by a reorganization of the overall budget for research and

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[19]See Appendix 29.

development. United States policy would be based upon several important assumptions. First, it would acknowledge that the knowledge now available is inadequate to the resolution of many of the development problems of less developed countries. Thus, new and additional research is required. Second, a new science for development policy would recognize that the knowledge creation capacity of the world resides within and among industrial states and especially, the United States. Furthermore, very little of this capability for R&D exists in LDC's, and Africa, as a part of this group, is particularly handicapped. Third, the new policy would take into account the fact that existing R&D is heavily devoted to the problems of industrial countries.

As a consequence of accepting these assumptions, the United States would: 1) refocus its own knowledge creation capacity to address the development problems of Third World countries and those global problems that it shares with those countries; 2) increase its participation in international organizations (such as the Consultative Group) which create knowledge not now available but necessary for the well being of both developed and developing countries; 3) foster the development of R&D capabilities within LDC's so that local specific, adaptive, necessary basic research can be pursued.

A. <u>The Reorientation of Existing U.S. Capacity -- Research</u>

An overwhelming proportion of research carried out in the world today in many fields of the biological and physical sciences is undertaken at American universities. The direction of much of this research is in part determined by the public monies which make it possible. This

funding determines the priority areas for research and thus has thus far imposed U.S. public policy priorities (e.g. defense as compared with development) on scientific development. This can and ought to be changed. U.S. policy needs to be reoriented not merely in AID but all departments of Government such as HEW, Agriculture, Energy to increase attention, funding and support in areas of research related to LDC's. Title XII to the Foreign Assistance Act as amended in 1975 calls for Government support of land grant and other eligible universities in programs related to agricultural institutional development and research so that they might improve their participation in American and international efforts related to solving food and nutrition questions. This is only a first step, however, and similar redirection of university research capability needs to be undertaken in other fields of science. It is however exactly this type of change which will reach African countries.

As U.S. university research capacity is redirected, U.S. institutions of higher learning will begin to generate knowledge required for LDC development. Perhaps as important will be the new role U.S. universities will play in linking U.S. capacity to international efforts and LDC international development. For most African states, in particular, long-term cooperative work in science with U.S. universities would support their own indigenous capacity building. Thus, the reoriented American university research capacity should be used for:

1. Coordinated research with African universities and research institutions and International Research Centers.

2. Coordinated training components for Africans related to No. 1.

3. Coordinated funding components.

As we have seen African states are in need of long-term science aid. The redirection of U.S. public funding into relevant development areas and coordination between U.S. universities and African universities would be highly desirable. Indeed long-term scientific coordination of joint research and scientific exchange between U.S. and African institutions would not merely constitute a more cost effective form of aid for African states but would enhance the possibility of positive development payoffs of such research. Government funding agencies and American universities should be selective in their choice of African countries, universities and research institutions with which to establish such relationships, rather than attempt such links with large numbers of institutions. However, after having made some careful commitments funding and programming should be long term, at least 5-10 years.

What is being suggested is neither new nor untried. However, most attention has so far been focused on non-African LDC's. For example, during the past 20 years six American universities have been involved in agricultural activities in India. During this period almost $31 million and another 11 million U.S.-owned Indian rupees were spent. About 700 man years of U.S. staff time were devoted to helping India improve its system of agricultural research and education. Over 1,000 Indian faculty members and graduate students studied in the U.S.[20] Similarly, the University of Wisconsin's Land Tenure Center, the Universities of Illinois, Michigan State, and others have been involved in LDC

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[20]Morgan, op. cit., p. 159.

R&D. The overall emphasis has neglected Africa, and the focus of U.S. universities and the utilization of their capacities has been limited to isolated projects rather than constituting a widespread phenomena within the research plant of American universities.[21]

The United States should also develop cooperative relationships with International Research Centers such as those that make up the Consultative Group.[22] The U.S. should offer its financial support for the programs of such centers. However, it is more important to develop research links between U.S. universities and these centers. American universities could increase their own capacities in LDC related research through coordinated activities with International Research Centers while at the same time contributing their local expertise, research findings, and training facilities to the international centers. In short, American coordination with international activities needs to be more formally established rather than, as is predominantly the case today, left to the informal links of individual scientists.[23]

For LDC's in general and Africa in particular it is becoming increasingly apparent that a social science capability needs to be made available to complement that which the natural sciences offer. Research undertaken in the hard sciences may lead to the development of a new technology such as an improved variety of the local food crop but the successful introduction of such new technology is highly dependent upon the socio-economic context. If American universities are to be more

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[21]See Appendix 32, 33, 34.

[22]See Appendix 35 and 36.

[23]See Appendix 30.

effectively employed to set up research and training which is relevant to African development, it is essential that they mobilize their social science faculties in conjunction with the natural sciences. Universities, as agents of development, are particularly well suited to bring interdisciplinary work to bear on these questions. Social science like the natural sciences will respond to increased funding for such programs. There are many illustrations to substantiate this: the increase and then the decline in geographic area research, the increase in urban related research during the Great Society programs, and the response to defense related activities. Social scientists ought to be incorporated into development projects from the outset of design and funding. This will not only increase the quality and appropriateness of the knowledge to be discovered but will develop as well a capacity for such research at American universities.

B. The Reorientation of Existing U.S. Capacity -- Education

American universities need to be utilized more effectively both in terms of the quantity and quality of Africans educated. While most observers advocate that as much education and training as is feasible should take place in Africa, it is realistic to expect a continuation of the need for Africans to study abroad especially for advanced degrees in the sciences. In general, the underutilization of the U.S. educational plant by Americans which is expected to continue in the decade to come allows the U.S. to meet an important need of African countries for training scientists abroad without displacing Americans. In fact the U.S. is one of the few industrial countries at the moment where nationals

need not be displaced from educational institutions in order to accommodate foreigners. The U.S. is, therefore, in a position to sustain and even accelerate the incorporation of foreign nationals into its higher education system. This is cost effective both for the educational institutions themselves and in terms of African development; and the U.S. institutions will continue to be used at full capacity. More and better trained African scientists can enhance African science capacities in ways which other forms of external investments cannot -- namely the creation of indigenous capacity along with affecting long-term development benefits.

The quantitative increase in training African scientists in U.S. institutions needs to be accompanied, however, with the qualitative improvement of U.S. education for Africans. This is so for several reasons. First, an African scientist trained inappropriately in relationship to the technical needs of his society, will find it difficult at a later point to address important development questions of concern to his own society. Second, unless an African scientist receives some additional training to allow him to be operational in an African setting the contribution he is able to make at home will be limited. Third, failures in both of the above contributes to the brain drain phenomenon so that an African scientist will be more likely to remain in the U.S. rather than return to Africa.

If American universities express a low interest in development related research, Africans will be unlikely to be encouraged to engage in research relevant to their own societies. Graduate students usually research topics related to those of their professors and are most commonly funded through the research grants of others. If for example a student

in the medical sciences is supported to do research on cancer rather than malaria, an opportunity has been lost to train an African scientist who can contribute directly to his own society's welfare. In addition, it is unlikely that he will wish to return to Africa where neither the interest, support, or facilities exist (or are likely to exist) related to his speciality. Thus, a training and education syndrome is induced which prevents the strengthening of African science capacity. The National Science Foundation has just begun a small pilot project to fund LDC scientists at American institutions to investigate problems of their own societies. This type of effort needs to be expanded and intensified.

Besides a general reorientation of research direction and support, some auxiliary training requirements also need to be met. Every African trained in the United States ought to receive formal instruction in the maintenance and the repair of equipment relevant to his field of science. Courses in equipment maintenance should command public and private industrial funding support. They should be organized as well by a national body like the National Science Foundation and made compulsory for Africans who are accepted into the graduate programs at U.S. universities. Further, each African graduate student should be required to enroll in a course on science policy and management. This training might be sponsored by such an institution as the Kennedy School for Public Policy. It might be organized through the National Science Foundation or the National Academy of Sciences.

The reason for such training programs is that in Africa the circumstances of the work environment are quite different than they are in the United States. Due to the absence of middle-level manpower in the sciences

many scientists become unoperational and their work comes to a standstill if they are unable to repair and maintain their own equipment. While the importance of training the necessary technicians is not questioned here, it is also true that scientists who themselves have some such training offer an immediate solution to the problem at the same time that they may over the long term be capable of supervising their own technicians. Also on the subject of science policy and management, given the very small numbers of African scientists, it is very likely that scientists trained in the United States will be involved in science management. There is nothing in the normal training of a scientist at an American institution to prepare him for such a task. Science management and planning are skills which have become highly refined in the United States and can be easily taught here. The experience of U.S. Government and industry is internationally recognized and up until this point it has not been transferred as a part of the training of LDC scientists.

With one additional year in the United States the education of an African scientist would be tailored to the work environment to which he should contribute. The expenditure will make his own work relevant to his society as well as decreasing his own career frustration concerning the pursuit of serious scientific research in Africa.[24]

C. Non-University Institutions: the Private Sector

Private foundations have in the past been at the forefront of science aid to developing countries but currently many have moved away

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[24]See Appendix 39, 40, 41, 42, 43.

from such programs. Private corporations have, in contrast, been oriented to the technical scientific needs of the United States. Government funding and influence could mobilize both of these resources in the name of science for development.

Private foundations especially Rockefeller and Ford have devoted considerable attention to global problems such as the eradication of malaria or the food crisis and in the process have contributed to the establishment of scientific capabilities in Third World countries. However, U.S. foundation activities in these areas appears to have reached a peak, especially in the case of Africa. This is in part due to their own financial problems of recent years. The degree of attention and funding which can be expected from these foundations on the subject of science for development might be increased with a vigorous government program in support of this endeavor. This would make it both feasible and profitable for such foundations to use their pilot project capabilities in conjunction with longer term U.S. capital assistance in support of African science. Foundations have in the past been able to sustain as well as launch their programs in development and science and their prior experience and sustained interest in this field could be reactivated with a government program of the same type.

American private industry constitutes one of the largest and largely untapped resources for the development of African science. Corporations not surprisingly most commonly engage in research related to product development for profit. Most research is undertaken for a market within the United States or one shared by other industrial countries; or to meet U.S. Government purchasing needs as in the case of

defense related research. It is therefore not surprising that so little private corporation research has been devoted to African development needs. While national policy cannot dictate private corporation research as such, it can however help to redirect it. Government departments contract out research to private industry in many areas where national interest and national policy suggest that knowledge production is desirable. Many private corporations operate wholly or partially through government contracts especially in defense. Much of the research and know-how in the electronics field was undertaken and sponsored through government agencies. Industry responds to the availability of government contracts in the same manner as do universities. When funding becomes available for topics that are relevant to African development, that seem to have some market potential, private corporations will enter that area. The partial redirection of government-supported research in health, medicine, and agriculture by U.S. industry could make an important impact on the overall enhancement of the U.S. science capabilities as well as that in Africa.

D. Rationalizing the Policy Mechanism

The United States Government lacks both the capacity to coordinate its own policy network in the area of science for development and the capacity to carry out effective programs in that area in Africa. Only a small proportion of the budgets of relevant government agencies are allocated to science and development; smaller still are the funds earmarked for Africa. Historically, government departments like HEW, Agriculture, and institutions such as the National Science

Foundation have dealt with R&D without considering the larger international context of their work. The internationalization of knowledge and the growing resource interdependence of the North and the South have not yet been fully considered in the light of a national policy for science for development.

The U.S. Agency for International Development is the branch of the Government currently vested with primary responsibility for development and the Third World. Many external and internal studies have criticized AID for its program and have made recommendations as to its future direction.[25] This report is more narrowly concerned with AID's structure and capabilities as they relate to science aid to Africa. Presently, AID lacks adequate staff in science both at the planning and policy level and at the technical level in terms of program implementation. Further, AID's mandate under the New Directions Legislation poses problems for its vigorous support of Third World science and research. The long-range goal of meeting Basic Human Needs is frequently judged by Congress in terms of short-range programs which deliver services and goods to poor people immediately. While the redirection of development philosophy is understandable in the light of past project failures and the skewed income patterns of many Third World countries, the trend away from the building of infrastructure in Africa towards stopgap food and health aid does not necessarily rectify the mistakes of the past. In some cases it may magnify them. AID's overall development program should embrace projects which reach the poorest

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[25]See Lincoln Gordan and Associates, An Assessment of Development Assistance Strategies, (Brookings Institution)

strata in Third World societies, but they should also provide for the creation of indigenous capabilities which over the long run assure such countries of developmental self-reliance.

The basic bureaucratic structure of AID has led to a confused diffusion of responsibilities in this area. In the absence of a science for development policy random activities are undertaken within AID's substantive divisions as well as within its Africa Bureau. These activities lack overall coordination and prove at times to be counter productive to the overall development of science capacity in African states.

Given current assistance guidelines, AID cannot address the science needs of states like Nigeria which have the resources to purchase its own aid. Nigeria, affluent due to its oil resources, suffers from many of the same problems of manpower and technical expertise which characterize smaller and poorer states. The U.S. Government needs to develop a mechanism for meeting the needs of such states. Nigeria possesses the resource base upon which to build an indigenous research structure. Without assistance to do so, it remains dependent upon international business and other external economic actors to articulate the technical perimeters of its development stategy.

Thus, AID's policy making division needs to develop the manpower and institutional capacity with which to:

a. serve as a spokesman for a policy of science for development to the Executive Branch, other government departments, and the U.S. populace.

b. obtain the manpower with which to contribute to African science policy development.

c. use its know-how and capacity in (a) and (b) to help organize and affect the relevant programs in all AID divisions so that science becomes integrated into national and regional development planning and aid packages.

d. develop the capacity to link U.S. national, international, and African science for development programs so as to minimize overlap and maximize policy and resource coherence.

However, even with increased AID capacity in the field of science, AID will continue to confront institutional limitations which adversely affect the ability of the United States to respond to African science and research needs. The question of reaching such states as Nigeria is such a limitation. Further, it must be remembered that AID is, in the main a resource transfer agency, the coordination of efforts in science and other related development fields within the United States Government is not its historical mission. Nor has AID proven itself capable of generating creative thinking and activities in the field of science related to development.

The fact that AID is not structured to meet the challenge of research and development in Africa is not unique to the history of aid in the United States. Other countries including Canada and Sweden have found it necessary to create a new institutional mechanism in order to promote science and research in the Third World. The fact that we now understand that our own technology and technical methods cannot be transferred wholesale to the Third World is not easily grafted upon institutions which were founded upon earlier assumptions. African countries need the capacity to generate their own social, political, economic and technical solutions to their own problems. This is not simply because national self-reliance is better than technical dependence but because

technical solutions created for one set of circumstances at the very least need to be adapted for circumstances for which they were not designed.

Canada's International Development and Research Center, the IDRC, was established to provide less developed countries with the internal capacity for science and research. It is interested both in creating research capabilities for the conduct of indigenous research on indigenous problems and for the conduct of research which will allow knowledge from other environments to be applied to the Third World. According to David Hopper, the IDRC will create programs:

> a. to enlist the talents of natural and social scientists and technologists of Canada and other countries;
>
> b. to assist the developing regions to build up the research capabilities, the innovative skills and the institutions required to solve their problems;
>
> c. to encourage generally the co-ordination of international development research; and
>
> d. to foster co-operation in research on development problems between the developed and the developing regions for their mutual benefit.[26]

The Canadian effort has allowed its research aid the flexibility and creativity that large resource transfer institutions have difficulty mustering. Further, the IDRC has been enthusiastically received in Africa. The United States might do well to pursue a similar institutional investment. Such an institution might incorporate at the same time an ability to pursue long-term research, to meet immediate needs for aid and information in the event of program crisis, and the capacity to

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26W. David Hopper, "Research Policy: Eleven Issues," IDRC, pp. 3-4.

employ Africans in the formulation of U.S. science for development policy and integrate U.S. research with that in Africa.

Many of the most promising and potentially fruitful areas of scientific research are related to development problems for which there is as yet no clearly established research stategy. The high risk nature of such endeavors makes it difficult to justify as a part of AID country programs. Similarly, AID's complicated bureaucracy make it unsuitable for filling short-term manpower and resource gaps in science programs where such aid is the difference between the continuation and the termination of an African national research program. On top of this, AID as a resource transfer agency does not have a mandate to establish cooperative research ventures. Shared research projects, the cooperation of research institutions, and the participation of Africans in the formulation of American science for development policy would meet the special needs of African science.

A potential American counterpart to the Canadian IDRC is currently in the planning stages. The Foundation for International Technological Cooperation (FITC) might address the innovations in programs for which AID has no mandate. Ideally, the FITC would be given some degree of institutional autonomy so that it might establish an institutional character somewhere between that of an aid agency and that of an agency for international program coordination. In other words, it would be interested both in assistance programs and in the encouragement of scientific cooperation between the United States and Third World countries. Absolutely essential, as must be apparent at this point in this report, is a strong American commitment to such an agency so that research programs

may be initiated which are not limited by short-term aid commitments. The substantive focus of the research to be supported would embrace problems of special importance to developing countries in terms of basic Human Needs and problems which are of mutual importance (such as energy).[27]

The FITC would not simply be an adjunct to an already over-developed aid bureaucracy but rather it would be the institutional focus for the coordination of a science for development policy. The support of research programs is not the same variety of task as the support of resource transfers. The United States can postpone aid to African countries in this regard and wait for some other aid mechanism to establish an African internal research network. Or, it can begin to see the benefits for its own national welfare in the creation of a program of cooperative science and research which leaves both the United States and African countries knowing more about a complex set of problems about which both are concerned.

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[27]See Revised FITC Document, December 4, 1978, (Draft prepared by FITC Planning Office).

Summary of recommendations for improved U.S. administration of policies and their implementation related to science for African development:

a. Improved staffing integration of science specialists in AID and other departments, African Regional Bureaus and substantive divisions, relevant to African development.

b. Development of a science policy, planning, and management support system within AID with adequate capital resources and Africa specific know-how as well as use of such a support system by the appropriate divisions of AID. The latter should become a matter of internal AID policy. The task of this system would be:

1. Assessing scientific needs, interests, resources and policies in African states.
2. Recommending areas of research and investment in science that deserve increased support.
3. Developing AID projects and programs that include sector specific or multi-sector research or other scientific components.
4. Providing scientific planning and management advice during such project implementation.
5. Organizing information from science project evaluation and other sources relative to African science policy, planning, and management.

c. Establishment and adequate staffing and funding of the proposed Foundation for International Technological Cooperation, FITC. Adequate attention within FITC to African states within its project and program structure.

d. Greater emphasis on LDC's and specifically African states within an expanded programmatic and funding focus in all relevant departments of government (e.g. HEW, Agriculture, Energy, etc.) concerned with science capacity building.

e. Increased emphasis on the part of the NSF to include a greater program focus on LDC/Africa related activities within an overall expansion of its international activities.

f. Continuing support and expansion of National Academy of Science Africa-related activities.

g. Better coordination and planning among U.S. Government agencies relating to Africa science activities carried on in the U.S., in Africa, and at International Research Centers.

h. Greater cooperation and coordination of U.S. Government effort with that of other developed countries active in African science development.

i. More effort to generate, organize, and make useable for policy purposes, information regarding local African conditions so as to improve the U.S. information base.

j. Better coordination and use of information generated by UN and other international bodies bearing on Africa-related science development.

k. More participation of Africans in U.S. science policy making and program development for Africa.

l. Commencement of a process leading to a national science policy for development. The politicization of the issues and their import can be expected to reach an international peak in 1979 in relation to the UN Conference on Science and Technology for Development. The high visibility generated internationally should be capitalized on nationally through executive leadership.

m. Greater encouragement of government cooperation with U.S. private industry, foundations, and interest groups to bring them into the science for development process and policy making process. U.S. public policy making should help foster a policy environment for science for development which draws upon and integrates nongovernmental capacity, know-how, and resource allocation.

CHAPTER FIVE

Policy Recommendations:
Strengthening African Capabilities

While in the immediate future "front line" science will continue to be undertaken in the countries in which there is a well articulated structure of research like the United States, an investment in African capabilities is an investment in the twenty-first century.

There are many important reasons why indigenous science capabilities should be developed in the Third World. First, artificial distinctions often made between science and technology, which are made in order to demonstrate that Africa needs technology but not science, simply do not hold when examined in the light of the problem of technology diffusion. The diffusion of technology is very much based upon the ability of local technicians and researchers to modify it to meet local circumstances. Much of today's technology is science based and it requires going back to doing science in order to determine how to adapt it to the needs of specific countries. Secondly, in the nineteenth century the lead time between a scientific discovery and its technological application tended to be long. In contrast, today it is a matter of years rather than decades and the capacity to participate in that process for the purpose of national economic production is based upon indigenous science capabilities. Without such a capability African countries will

with the dawn of the new century remain technologically noncompetitive with the rest of the world.[28] Thirdly, the mere existence of a research infrastructure increases the technology imports an individual African country might choose to consider.[29] The role of an African scientist as a conduit for scientific and technical knowledge into Africa is just as important as any research contribution he might himself make. If national capacity in key scientific areas is not developed, African societies are isolated from the ability to make public choices in the sciences and in technology which concern the implementation of their development goals. Important decisions as to what should be introduced, which bodies of knowledge are most relevant, etc., will continue to be made outside of Africa.

Finally, the general education of the society is very much dependent upon the development of internal science and research capabilities. Ignoring the question of decision making and overall development direction for a moment, science can contribute to the common man's lot in programs of scientific education beginning at the primary education level.

African capacity building in science ought to be perceived as an essential component of both short- and long-term development. It must be borne in mind that science capacity development is slow and that unless this process is begun, African societies will not only continue to lack the national science capacity needed for development today but they will continue to be plagued thirty or forty years from now with

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[28] Michael Moravcsik, "Science and the Developing Countries," US/UNCSTD, prep. 1977.

[29] Ibid., Moravcsik, p. 7.

such an institutional disability. The absence of such a capability in the year 2025 will be even more catastrophic for development -- in technical not to mention social and economic terms.

All African states find themselves at a development stage where science operates at the margin of economic and social life; where the number of researchers and trained scientists is low; where national fund allocations for research are small even in relation to national budgets; where production of university graduates and undergraduates is low; where national support services for scientists are poor; and where many of the best trained scientists study abroad and do not return home. It is sometimes argued that the way for African governments to correct this situation is to influence demand for indigenous science and technology with fiscal incentives and penalties, price policy, and the articulation of clear sector and national development plans. Governments will be unlikely to pursue such a course as long as the prospects for science aid are so meagre. More effective science development policies in Africa can be stimulated by a greater interest on the part of external donors in the policy area. African disinterest is in many respects a reflection of the international constraints under which national development operates.

The range of needs and the possible program alternatives are almost infinite. The United States might choose to integrate a program of science capacity building in individual states with other external donors, or it might choose to pursue a program of integrated science development alone for just a few African states. Whichever course is chosen, the important thing to keep in mind is the relationship of the various

components of such a policy to one another. The following taxonomy of policy measures is suggestive of such relationships.

Taxonomy of Potential Measures for Strengthening African Science Capabilities[30]

Group I Measures to Develop Scientific Infrastructure and Institutions

A. Create or expand national, regional or local research institutions; create a network of research institutions in key economic sectors.

B. Develop science planning bodies, academies of science, and research councils.

C. Establish funding mechanisms for private research.

D. Train research managers and administrators.

Group II Measures to Develop Science Support Services

A. Train science laboratory technical staffs.

B. Establish equipment maintenance and repair services.

C. Establish technical norms and standards.

D. Develop information systems -- libraries, museums.

E. Institute geodesical and geographical surveys, meteorological services and the like.

F. Develop national and regional consulting services.

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[30]This taxonomy has been borrowed and partially revised from an FITC document, "Comment on FITC Capacity Building" by Thomas Arndt with permission of the author. (mimeo)

Group III Development of Education

A. Development of graduate and undergraduate science programs.

B. Improvement of secondary and primary school science education.

C. Development of technical training schools, apprenticeship programs.

D. Manpower analysis and forecasting.

E. Adult literacy training.

Group IV Measures to Improve International Scientific Exchange

A. Organize national, regional, and international research networks.

B. Encourage travel, conferences, information exchange, and scientist exchange programs.

C. Take measures to control the brain drain.

A. Group I; Measures to Develop Science Infrastructure and Institutions.

Institution building, once fashionable, has become a development assistance policy area of ill repute. This is due in large part to the fact that early support for institutions in Africa failed because the attempts were premature, or poorly supported, or both. Institution building needs to be resurrected and there are a number of ways this can be done in the area of science for development.

An entire university department might be strengthened with a decade or more of comprehensive support. African scientists would be educated

abroad in the context of programs formulated to meet the special needs of their work environments. Such students would be assured of support for thesis research on topics relating to African development. Sabbatical and exchange programs would be established so that once the new faculty members returned home they would not be isolated off from the progress of scientific knowledge. Grants would be established for continued research beyond the thesis; and technical personnel trained. Equipment would be purchased.

The support for departments of e.g. chemistry, biology, or physics in Africa would take time but it would also foster over time the attraction of the best African students to their own universities both for education and academic employment. It would also establish permanent cooperative relations between African universities and United States science.

Regional or subregional centers of research might be supported as adjuncts and catalysts of national research. Such centers of excellence as the IITA or ICIPE which address themselves to important development problems at the same time that they foster basic research are successful African examples of such institutions. Many areas of animal and human health, agriculture, and the environment lend themselves to such research enterprises. The utility of such research facilities lies not merely in their ability to generate the needed know-how, but as in the case of strong university departments, in their education and training programs. Such centers should not be seen as substitutes for the development of national programs of research but as a means to begin to Africanize international science.

The United States might encourage private business to assist in the establishment of local research laboratories. The U.S. private sector could make an important contribution to the development of African infrastructure and institution building, the development of science support services and education. In addition, private industry excels in its research management and administration capacity. One of Africa's greatest needs is precisely in this area of manpower development.

A fourth category of institution building concerns the establishment and funding of African academies of science and research councils. While such institutions are not the quick fix for the problem of science and development that they were thought to be in the sixties, they are nevertheless important as links between African science and that of the rest of the world and as fora for peer review and support within African countries. The American National Academy of Sciences and the National Science Foundation are particularly well suited to lend support in this area.

B. Group II; Measures to Develop Science Support Services

The American trained African scientist who lacks equipment, a way to repair and maintain it, and the personnel to support his work will not be able despite his training to undertake research in his home country. Laboratories come to a standstill when equipment breaks down and there are no spare parts available to fix it. Further, a newly trained scientist and the students he begins to teach who lack access to up-to-date information in their own fields of research because libraries and other information systems are inadequate will find themselves asking

more questions than they are able to seriously explore. Investments in other areas are rendered ineffective in a short time when these systems of support are nonfunctional. And, the international brain drain is encouraged because working and studying conditions are undermined.

Beyond the special training programs suggested in the last chapter, the United States should seek out other alternatives for the development of science support services. This country is particularly experienced in the development of data collection and dissemination systems. Much about the natural and man-made environment in Africa is still a mystery. Research can address this but that which is known is so unorganized that much information remains the purview of select groups rather than being readily available for the interested and motivated student of science.[31]

Other investments in science for development should be preceded by feasibility studies assessing the state of support services. Such studies would result in the development of support services around specific research programs and would thus be immediately in demand and oriented to a specific set of R&D goals.

C. Group III; Development of Education

Science education at all levels constitutes an essential element of educational planning in societies which aim to integrate science into overall modernization. Science education cannot simply be focused upon the small elite of the professionally trained but must address issues of mass education. It is a cliché that American society is at root a

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[31]See Appendix 44.

scientific and technological culture. While the American version of this culture is certainly not the goal of most African states, many still think of science policy as something which can take place independent of social and cultural change.

Science education needs to be developed at both secondary and primary school levels; in the first instance to generate interest amongst Africans in the sciences (now largely educated in the humanities and social sciences) and in the second place to help develop science as a component of African cultures. The low porportion of Africans selecting science as a field for University study can be traced directly to the quantity and quality of science education which African school children receive in the lower grades. UNESCO has been active in the development of science curricula and programs in Africa but its assistance has not even begun to exhaust the need.

Part of a more coherent U.S. policy for the development of African science ought to embrace greater U.S. interest and participation in the development of national education plans in Africa. A vastly increased Peace Corps effort, HEW funding and staffing support, U.S. private foundations concerned with less developed countries and education, cooperation with UNESCO are just a few of the areas to be addressed. The overall social context of African societies also requires increased effort at adult literacy as a part of the effort to make science and technology and its application relevant to the employment opportunities of the African worker. In connection with UNCSTD preparations as well as earlier efforts African governments have been urged to undertake more accurate manpower analysis and to engage in manpower forecasting.

This activity should be extended beyond the Conference and incorporated into assistance in the area of the development of scientific and technical education.

The introduction of a stronger science component in African primary, secondary and college education will assure the basis for institution building: for strengthening of university departments in terms of research and teaching and for the establishment of technical training institutes. It is a long-term investment in African science capacity building which will make other efforts in the same policy area likely to grow beyond the period of donor assistance into indigenous programs of science for development.

D. Group IV; Measures to Improve International Scientific Exchange

African scientists suffer perhaps more than others in other regions of the less developed world from geographical remoteness. African science is literally as well as figuratively at the periphery of international science. This leads the African scientist to work elsewhere or if he must remain in Africa to become professionally out of touch with mainstream science.

To remedy this situation and therefore to encourage the doing of science in Africa a number of measures can be taken. First, as already discussed earlier, information networks and facilities need urgent development on the African continent. Data banks, up-to-date libraries, central information centers, etc., need support. The U.S. aid policy in conjunction with bilateral and multilateral agencies ought to increase its support in these areas. International travel and exchange

programs for scientists ought to be increased but in such a way that meaningful links overseas can be established. A quick trip to an international conference may be useful for an African scientist but a regular exchange with an overseas university or research institution either as sabbatical or direct exchange is key. An African scientist with the promise of a regular relationship with an overseas research facility will stay abreast of his field, find adequate time for research (and a needed escape from his heavy teaching load), and as a result will be encouraged to remain in Africa. Further, U.S. science will benefit as well from the opportunities for collaboration with men who understand best the problems their countries confront. The National Academy of Sciences and the National Science Foundation are each well suited to facilitate such assistance.

Taking measures to improve international scientific exchanges with Africa is not merely a way of expanding African capacity but it is an important aspect of sustaining already existing capacity. The U.S. wastes both American and African resources when a man who is educated in the States is left to his own devices to continue his research in Africa.

CHAPTER SIX

Science for Development --

No Easy Answers

Thirty years ago in his first inaugural address President Truman outlined the basic logic for a program of American development assistance. People were destitute and hungry, he said, and Americans had the know-how to help them change their own circumstances. We were in a special situation according to Truman of having amassed a body of technical methods and expertise which when transferred abroad would trigger important changes in the standard of living for millions of people.

> More than half the people of the world are living in conditions approaching misery. Their food is inadequate. They are victims of disease. Their economic life is primitive and stagnant. Their poverty is a handicap and a threat both to them and to more prosperous areas.
>
> For the first time in history humanity possesses the knowledge and the skill to relieve the suffering of these people.
>
> The United States is pre-eminent among nations in the development of industrial and scientific techniques. The material resources which we can afford to use for the assistance of other peoples are limited. But our imponderable resources in technical knowledge are constantly growing and are inexhaustible.....

Truman's clarion call was based upon a major assumption concerning development which we have only recently recognized to be faulty -- that we were in possession of the knowledge and the expertise which might be

easily transferred to other circumstances to trigger development change. We thought of development in those days as a pump priming operation and development aid to Africa was thought of in the same terms -- both in terms of politics and technics -- as just another version of the Marshall Plan. The need for basic research, for scientific capabilities in Africa, for searching for solutions to problems our own techniques could not address -- this is where we now find ourselves. The task is much more difficult than we once thought. At the same time, the chance for meaningful and long lasting change is much greater now, than it was when we began our development assistance efforts.

To date, we have underutilized our own science capacity in order to address the many intractable problems facing Africa. We have generously though not always wisely offered our educational facilities to Africans. As a result we have trained scientists who were ill prepared to undertake research in the name of African development. We have enlarged our aid program at the same time that we continued to hold on to the notion that our own American experience and expertise was best for the solving of African problems.

The failure of many past programs has led to frustration and bitterness concerning our own aid program at home. Congress queries 'how we can be spending more and achieving less?' In our own frustration we have built larger and larger institutional mechanisms for accounting purposes -- where does the money go? what was the result? who were the beneficiaries?[32] It has taken us a very long time,

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[32]See Appendix 45-52.

especially in such areas as science where our own national self-confidence is great, to understand the need to undertake programs which are carefully tailored to the concrete circumstances of specific development problems in specific countries. This process of knowledge adaptation implies research -- basic and applied.

While we understand better the need for science and research as a basis of development, we are faced in the late seventies with a political environment which is not receptive to yet another clarion call for more and better assistance programs. Political instability abroad, the hostility of less developed countries in many international economic policy making fora, discontent at home with the problem of inflation, and the overall record of assistance as a well-meaning but inept endeavor is the context in which aid has come to be perceived as a cross we bear as the international guardian of world peace and welfare. What we have lost sight of is a recognition of the fact that there has always been, and continues to be, a reason why aid serves our own national interest as well as that of African states. Today, this is more the case than it ever has been. Our own dependence upon the resources and goodwill of other states is gradually being revealed. Continued assertion of national independence in the realms of energy, trade, and environmental degradation inhibits real progress in the solution of these problems for ourselves as well as for other states. In an increasingly interdependent world neither the United States nor less developed countries can live in splendid (or miserable) isolation.

Science for development cannot be isolated from the social and economic policies of either the United States or African countries. Science planning and policy making needs to be related to the overall values and priorities of a society. From the point of view of the United States, a policy of science for development needs to be justified in the broadest possible interpretation of U.S. social, political and economic interests. It will inevitably be linked to our own understanding of how the international environment serves our own national interest, and what role science plays in that process. For African states science needs to become incorporated into their most basic activity of development planning. Science councils and science advisors need to be taken more seriously, and external resources explored more thoroughly. Science cannot magically solve the problem of development or that of international interdependence. But it is a sound basis for mutual collaboration and the extent to which it is taken seriously is a good indicator of the extent to which the problems themselves are being given serious attention.

ANNEX A

Chapters Two and Three

Appendix 1-4	UNESCO Statistical Tables: Development in Humane and Financial Resources for Science and Technology. Division of Statistics on Science and Technology. Office of Statistics 1978-CSR-S-5.
Appendix 5-13	UNESCO/SC/CASAFRICA refl. Statistics on Research and Experimental Development in African Countries. Paris 1973.
Appendix 14-25	UNESCO Statistics in Science and Technology. Extracted from UNESCO Statistical Yearbook 1976, 1977.

TABLE I Scientific and technical manpower resources

Region Country	Stock of scientists & engineers			Scientists & engineers engaged in R & D (in F.T.E.)			Number of R&D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
	Year	Total	per 10 000 population	Year	Total	per 10 000 population				
AFRICA										
Botswana	1972 1/	786	12.5	1967 1973	10 24	0.2 0.4	0.6 0.8	1967 1975	0.55 0.69	131 315
Central African Empire	1969 2/	124	0.8	1969 3/ 1975 4/	26 76	* 0.2 * 0.3	3.9 0.04	1967 1971	* 1.50 * 1.64	* 133 * 180
Chad				1969 2/ 1971 5/	19 85	0.1 0.2	1.1 1.2	1967 1975	3.43 4.03	78 121
Djibouti	1973	35	3.5					1967 1975	0.09 0.11	... ...
Gabon				1969 6/ 1970 6/	6 8	0.1 0.2	3.3 2.5	1967 1975	0.47 * 0.53	832 *2 267
Ghana	1966 7/ 1970 7/	5 137 6 897	* 6.5 8.0	1969 1975	1 015 3 889	* 1.2 3.9	8/ 1.1 8/ 1.4	1967 1975	* 8.08 9.87	* 276 464
Ivory Coast				1967 1970	204 319	0.5 0.7	0.8 0.7	1967 1975	* 4.02 4.89	* 304 686
Kenya	1970 1/7/9/ 1975 7/	3 000 5 130	2.7 * 3.8	1970 10/ 1975 11/	569 361	* 0.5 0.3	17/ * 1.8 0.5	1967 1975	10.12 13.40	111 217
Madagascar				1970 12/13/ 1971 13/	165 201	0.2 * 0.3	* 0.4 0.5	1967 1970	6.33 6.75	133 166
Malawi				1967 3/14/	14	0.0	...	1967 1975	4.12 * 5.04	67 * 150
Mauritius				1970 1975	78 135	0.9 1.5	0.7 1.1	1967 1975	0.79 0.88	325 581
Nigeria	1970/71 15/	19 885	* 3.6	1970/71 15/	2 083	* 0.4	* 0.4	1967 1975	* 51.11 * 62.93	* 116 * 390

Table II. Financial resources for research and experimental development activities

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: As % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
AFRICA									
Botswana	S.A. Rand	1968	*468	* 655	* 0.9	76 600	*0.8	*1.2	36 000
		1973	220	318	0.2	157 300	0.3	0.4	9 167
Central African Empire	Franc C.F.A.	1969	183 908	710	0.3	258 400	116.4	0.5	7 073 400
Chad	Franc C.F.A.	1/ 1969	227 060	876	0.3	313 100	63.6	0.3	11 950 500
		2/ 1973	255 220	1 151	0.3	356 500	65.9	0.3	...
Gabon 3/	Franc C.F.A.	1969	1 647	6.4	0.001	486 500	3.4	0.01	274 500
		1970	1 895	6.8	0.001	554 300	3.8	0.01	236 875
Ghana 4/	Cedi	1971	21 612	21 011	0.7	3 214 700	2.4	2.4	* 7 047
Ivory Coast	Franc C.F.A.	1967	1 661 000	6 727	0.6	1 221 600	413.2	1.7	8 142 160
		1970	1 401 124	5 044	0.3	1 843 500	325.1	1.2	4 392 200
Kenya	Shilling	5/ 1971	* 102 940	*14 412	0.8	1 793 300	*8.8	*1.2	* 180 914
Madagascar	Franc	5/6/1969	1 480 000	5 713	0.6	1 020 700	219.3	0.8	6 577 778
		7/1971	2 294 000	8 281	0.7	1 216 500	321.3	1.2	11 412 935
Malawi	Pound	1971	* 1 581	*1 934	* 0.4	425 400	*0.3	*0.4	...
Mauritius	Rupee	1967	* 3 622	* 752	0.3	256 700	*4.7	*1.0	* 62 448
		1975	17 795	2 965	0.6	511 300	20.7	3.4	131 815
Nigeria	Naira	8/ 1966	* 15 380	21 532	* 0.3	6 562 300	*0.3	*0.4	...
		9/ 1970	23 800	33 320	0.3	11 384 400	*0.4	*0.6	*11 426
Senegal 10/11/	Franc C.F.A.	1972	2 176 000	8 639	0.7	1 246 000	*528.1	*2.1	5 551 020
Seychelles	Rupee	11/ 1970	209	38	...	...	4.2	0.8	209 000
		1973	402	74	...	...	6.7	1.2	402 000

TABLE II (contd.)

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: As % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
Togo 11/	Franc C.F.A.	1971	1 070 829	3 866	1.0	388 100	532.8	1.9	9 074 822
United Republic of Cameroon	Franc C.F.A.	1967	*1 055 000	4 273	*0.5	845 800	*189.3	* 0.8	...
		1970	*1 765 000	6 363	*0.5	1 341 200	*299.7	* 1.1	5 364 742
Upper Volta	Franc C.F.A.	1970	*412 768	*1 486	0.3	426 600	* 76.7	* 0.3	...
Zambia	Kwacha	11/ 1969	*1 500	*2 100	0.1	1 552 700	* 0.4	* 0.5	* 25 000
		1972	6 261	8 765	0.4	2 007 100	1.4	2.0	* 24 081
ARAB STATES									
Bahrain	Dirham	1976	498	1 259	*0.2	12/ 576 800	1.8	* 4.7	...
Egypt	Pound	1973	29 940	75 646	0.8	8 966 700	0.8	2.1	2 807
		13/1976	33 440	85 459	*0.7	12/11 546 000	0.9	2.2	...
Iraq 14/	Dinar	1971	1 840	5 189	0.1	5 969 800	0.2	0.5	13 630
		1974	7 409	25 026	0.2	12 530 700	0.7	2.3	4 986
Jordan 15/	Dinar	1975	1 540	4 821	0.4	1 244 700	0.6	1.8	6 553
		1976	2 074	6 246	*0.5	12/1 244 700	0.7	2.2	...
Kuwait 16/	Dinar	1973	* 230	* 780	0.01	7 669 600	* 0.3	* 0.9	* 1 122
		1976	13 279	45 416	*0.5	12/9 162 000	12.9	44.1	...
Lebanon 6/17/	Pound	1967	10 000	3 121	...	...	* 4.4	* 1.4	39 526
		1974	13 175	5 665	...	...	* 4.7	* 2.0	...
Libyan Arab Jamahiriya	Dinar	1976	14 300	48 303	*0.5	12/10 435 200	* 5.9	*19.8	...
Morocco 18/	Dirham	1976	6 196	1 402	*0.01	12/7 889 800	0.3	0.08	...
Oman	Ryal	1976	427	1 236	*0.07	12/1 599 300	0.5	1.6	...
Qatar	Ryal	1976	3 775	953	...	...	37.8	9.5	...

TABLE II (contd.)

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: As % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
Somalia	Shilling	1976	26 250	4 170	* 1.3	12/ 318 800	8.0	1.3	...
Sudan	Pound	1973	3 012	8 649	0.3	3 002 800	0.2	0.5	* 1 103
Syrian Arab Republic	Lira	1976	27 077	6 965	* 0.1	12/ 4 869 500	3.6	0.9	...
Tunisia	Dinar	1977	8 544	19 916	* 0.5	12/ 4 225 200	*1.5	*3.5	...
Yemen Arab Republic	Rial	1974	9 923	2 171	...	...	6.0	1.3	165 383
ASIA									
Bangladesh 19/	Taka	1974	113 530	24 159	0.3	7 909 100	1.5	0.3	* 68 848
Brunei	Dollar	11/ 1971	2 425	795	...	...	* 17.3	* 5.7	346.429
		1974	3 055	1 270	...	...	20.4	8.5	138 864
Burma	Kyat	1973	11 960	2 439	0.1	2 523 600	0.4	0.08	...
Cyprus	Pound	1967	633	1 751	0.4	477 100	1.1	3.0	8 792
		1971	1 088	2 650	0.3	779 100	1.8	4.3	9 299
India	Rupee	1969	1 166 200	155 489	0.3	53 634 900	2.2	0.3	15 838
		1972	1 942 600	256 229	0.4	66 506 500	3.4	0.5	18 721
Indonesia 20/	Rupiah	1972	3 315 570	7 991	0.05	16 028 400	26.3	0.06	...
		1975	19 496 580	46 987	0.2	24 184 900	143.3	0.3	1 592 337
Iran	Rial	1970	4 414 595	58 273	0.3	20 206 100	154.0	2.0	1 468 106
		21/ 1972	3 531 807	46 620	0.2	27 437 100	115.6	1.5	721 366
Israel 11/ 22/	Pound	1969	175 000	49 998	0.9	5 836 700	62.3	17.8	* 62 500
		1975	803 000	126 312	1.0	12 398 000	236.9	37.3	* 239 701

TABLE 19 Historical data on trends in expenditure for research and development

Country	Fiscal year beginning	Currency	Expenditure for R & D		
			Total (000)	Current expenditure	
				Amount (000)	Percentage of total (%) 1/
Algeria 2/	1971	Dinar	77 500	67 500	87.1
	1972		78 000	68 000	87.2
Chad 3/4/5/	1965	Franc CFA	176 868	169 456	95.8
	1966		185 800	173 900	93.6
	1967		183 900	180 872	98.4
	1968		194 575	188 090	96.7
	1969		187 360	183 060	97.5
Gabon 6/	1969	Franc CFA	1 647	1 603	97.3
	1970		1 895	1 882	99.3
Libyan Arab Republic 3/5/	1965	Pound	...	202	...
	1966		...	195	...
Madagascar	1966	Franc	7/ 8/ 997 000	7/8/955 000	95.8
	1969		7/ 8/ 1 480 000	7/8/ 1 438 000	97.2
	1970		8/9/ 2 043 000	8/9/ 2 015 000	98.6
	1971		9/ 2 294 000	9/ 2 294 000	100.0
Malawi 3/ 10/	1965	Pound	...	2	...
	1966		...	17	...
	1967		...	37	...
	1968		...	26	...
Mauritius and deps.	1966	Rupee	• 3 286	2 858	• 86.8
	1967		• 3 622	3 153	• 87.1
	1968		• 3 897	3 413	• 87.6

TABLE 19 (contd.)

Country	Fiscal year beginning	Currency	Expenditure for R & D		
			Total (000)	Current expenditure	
				Amount (000)	Percentage of total (%) 1/
Mauritius and deps.	1969	Rupee	* 4 187	3 621	* 86.5
	1970		* 5 124	4 290	* 83.7
Rwanda 3/	1963	Franc	...	[illegible] 000	...
	1964		...	1[illegible] 900	...
	1965		...	19 500	...
	1966		...	18 500	...
	1967		...	24 400	...
Somalia 3/	1963	Shilling	...	* 600	...
	1964		...	* 600	...
	1965		...	* 700	...
	1966		...	* 720	...
	1967		...	* 770	...
Tunisia 2/3/	1964	Dinar	...	159	...
	1965		...	172	...
	1966		...	187	...
	1967		...	205	...

Notes: 1. Please refer to notes in the two preceding columns.
2. Data relate to higher education sector only.
3. Not including data for law, humanities, education and arts.
4. Partial data; data given are for the "Institut d'élevage et de médecine vétérinaire des pays tropicaux" and the "Institut de recherche du coton et des textiles exotiques"
5. Data relate to general service sector only.
6. Data relate to the "Office de la recherche scientifique et technique Outre-mer (ORSTOM) only.
7. Not including data for productive sector.
8. Not including data for humanities, education and arts.
9. Not including data for productive sector (integrated R & D)
10. Data are for University of Malawi only.

TABLE 10 (contd.)

Country	Fiscal year beginning	Currency	Type of expenditure	Total (000)	Source of funds: Government funds (000)	Special funds (000)	Productive enterprise funds (000)	Foreign funds (000)	Other funds (000)
Mauritius	1970	Rupee	total	* 5 124	21 81	-	2 724	130	89
			%	100.0	*42.6	-	* 53.2	*2.5	* 1.7
			current	4 290	1 656	-	2 425	120	89
			%	100.0	38.6	-	56.5	2.8	2.1
Nigeria 2/10/	1970	Pound	total	11/11 911	11 513	-	-	* 398	-
			%	100.0	96.7	-	-	* 3.3	-
Upper Volta	1970	Franc CFA	total	* 412 768	*30 513	-	-	*323 377	* 58 878
			%	100.0	* 7.4	-	-	* 78.3	* 14.3

Notes:
1. Data relate to higher education sector only.
2. Not including data for law, humanities, education and arts.
3. Data for total expenditure relate to 5 research institutes only whilst data for current expenditure relate to only 4 of the 5 institutes.
4. Partial data; data given are for the "Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux" and the "Institut de Recherche du Coton et des Textiles Exotiques."
5. Data relate to general service sector only.
6. Not including 2 million CFA francs for which breakdown is not available.
7. Not including data for humanities, education and arts but including architecture and some educational research.
8. Not including capital expenditure for productive sector (integrated R & D) and higher education sector.
9. Not including data for productive sector (integrated R & D).
10. Not including data for social sciences.
11. Data refer to Federal and State Governments' Budgetary Estimates for research and technical development services and university expenditure on R & D.

manpower. On the other hand, the fraction of R&D expenditure in the productive sector is generally higher than that of R&D personnel.

Current expenditure for R&D by type of R&D activity

72. The distribution of R&D activities by type of research, i.e. fundamental research, applied research and experimental development, is an indication of the orientation and structure of R&D efforts. Unfortunately, it was not possible to collect and analyse the appropriate statistical data for many African countries. Some general idea of the distribution of R&D expenditure by type of R&D activity can be given on the basis of the data presented in Table 17 for 6 African countries. Again, no distinctive pattern can be drawn on the basis of these data, though, in general, applied research among these three types of R&D activity would seem to be presented as the largest consumer of current R&D expenditure for all these countries. For example, in Chad the share of current expenditure on applied research in total expenditure for R&D accounts for about 80%, Madagascar 74% and Mauritius 98% of total R&D expenditure. On the other hand, the share of fundamental research varies greatly and ranges from only 1.7% for Kenya to 34.4% for Ivory Coast. The data on the expenditure for experimental development are given for only 2 countries, Ivory Coast and Mauritius, where their shares are shown as 14.3% of total and 2.3% of current R&D expenditure respectively.

Expenditure for R&D by source of funds

73. There are five major sources of funds distinguished in Unesco science statistics: government funds, special funds, productive enterprise funds, foreign funds and other funds.

The structures of financing by these sources of funds are given in Table 18 for 10 reporting countries. In most of the countries government funds constitute the main source of financing as is seen from the following figures:

TABLE J. Government funds as percentage of total R&D funds

	Total	Current
Algeria	100 (1)	100 (1)
Central African Republic	78.4 (2)	73.1 (2)
Chad	49.8 (3)	49.8 (3)
Ivory Coast	30.4	...
Kenya	81.7	77.4
Malawi	54.1	60.4
Mauritius	42.6	38.6
Nigeria	96.7	...

(1) Data for higher education sector only.
(2) Data on total expenditure are only for 5 research institutes and on current expenditure for 4 out of 5 of these institutes.
(3) Data are for general service sector only.

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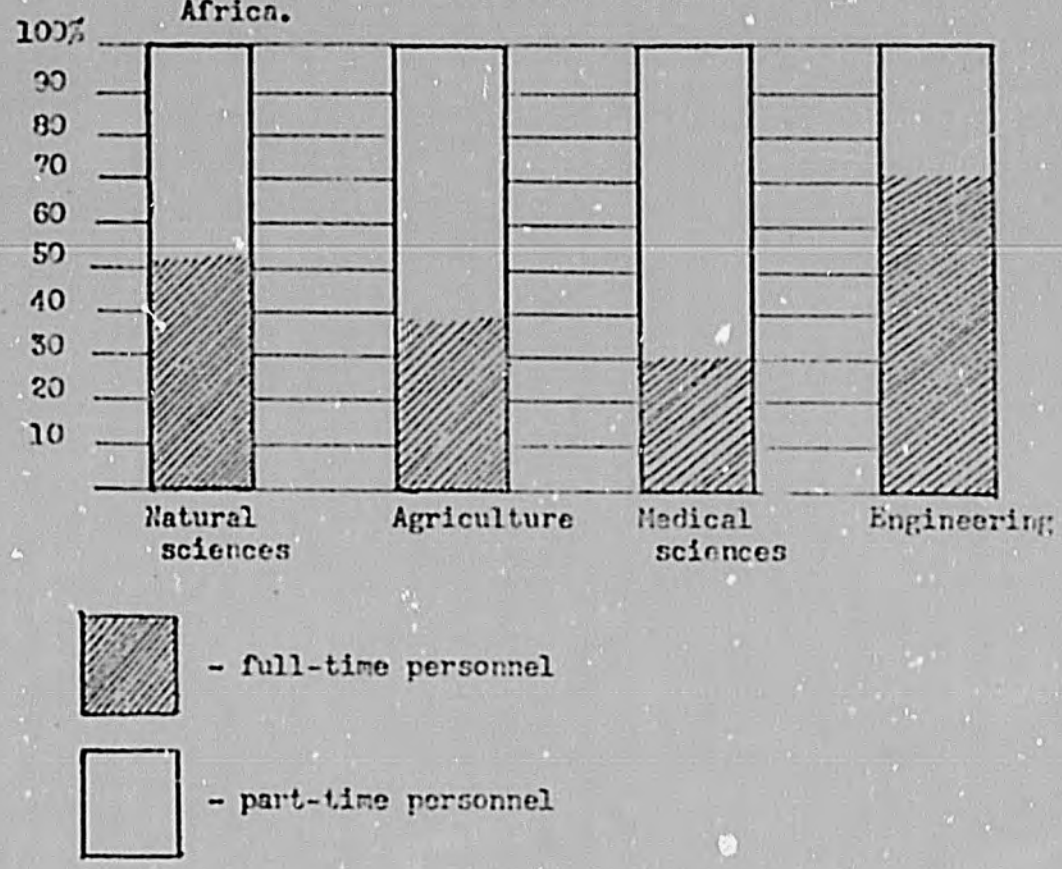
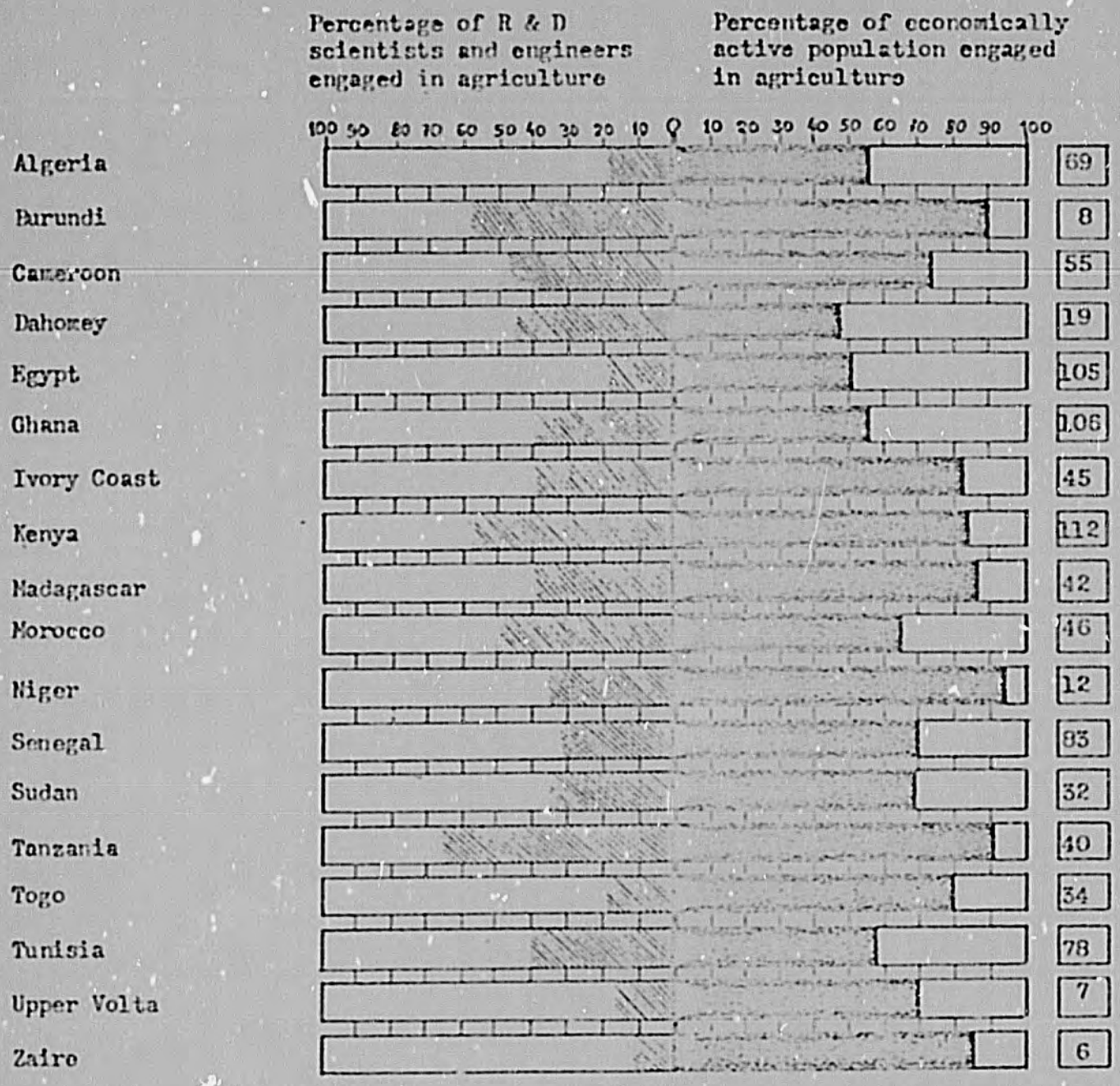
FIGURE 5

Full-time and part-time scientists and engineers in main techno-scientific groups of R & D in Africa.



34. Tables 6 and 7 represent data on distribution of scientific and technical manpower engaged in R&D by sector of performance - in absolute figures and as percentage of total. Unesco practice distinguishes three sectors of R&D performance, i.e. higher education, productive sector and general service sector. Of 36 countries listed in the tables only 18 show data for all three sectors. Higher education sector is shown for 26 countries, and general service - for 23 countries. The absence of appropriate data for certain countries does not necessarily mean that there are no R&D activities in a sector, but only that data were omitted in the Survey. However, the data shown in the tables enable one to make some general observations. The higher education sector is the most important employer of scientists and engineers: for all African countries this sector includes 55% of total R&D scientists and engineers. The rest are divided between the productive sector - 36% and general service sector only 9%. Country by country analysis however shows large variations from this pattern. Much above average proportions of scientists and engineers in higher education sector are found in Guinea 80%, Lesotho 80%, Libya 85% and Sierra Leone 88%; but this percentage never drops below 30% in all countries showing data for this sector, except for 5 countries: Burundi 17%, Cameroon 28%, Mauritius 11%, Morocco 19% and Tanzania 18%. In all African countries the productive sector is found to be another important employer of scientific and technical manpower in R&D. In 5 countries:

FIGURE 4 R & D scientific manpower and economically active population in agriculture



their stock of scientific and technical manpower. In seven out of the following 8 countries shown in Table B their numbers do not exceed 10% of total stock.

TABLE B. Scientists, engineers and technicians engaged in R&D as percentage of corresponding stock

	Total scientific and technical manpower	Scientists and engineers	Technicians
	%	%	%
Cameroon	5.8	10.0	4.7
Congo	3.1	7.4	0.7
Ghana	5.8	5.3	6.0
Kenya	16.5	19.5	15.6
Nigeria	3.8	3.8	3.8
Rwanda	3.9	9.2	1.5
Somalia	1.3*	2.3*	1.1*
Upper Volta	30.5	30.0	31.4

20. It is interesting to note that this proportion of employment of scientific and technical manpower in research and development is on the whole similar to that in the countries of other regions of the world. In Asia and Europe, for example, it rarely exceeds 10%. For more than half of the countries listed above scientists and engineers have a higher percentage of employment in R&D than technicians.

21. Table 3 shows the total number of scientists, engineers and technicians engaged in R&D, the ratio of technicians per scientist and engineer, and the number of scientists and engineers per million inhabitants for 36 African countries.

22. Only in 5 countries (Algeria, Arab Republic of Egypt, Ghana, Kenya and Nigeria) do the totals number more than 1,000 persons. In the others their numbers vary considerably, ranging from 28 (Mauritania) to 995 (Sudan). Scientists and engineers are shown as a total of full-time and part-time personnel, and the percentage of those working part time is also shown. It can be seen from the table that the number of part-time scientists and engineers is rather large and reaches on average 46% for all the countries. The highest percentages of part-time scientists and engineers engaged in R&D are in the Arab Republic of Egypt 60%; Guinea 81%; Lesotho 80%; Libya 73%; Sierra Leone 77% and in Zaire 69%. It is evident that the majority of part-time scientists and engineers are found in the sector of higher education where research work is usually combined with training and teaching.

23. Scientists and engineers for the countries of Africa taken as a whole constitute about 50% of the total scientific and technical manpower engaged in R&D. In this connexion, it is worth while referring to the recommendations of the Lagos Conference on the Organization of Research and Training in Africa in Relation to

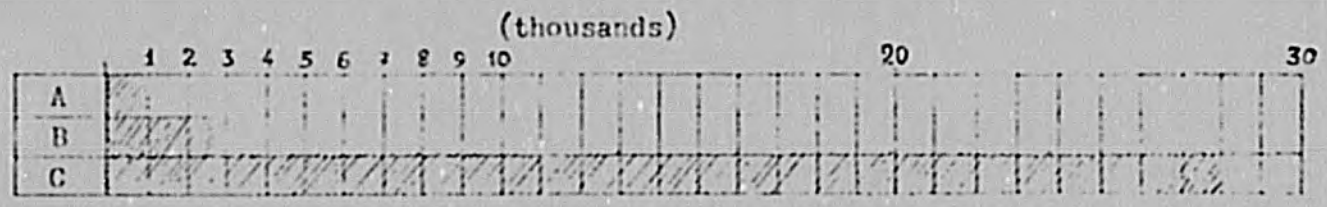
In the other countries the percentage is distinctly higher: Nigeria 57%, Togo 69%, and Upper Volta 61%. The average of highly qualified personnel for all reporting countries of the continent does not exceed 35% of the total stock. For comparison, the average for this category in Europe (in 10 reporting countries) is about 40% and in Asia (in 12 reporting countries) - 55% of total scientific and technical manpower.

16. Table 2 of the Appendix shows the relation of scientists, engineers and technicians to total and economically active population in 15 African countries. The ratios of scientific and technical manpower per million inhabitants in different countries vary considerably. In 6 countries they are more than 1,000 (Ghana - 2,545, Kenya - 1,058, Malawi - 1,524, Mauritius - 3,330, Tanzania - 1,193 and Tunisia - 2,780). For other countries the ratios range from 52 to 750, as seen from the table. Of course, one should keep in mind the limitations mentioned in the introduction which have an obvious bearing on the comparability of these ratios.

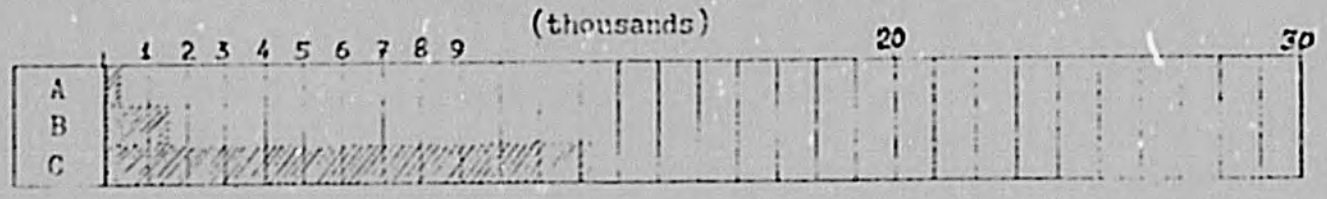
17. There are also significant differences in ratios of scientists and engineers per million inhabitants in different countries. For 4 countries they do not exceed 100 (Central African Republic, Rwanda, Somalia and Upper Volta), for 9 other countries they range between 120 and 450 (Cameroon, Congo, Kenya, Malawi, Nigeria, Sudan, Tanzania, Togo and Tunisia). Only for Ghana and Mauritius the ratios are rather considerable (720 and 795 respectively). Nevertheless, the average ratios of scientists, engineers and technicians for all these countries seem to be extremely low when compared with countries of other regions of the world. This can be illustrated by the following graphs in Fig. 2 based on available, though in some cases partial, statistical data for the countries of Africa, Asia and Europe:

FIGURE 2

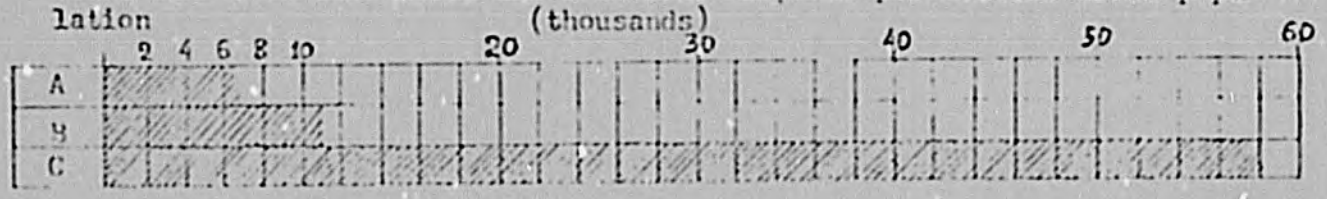
Total number of scientific and technical manpower per million inhabitants



Total number of scientists and engineers per million inhabitants.

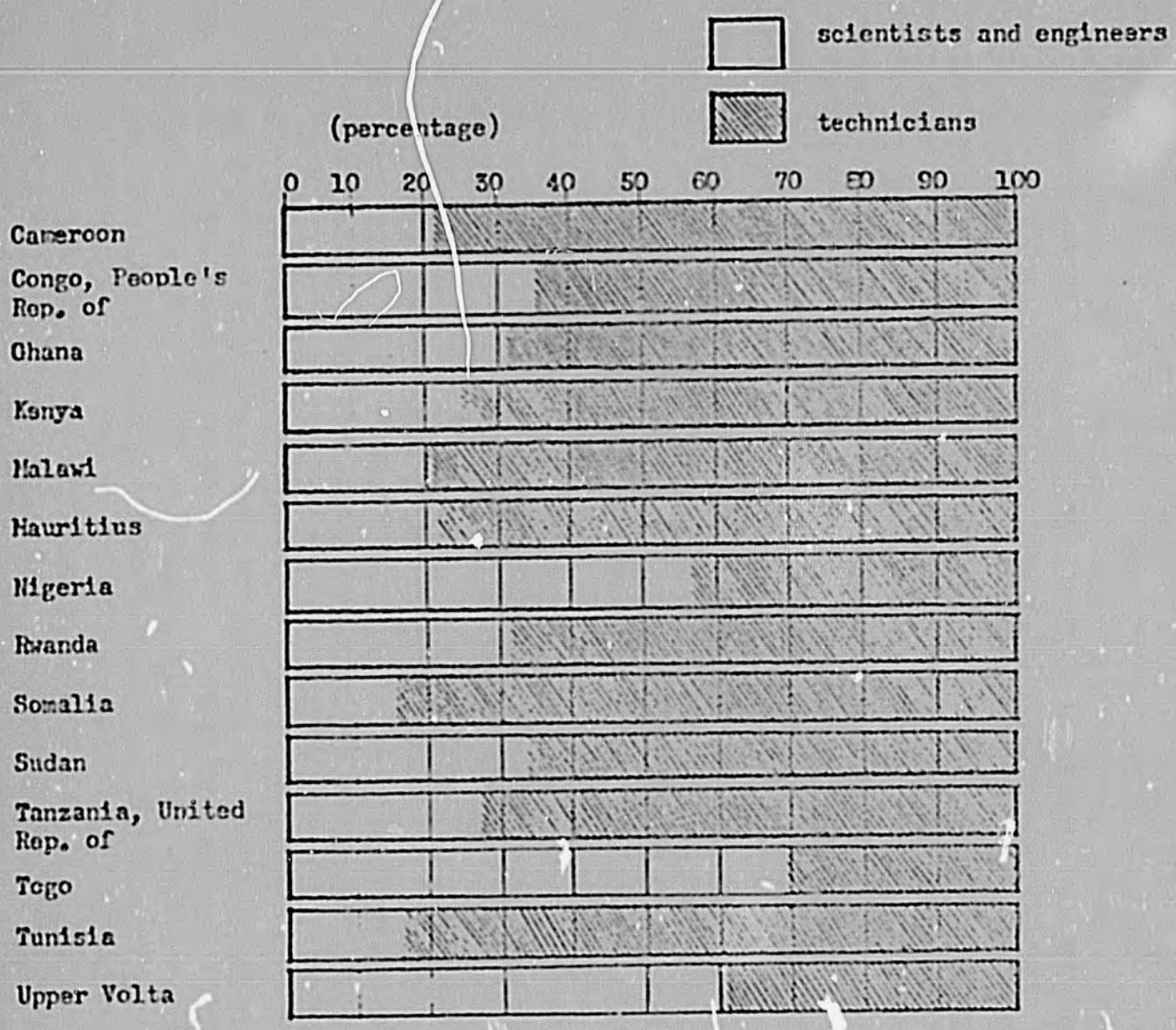


Total number of scientific and technical manpower per million urban population



A - Africa ; B - Asia (not including Japan); C - Europe (not including USSR)

FIGURE 1 Proportions of scientists, engineers and technicians in total stocks of scientific and technical manpower in African countries



Scientific and technical manpower
Personnel scientifique et technique
Personal científico y técnico

7.1 Total stock of scientists, engineers and technicians
Effectif total des scientifiques, des ingénieurs et des techniciens
Número total de científicos, ingenieros y técnicos

Please refer to introduction for definitions of categories in this table.

SET = Scientists, engineers and technicians

Number of countries and territories presented in this table: 84

Pour les définitions des catégories présentées dans ce tableau, se référer à l'introduction.

SET = Scientifiques, ingénieurs et techniciens

Nombre de pays et de territoires présentés dans ce tableau: 84

En la introducción se dan las definiciones de las categorías que figuran en este cuadro.

SET = Científicos, ingenieros y técnicos

Número de países y de territorios presentados en este cuadro: 84

COUNTRY / PAYS / PAIS	YEAR / ANNEE / AÑO	TOTAL / TOTAL / TOTAL (SET)	SCIENTISTS AND ENGINEERS / SCIENTIFIQUES ET INGENIEURS / CIENTIFICOS E INGENIEROS		TECHNICIANS / TECHNICIENS / TECNICOS	
			TOTAL	F	TOTAL	F
		(1)	(2)	(3)	(4)	(5)
AFRICA						
BOTSWANA[1]	1972	1 527	786	...	741	...
EGYPT	1973	...	593 254	...	...	...
FRENCH TERRITORY OF THE AFARS AND ISSAS	1973	35	35	4	-	-
GHANA[2]	1970	21 993	6 897	789	15 096	7 964
KENYA	1972	13 541	3 955	...	9 586	...
LIBYAN ARAB JAMAHIRIYA[3,4]	1973	*18 921	*8 319	...	*10 602	...
NIGERIA[3,5]	1970	35 126	19 835	...	15 241	...
SEYCHELLES[2]	1973	...	*300	...	...	...
SUDAN[6]	1971	*16 431	*13 792	...	*2 639	...
TOGO[7]	1971	672	461	...	211	...
UNITED REPUBLIC OF CAMEROON[8]	1970	*3 500	...	...	...	...
ZAMBIA	1973	37 000	11 000	...	26 000	...
AMERICA, NORTH						
ANTIGUA[10]	1970	*780	*480	*610	*300	./.
BAHAMAS	1970	*6 600	*3 000	*800	*3 600	*2 100
BELIZE[11]	1970	728	201	96	527	271
BERMUDA[2]	1970	3 603	1 626	569	1 977	808
BRITISH VIRGIN ISLANDS[2,12]	1973	*320	*120	*40	*200	*100

Appendix 15

9.3 Scientific and technical manpower and expenditure for R & D (selected indicators)
Personnel scientifique et technique et dépenses de R-D (indicateurs sélectionnés)
Personal científico y técnico y gastos de I y D (indicadores seleccionados)

COUNTRY / PAYS / PAIS	YEAR / ANNEE / AÑO	TOTAL STOCK[1] / EFFECTIF TOTAL[1] / NUMERO TOTAL[1]: SCIENTISTS AND ENGINEERS PER 10 000 POPULATION / SCIENTIFIQUES ET INGENIEURS PAR 10 000 HABITANTS / CIENTIFICOS E INGENIEROS POR 10 000 HABITANTES	TECHNICIANS PER 10 000 POPULATION / TECHNICIENS PAR 10 000 HABITANTS / TECNICOS POR 10 000 HABITANTES	PERSONNEL ENGAGED IN R&D[1] / PERSONNEL EMPLOYE A DES TRAVAUX R-D[1] / PERSONAL DEDICADO A ACTIVIDADES DE I Y D: SCIENTISTS AND ENGINEERS (FTE) PER 10 000 POPULATION / SCIENTIFIQUES ET INGENIEURS (FTE) PAR 10 000 HABITANTS / CIENTIFICOS E INGENIEROS (FTE) POR 10 000 HABITANTES	TECHNICIANS PER 10 000 POPULATION / TECHNICIENS PAR 10 000 HABITANTS / TECNICOS POR 10 000 HABITANTES	NUMBER OF TECHNICIANS PER SCIENTIST AND ENGINEER / NOMBRE DE TECHNICIENS PAR SCIENTIFIQUE ET INGENIEUR / NUMERO DE TECNICOS POR CIENTIFICO E INGENIERO
		(1)	(2)	(3)	(4)	(5)
SEYCHELLES[8]	1973	*51.2	...	0.2	-	-
SUDAN[8,9]	1974	*8.6	*1.6	1.6	1.2	0.7
TOGO	1971	*2.3	*1.0	*0.6	*0.1	*0.2
TUNISIA[10]	1972	...	...	* 1.5	* 1.0	*0.7
UNITED REPUBLIC OF CAMEROON[3]	1970	*6.0	---->	0.6	...	...
UPPER VOLTA	1970	...	...	...	...	...
ZAMBIA[11,12]	1973	23.7	56.0	0.6	1.7	3.1
AMERICA, NORTH						
ANTIGUA	1970	*68.6	*42.9	...	...	...
BAHAMAS	1970	*176.5	*211.8	*1.1	*0.1	*0.1
BELIZE	1970	16.8	43.9	1.2	0.3	0.3
BERMUDA	1970	325.2	355.4	0.8	0.6	0.8
BRITISH VIRGIN ISLANDS	1973	*100.0	*166.7	-	-	-
CANADA	1973	280.9	...	6.9	6.0	0.9
CAYMAN ISLANDS	1971	200.0	350.0	3.0	3.0	1.0
EL SALVADOR	1974	13.8	4.5	2.0	*1.3	0.6
GUATEMALA	1974	*9.8	*12.5	*0.5	*0.8	*1.4
JAMAICA	1971	...	...	...	...	...
MEXICO[8]	1974	...	...	1.0	...	...
NICARAGUA[13]	1971	...	...	...	...	...
PANAMA[14]	1975	2.2	3.4	1.2	1.8	1.5
ST. PIERRE AND MIQUELON	1972	...	...	11.7	6.7	0.6
TRINIDAD AND TOBAGO[10]	1970	...	...	3.7	1.9	0.5
TURKS AND CAICOS ISLANDS	1975	26.7	*41.7	5.0	-	-
UNITED STATES OF AMERICA	1974	75.2	43.8	24.8	2.0	0.1
AMERICA, SOUTH						
ARGENTINA[15]	1974	155.7	818.4	3.2	4.4	1.4
BOLIVIA	1974	17.7	...	...	...	...
BRAZIL[6]	1974	58.5	127.3	*0.8	...	...
CHILE	1975	...	...	5.8	...	...
COLOMBIA[10]	1971	...	...	0.5	...	...
ECUADOR	1970	...	...	1.0	0.8	0.9
FALKLAND ISLANDS (MALVINAS)	1971	...	...	-	-	-
PERU[16]	1970	*57.0	*40.2	1.2	0.8	0.6
URUGUAY[8,17]	1971	*65.4	*104.8	*3.9	*3.7	*0.9
VENEZUELA[11]	1973	...	...	2.6	0.8	0.3

9.3 Selected indicators for scientific and technical manpower and expenditure for research and experimental development

Indicateurs sélectionnés pour le personnel scientifique et technique et les dépenses de recherche et de développement expérimental

Indicadores seleccionados para el personal científico y técnico y los gastos de investigación y de desarrollo experimental

Please refer to introduction for definitions of categories included in this table.

FTE = Full-time equivalent
SET = Scientists, engineers and technicians

Number of countries and territories presented in this table: 117

Pour les définitions des catégories présentées de ce tableau, se référer à l'introduction.

FTE = Equivalent plein temps
SET = Scientifiques, ingénieurs et techniciens

Nombre de pays et de territoires présentés dans ce tableau: 117

COUNTRY / PAYS / PAIS	YEAR / ANNEE / AÑO	TOTAL STOCK[1] / EFFECTIF TOTAL[1] / NUMERO TOTAL[1]: SCIENTISTS AND ENGINEERS PER 10 000 POPULATION / SCIENTIFIQUES ET INGENIEURS PAR 10 000 HABITANTS / CIENTIFICOS E INGENIEROS POR 10 000 HABITANTES	TOTAL STOCK[1] / EFFECTIF TOTAL[1] / NUMERO TOTAL[1]: TECHNICIANS PER 10 000 POPULATION / TECHNICIENS PAR 10 000 HABITANTS / TECNICOS POR 10 000 HABITANTES	PERSONNEL ENGAGED IN R&D[1] / PERSONNEL EMPLOYE A DES TRAVAUX R-D / PERSONAL DEDICADO A ACTIVIDADES DE I Y D: SCIENTISTS AND ENGINEERS (FTE) PER 10 000 POPULATION / SCIENTIFIQUES ET INGENIEURS (FTE) PAR 10 000 HABITANTS / CIENTIFICOS E INGENIEROS (FTE) POR 10 000 HABITANTES	TECHNICIANS PER 10 000 POPULATION / TECHNICIENS PAR 10 000 HABITANTS / TECNICOS POR 10 000 HABITANTES	NUMBER OF TECHNICIANS PER SCIENTIST AND ENGINEER / NOMBRE DE TECHNICIENS PAR SCIENTIFIQUE ET INGENIEUR / NUMERO DE TECNICOS POR CIENTIFICO E INGENIERO
		(1)	(2)	(3)	(4)	(5)
AFRICA						
ALGERIA[3]	1972	...	...	0.2	0.1	0.4
BOTSWANA[4]	1973	12.5	11.8	0.4	0.3	0.8
CENTRAL AFRICAN EMPIRE	1975	...	...	•0.3	•0.01	•0.04
CHAD[5]	1971	...	...	0.2	0.3	1.2
EGYPT	1973	166.6	...	3.0	...	...
FRENCH TERRITORY OF THE AFARS AND ISSAS	1973	3.5	-	...	...	...
GABON[3]	1970	...	...	0.2	0.4	2.5
GHANA[6,7]	1972	8.0	17.5	3.9	5.5	1.4
IVORY COAST[3]	1970	...	...	0.7	0.5	0.7
KENYA[6,7]	1970	3.3	7.9	•0.5	•0.9	•1.8
LIBYAN ARAB JAMAHIRIYA	1973	•37.0	•65.0	• 0.2	•0.9	•2.8
MADAGASCAR[3]	1971	...	...	•0.3	•0.1	•0.5
MAURITIUS	1975	...	...	1.5	1.6	1.1
NIGERIA[3,7]	1970	3.6	2.8	•0.4	•0.1	•0.4
SENEGAL[3]	1972	...	...	•1.0	•1.2	•1.3

COUNTRY / PAYS / PAIS	YEAR / ANNEE / AÑO	PERSONNEL ENGAGED IN R & D / PERSONNEL EMPLOYE A DES TRAVAUX DE R-D / PERSONAL DEDICADO A ACTIVIDADES DE I Y D: TOTAL / TOTAL / TOTAL	SCIENTISTS AND ENGINEERS / SCIENTIFIQUES ET INGENIEURS / CIENTIFICOS E INGENIEROS: NUMBER (FTE) / NOMBRE (FTE) / NUMERO (FTE)	INDEXES OF SCIENTISTS AND ENGINEERS (1969 = 100)[1] / INDICES DES SCIENTIFIQUES ET INGENIEURS (1969 = 100)[1] / INDICES DE LOS CIENTIFICOS E INGENIEROS (1969 = 100)[1]
DEVELOPING COUNTRIES		(1)	(2)	(3)
AFRICA				
GABON[2]	1969	84	6	100
	1970	86	8	133
GHANA[3]	1969	2 096	1 [illegible]15	100
	1970	4 092	1 713	169
	1971	7 610	3 067	302
	1972	8 559	3 559	351
MADAGASCAR[4,5]	1970	224	165	100
	1971	298	201	122
MAURITIUS	1969	•335	61	100
	1970	•364	78	128
	1973	477	91	149
	1974	624	144	236
	1975	605	135	221
SEYCHELLES	1969	...	1	100
	1970	...	1	100
	1971	2	2	200
	1972	2	2	200
	1973	1	1	100
SUDAN[6]	1971	5 328	249	100
	1974	16 205	•2 731	1097
ZAMBIA[7]	1969	•240	•60	100
	1970	•285	•75	125
	1973	1 060	260	433
AMERICA, NORTH				
BERMUDA[8]	1969	10	4	100
	1970	10	4	100
GUATEMALA[4]	1970	364	230	100
	1972	•522	•267	116
	1974	749	310	135
ST. PIERRE AND MIQUELON[9]	1969	6	5	100
	1970	14	7	140
	1972	37	7	140
TURKS AND CAICOS ISLANDS[4]	1970	0.5	0.5	100
	1972	3	2	400
	1973	4	2	400
	1974	3	3	600
	1975	3	3	600

Appendix 18

8 Expenditure for R & D
Dépenses affectées à la R D
Gastos destinados a I y D

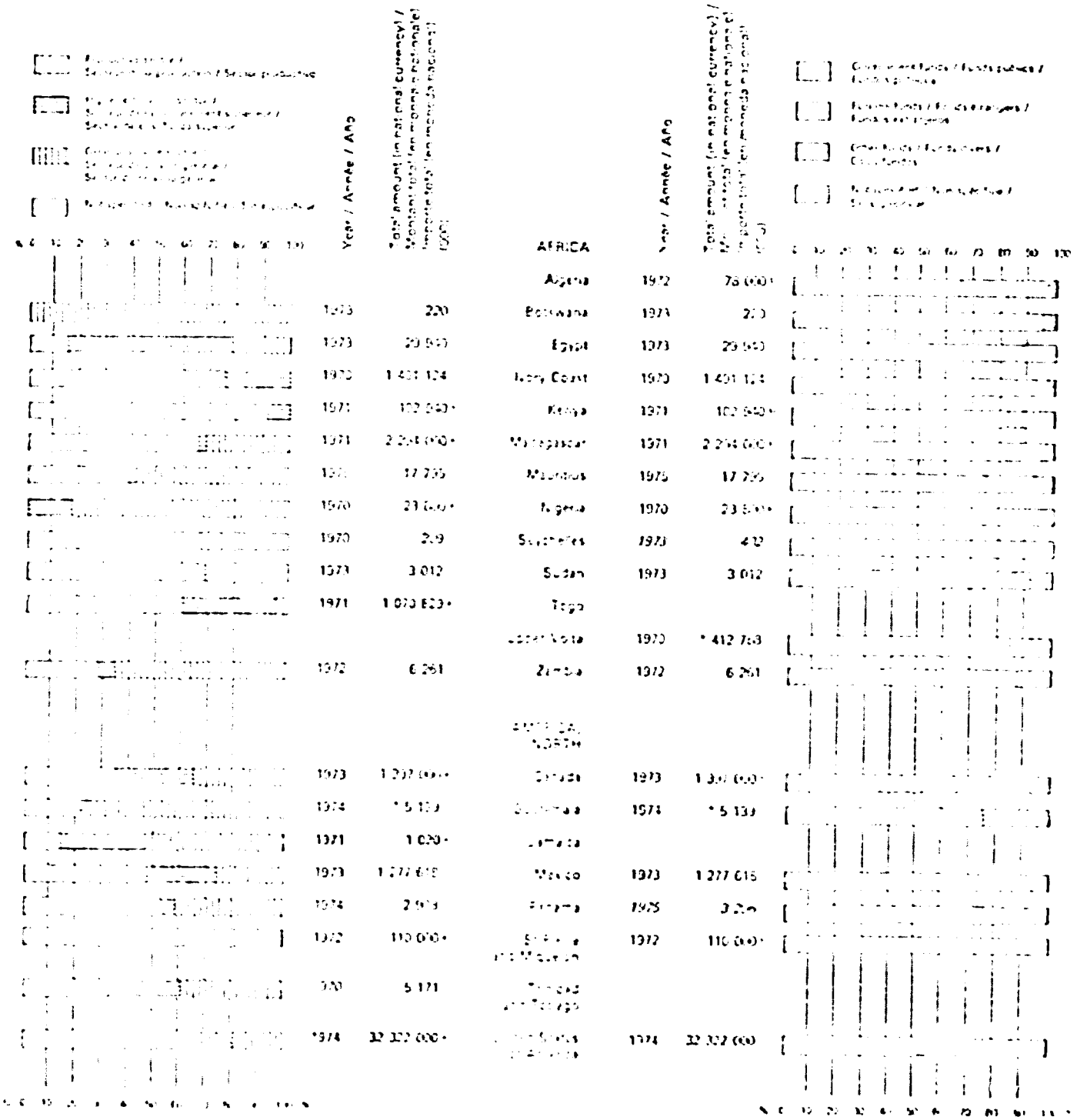
Chart 2: Expenditure for R & D: percentage distribution by sector of performance and by source of funds

Graphique 2: Dépenses consacrées à la R D: Répartition en pourcentage par secteur d'exécution et par source de financement

Gráfico 2: Gastos destinados a I y D: repartición en porcentaje por sector de ejecución y fuente de financiamiento

Sector of performance / Secteur d'exécution / Sector de ejecución

Source of funds / Source de financement / Fuente de financiamiento



	Year / Année / Año	Total amount (in national currency) / Montant total (en monnaie nationale) / Importe total (en moneda nacional) (000)
AFRICA		
Algeria	1972	76 000+
Botswana	1973	200
Egypt	1973	29 940
Ivory Coast	1970	1 401 124
Kenya	1971	102 940+
Madagascar	1971	2 294 000+
Mauritius	1975	17 755
Nigeria	1970	23 600+
Seychelles	1973	419
Sudan	1973	3 012
Togo		
Upper Volta	1970	* 412 768
Zambia	1972	6 261
AMERICA, NORTH		
Canada	1973	1 337 000+
Guatemala	1974	* 5 139
Jamaica		
Mexico	1973	1 277 615
Panama	1975	3 [illegible]
United States of America	1972	110 000+
Trinidad and Tobago		
[illegible]	1974	32 332 000

BEST AVAILABLE DOCUMENT

Appendix 19

Expenditure for R & D
Dépenses afférentes à la R-D
Gastos destinados a I y D

Sector of performance / Secteur d'exécution / Sector de ejecución

Source of funds / Source de financement / Fuente de financiamiento

	Sector of performance		Source of funds	
AMERICA, SOUTH				
Argentina	1974	1 630 600 *	1974	1 630 600 *
Colombia	1971	210 614 *		
Ecuador	1970	90 515 *		
Peru	1970	984 636 *		
Uruguay	1972	1 858	1972	1 858
Venezuela	1970	102 270		
ASIA				
Bangladesh	1974	113 530 *	1974	113 530 *
Brunei	1974	3 055	1974	3 055
Cyprus	1971	1 088	1971	1 088
India	1972	1 942 600	1972	1 942 600
Iran	1972	3 531 807 *	*1971*	*4 856 054*
Iraq	1974	7 409 *		
Israel	1975	803 *		
Japan	1974	2 716 032 *	1974	2 716 032 *
Korea, Republic of	1974	23 012 000 *	1974	23 012 000 *
Pakistan	1973	150 430 *	1973	150 430 *
Philippines	1973	218 106 *	1973	218 106 *
Singapore	1975	5 322		
Turkey	1972	622 400 *		
Yemen Arab Republic	1974	9 923 *	1974	9 923 *
EUROPE				
Czechoslovakia	1973	14 761 798	*1975*	*15 867 000*
Denmark	1973	1 654 000	1973	1 654 000
Finland	1973	624 220	*1971*	*435 577 ***
France	1974	23 031 400	1974	23 031 400
Germany, Federal Republic of	1973	19 247 000 *	1973	19 247 000
Hungary	1975	12 439 000 *	*1975*	*13 594 000*
Iceland	1970	164 500 *		
Ireland	1971	23 471	1974	23 471
Italy	1974	916 833 *	1974	916 833 *
Netherlands	1974	3 892 000 *	1974	3 892 000 *
Norway	1975	2 002 000	1975	2 002 000
Poland	1975	37 011 200	*1973*	*29 000 000*
Portugal	1972	854 150	1972	854 150

Appendix 20

R & D: personnel by sector of performance
R D: personnel par secteur d'exécution
I y D: personal por sector de ejecución

COUNTRY / PAYS / PAIS	YEAR / ANNEE / AÑO	TYPE OF PERSONNEL / CATEGORIE DE PERSONNEL / CATEGORIA DE PERSONAL	SECTOR OF PERFORMANCE / SECTEUR D'EXECUTION / SECTOR DE EJECUCION: ALL SECTORS / TOUS SECTEURS / TODOS LOS SECTORES	PRODUCTIVE SECTOR / SECTEUR DE LA PRODUCTION / SECTOR PRODUCTIVO: INTEGRATED R&D / ACTIVITES DE R-D INTEGREES / ACTIVIDADES DE I Y D INTEGRADAS	NON-INTEGRATED R&D / ACTIVITES DE R-D NON INTEGREES / ACTIVIDADES DE I Y D NO INTEGRADAS	HIGHER EDUCATION / ENSEIGNEMENT SUPERIEUR / ENSEÑANZA SUPERIOR	GENERAL SERVICE / SERVICE GENERAL / SERVICIO GENERAL
			(1)	(2)	(3)	(4)	(5)
AFRICA							
ALGERIA	1972	TOTAL IN R & D	...	...	...	342	...
		SCIENTISTS AND ENGINEERS	...	...	...	242	...
		TECHNICIANS	...	...	...	100	...
		AUXILIARY PERSONNEL	...	...	...	-	...
BOTSWANA	1973	TOTAL IN R & D[1]	42	-	-	-	42
		SCIENTISTS AND ENGINEERS	24	-	-	-	24
		TECHNICIANS	18	-	-	-	18
CENTRAL AFRICAN EMPIRE	1975	TOTAL IN R & D	...	...	...	85	...
		SCIENTISTS AND ENGINEERS	..	...	...	76	...
		TECHNICIANS	...	...	...	3	...
		AUXILIARY PERSONNEL	...	...	...	6	...
EGYPT	1972	SCIENTISTS AND ENGINEERS	10 665	4 874	---->	3 752	2 039
GABON[2]	1970	TOTAL IN R & D	86	-	-	-	86
		SCIENTISTS AND ENGINE	8	-	-	-	8
		TECHNICIANS	20	-	-	-	20
		AUXILIARY PERSONNEL	58	-	-	-	58
GHANA	1972	TOTAL IN R & D	8 559	1 627	1 539	2 878	2 515
		SCIENTISTS AND ENGINEERS	2 559	700	759	1 200	900
		TECHNICIANS[3]	5 000	927	780	1 678	1 615
		AUXILIARY PERSONNEL[3]	./.	./.	./.	./.	./.
IVORY COAST	1970	TOTAL IN R & D[1]	541	-	393	148	-
		SCIENTISTS AND ENGINEERS	319	-	192	127	-
		TECHNICIANS	222	-	201	21	-

Appendix 21

7.4 R & D: personnel by sector of performance
R D: personnel par secteur d'exécution
I y D: personal por sector de ejecución

COUNTRY / PAYS / PAIS	YEAR / ANNEE / AÑO	TYPE OF PERSONNEL / CATEGORIE DE PERSONNEL / CATEGORIA DE PERSONAL	SECTOR OF PERFORMANCE / SECTEUR D'EXECUTION / SECTOR DE EJECUCION: ALL SECTORS / TOUS SECTEURS / TODOS LOS SECTORES	PRODUCTIVE SECTOR / SECTEUR DE LA PRODUCTION / SECTOR PRODUCTIVO: INTEGRATED R&D / ACTIVITES DE R-D INTEGREES / ACTIVIDADES DE I Y D INTEGRADAS	NON-INTEGRATED R&D / ACTIVITES DE R-D NON INTEGREES / ACTIVIDADES DE I Y D NO INTEGRADAS	HIGHER EDUCATION / ENSEIGNEMENT SUPERIEUR / ENSEÑANZA SUPERIOR	GENERAL SERVICE / SERVICE GENERAL / SERVICIO GENERAL
			(1)	(2)	(3)	(4)	(5)
KENYA[4]	1970	TOTAL IN R & D[1]	*1 603	*115	*1 230	*258	-
		SCIENTISTS AND ENGINEERS	*569	*42	*410	*117	-
		TECHNICIANS	*1 034	*73	*820	*141	-
LIBYAN ARAB JAMAHIRIYA	1973	TOTAL IN R & D	*295	*295	---->	-	-
		SCIENTISTS AND ENGINEERS	*50	*50	---->	-	-
		TECHNICIANS	142	142	---->	-	-
		AUXILIARY PERSONNEL	103	103	---->	-	-
MADAGASCAR[5]	1971	TOTAL IN R & D[1]	293	...	106	105	87
		SCIENTISTS AND ENGINEERS	101	...	84	50	67
		TECHNICIANS	97	...	22	55	20
MAURITIUS	1975	TOTAL IN R & D	605	-	217	61	327
		SCIENTISTS AND ENGINEERS	135	-	37	16	82
		TECHNICIANS	147	-	49	14	84
		AUXILIARY PERSONNEL	323	-	131	31	161
NIGERIA[6,7]	1970	TOTAL IN R & D	2 816	-	-	1 887	929
		SCIENTISTS AND ENGINEERS	2 083	-	-	1 711	372
		TECHNICIANS	*733	-	-	*176	557
		AUXILIARY PERSONNEL	-	-	-	-	-
SENEGAL	1972	TOTAL IN R & D[1]	908	47	498	281	82
		SCIENTISTS AND ENGINEERS	392	22	195	136	39
		TECHNICIANS	516	25	303	145	43
SEYCHELLES	1973	TOTAL IN R & D	1	-	1	-	-
		SCIENTISTS AND ENGINEERS	1	-	1	-	-
		TECHNICIANS	-	-	-	-	-
		AUXILIARY PERSONNEL	-	-	-	-	-

Appendix 22

R & D: personnel by place of performance 7.4
R&D personnel by place of residence
I & D: personnel by place of execution

			(1)	(2)	(3)	(4)	(5)
SUDAN	1974	TOTAL IN R & D	16 205	5 523	2 709	2 303	5 670
		SCIENTISTS AND ENGINEERS	*2 731	327	277	*915	1 212
		TECHNICIANS	1 998	458	436	258	846
		AUXILIARY PERSONNEL	11 476	4 738	1 996	1 130	3 612
TOGO [8]	1971	TOTAL IN R & D	240	99	-	123	18
		SCIENTISTS AND ENGINEERS	87	14	-	61	12
		TECHNICIANS	18	12	-	-	6
		AUXILIARY PERSONNEL	135	73	-	62	-
ZAMBIA	1973	TOTAL IN R & D	1 060	-	205	55	800
		SCIENTISTS AND ENGINEERS	260	-	25	35	200
		TECHNICIANS[1]	800	-	180	20	600
		AUXILIARY PERSONNEL[2]	./.	-	./.	./.	./.
AMERICA, NORTH							
BELIZE	1970	TOTAL IN R & D	34	5	-	-	29
		SCIENTISTS AND ENGINEERS	15	2	-	-	13
		TECHNICIANS	4	2	-	-	2
		AUXILIARY PERSONNEL	15	1	-	-	14
BERMUDA [9]	1970	TOTAL IN R & D	10	...	...	-	10
		SCIENTISTS AND ENGINEERS	4	...	...	-	4
		TECHNICIANS	3	...	...	-	3
		AUXILIARY PERSONNEL	3	...	...	-	3
CANADA [10]	1973	TOTAL IN R & D	40 723	19 103	./.	...	21 620
		SCIENTISTS AND ENGINEERS	15 244	7 928	./.	...	7 316
		TECHNICIANS	13 303	6 386	./.	...	6 917
		AUXILIARY PERSONNEL	12 176	4 789	./.	...	7 387
CAYMAN ISLANDS	1971	TOTAL IN R & D	9	6	-	3	-
		SCIENTISTS AND ENGINEERS	3	2	-	1	-
		TECHNICIANS	3	2	-	1	-
		AUXILIARY PERSONNEL	3	2	-	1	-
GUATEMALA	1974	TOTAL IN R & D[1]	749	-	290	113	346
		SCIENTISTS AND ENGINEERS	310	-	166	43	101
		TECHNICIANS	439	-	124	70	245
MEXICO	1974	SCIENTISTS AND ENGINEERS	5 896	701	1 272	1 968	1 955
PANAMA	1975	TOTAL IN R & D	982	-	600	24	133
		SCIENTISTS AND ENGINEERS	204	-	116	62	26
		TECHNICIANS	301	-	194	80	27
		AUXILIARY PERSONNEL	477	-	290	107	80

7.2 Number of scientists, engineers and technicians engaged in research and experimental development

Nombre de scientifiques, d'ingénieurs et de techniciens employés à des travaux de recherche et de développement expérimental

Número de científicos, ingenieros y técnicos empleados en trabajos de investigación y de desarrollo experimental

Please refer to introduction for definitions of categories in this table.

SET = Scientists, engineers and technicians

FTE = Full-time equivalent

Number of countries and territories presented in this table: 103

Pour les définitions des catégories présentées dans ce tableau, se référer à l'introduction.

SET = Scientifiques, ingénieurs et techniciens

FTE = Equivalent plein temps

Nombre de pays et de territoires présentés dans ce tableau: 103

En la introducción se dan las definiciones de las categorías que figuran en este cuadro.

SET = Científicos, ingenieros y técnicos

FTE = Equivalente de jornada completa

Número de países y de territorios presentados en este cuadro: 103

COUNTRY / PAYS / PAIS	YEAR / ANNEE / AÑO	TOTAL (SET)	SCIENTISTS AND ENGINEERS / SCIENTIFIQUES ET INGENIEURS / CIENTIFICOS E INGENIEROS (FTE) TOTAL	F	TECHNICIANS / TECHNICIENS / TECNICOS (FTE) TOTAL	F
		(1)	(2)	(3)	(4)	(5)
AFRICA						
ALGERIA[1]	1972	342	242	...	100	...
BOTSWANA	1973	42	24	-	18	
CENTRAL AFRICAN EMPIRE[1]	1975	79	76	8	3	
CHAD[2]	1971	187	85	...	102	...
EGYPT	1973	...	10 665	...	...	...
GABON[3]	1970	28	8	...	20	...
GHANA[4]	1972	8 559	3 559	...	5 000	...
IVORY COAST	1970	541	319	...	222	...
KENYA[5]	1970	•1 603	•569	...	•1 034	...
LIBYAN ARAB JAMAHIRIYA[6]	1973	•192	•50	...	142	...
MADAGASCAR[7]	1971	298	201	19	97	...
MAURITIUS	1975	282	135	7	147	
NIGERIA[7,8]	1970	•2 816	2 083	...	•733	...
SENEGAL	1972	908	392	...	516	...
SEYCHELLES	1973	1	1	-	-	
SUDAN	1974	•4 729	•2 731	•190	1 998	...
TOGO	1971	136	118	11	18	
TUNISIA[9]	1972	•1 370	•818	...	•552	...
UNITED REPUBLIC OF CAMEROON[5,10]	1970	...	329	...	...	...
ZAMBIA[5,11]	1973	1 060	260	...	800	...

7.3 R & D. personnel by field of science
R-D: personnel par discipline scientifique
I+D: personal por rama de la ciencia

7.3 Number of scientists and engineers engaged in research and experimental development by field of science

Nombre de scientifiques et d'ingénieurs employés à des travaux de recherche et de développement expérimental, par discipline scientifique

Número de científicos y de ingenieros empleados en trabajos de investigación y de desarrollo experimental, según la esfera científica

Please refer to introduction for definitions of categories in this table.

FT = Full-time
PT = Part-time
FT+PT = Full-time plus part-time
FTE = Full-time equivalent

Number of countries and territories presented in this table: 84

Pour les définitions des catégories présentées dans ce tableau, se référer à l'introduction.

FT = A plein temps
PT = A temps partiel
FT+PT = A plein temps et à temps partiel ensemble
FTE = Equivalent plein temps

Nombre de pays et de territoires présentés dans ce tableau: 84

En la introducción se dan las definiciones de las categorías que figuran en este cuadro.

FT = Jornada completa
PT = Jornada parcial
FT+PT = Jornada completa más jornada parcial
FTE = Equivalente de jornada completa

Número de países y de territorios presentados en este cuadro: 84

COUNTRY / PAYS / PAIS	YEAR / ANNEE / AÑO	SEX / SEXE / SEXO		TOTAL (1)	FIELD OF SCIENCE / DISCIPLINE SCIENTIFIQUE / RAMA DE LA CIENCIA: NATURAL SCIENCES / SCIENCES EXACTES ET NATURELLES / CIENCIAS EXACTAS Y NATURALES (2)	ENGINEERING AND TECHNOLOGY / SCIENCES DE L'INGENIEUR / INGENIERIA Y TECNOLOGIA (3)	MEDICAL SCIENCES / SCIENCES MEDICALES / CIENCIAS MEDICAS (4)	AGRICULTURE / AGRICULTURE / AGRICULTURA (5)	SOCIAL SCIENCES AND HUMANITIES / SCIENCES SOCIALES ET HUMAINES / CIENCIAS SOCIALES Y HUMANIDADES (6)
AFRICA									
ALGERIA[1]	1972	MF	FT	-	-	-	-	-	-
		MF	PT	726	349	31	99	247	--->
		MF	FTE	242	117	9	33	83	--->
BOTSWANA	1973	MF	FT	16	-	-	-	16	-
		MF	PT	16	-	-	-	16	-
		MF	FTE	24	-	-	-	24	-
		F	FTE	-	-	-	-	-	-
CENTRAL AFRICAN EMPIRE[1]	1975	MF	FT	62	35	5	-	4	1
		MF	PT	29	-	10	-	-	1
		MF	FTE	76	35	9	-	4	2
		F	FTE	8	1	3	-	-	-
CHAD[7]	1971	MF	FT	85	24	7	16	12	-
		MF	PT	-	-	-	-	-	-
		MF	FTE	85	24	7	16	12	-
EGYPT	1973	MF	FT	6 513	1 408	680	391	4 087	35
		MF	PT	11 256	2 301	1 944	2 889	2 092	2 0[illegible]
		MF	FTE	10 665	2 175	1 328	1 354	4 781	1 0[illegible]

COUNTRY / PAYS / PAIS	YEAR / ANNEE / AÑO	SEX / SEXE / SEXO	FT / PT / FTE	TOTAL / TOTAL / TOTAL	FIELD OF SCIENCE / DISCIPLINE SCIENTIFIQUE / RAMA DE LA CIENCIA: NATURAL SCIENCES / SCIENCES EXACTES ET NATURELLES / CIENCIAS EXACTAS Y NATURALES	ENGINEERING AND TECHNOLOGY / SCIENCES DE L'INGENIEUR / INGENIERIA Y TECNOLOGIA	MEDICAL SCIENCES / SCIENCES MEDICALES / CIENCIAS MEDICAS	AGRICULTURE / AGRICULTURE / AGRICULTURA	SOCIAL SCIENCES AND HUMANITIES / SCIENCES SOCIALES ET HUMAINES / CIENCIAS SOCIALES Y HUMANIDADES
				(1)	(2)	(3)	(4)	(5)	(6)
GREECE[3]	1970	MF	FT	8	4	-	-	-	4
		MF	PT	-	-	-	-	-	-
		MF	FTE	8	4	-	-	-	4
IVORY COAST	1970	MF	FT	319	84	-	14	173	48
		MF	PT	-	-	-	-	-	-
		MF	FTE	319	84	-	14	173	48
KENYA[4]	1970	MF	FT	*497	*49	*6	*48	*349	*45
		MF	PT	*347	*77	*120	*43	*107	-
		MF	FTE	*569	*68	*30	*5[illegible]	*371	*4[illegible]
LIBYAN ARAB JAMAHIRIYA	1973	MF	FT	30	19	---->	-	11	-
		MF	PT	64	21	---->	15	3	25
		MF	FTE	*50	*25	---->	*5	*12	*8
MADAGASCAR[5]	1971	MF	FT	151	67	15	5	64	-
		MF	PT	151	66	-	8	9	68
		MF	FTE	201	89	15	8	67	22
		F	FTE	19	18	-	-	1	-
MAURITIUS	1975	MF	FT	109	-	4	-	95	10
		MF	PT	66	14	18	-	32	2
		MF	FTE	135	5	10	-	110	10
		F	FTE	7	-	-	-	4	3
NIGERIA[6,7]	1970	MF	FTE	2 083	548	409	582	544	...
SENEGAL	1972	MF	FT	232	45	36	8	121	22
		MF	PT	377	40	28	101	22	186
		MF	FTE	392	65	45	142	132	108
SEYCHELLES	1973	MF	FT	1	-	-	-	1	-
		MF	PT	-	-	-	-	-	-
		MF	FTE	1	-	-	-	1	-
SUDAN[8]	1974	MF	FT	2 567	576	346	240	480	913
TOGO	1971	MF	FT	[illegible]	7	8	10	8	81
		MF	PT	18	2	-	-	-	16
		MF	FTE	118	8	8	10	8	84
		F	FTE	11	1	-	-	-	10
ZAMBIA	1973	MF	FTE	260	110	20	30	70	30
AMERICA, NORTH									
BAHAMAS[9]	1970	MF	FTE	*19	*2	-	-	*10	*7
		F	FTE	-	-	-	-	-	-
BELIZE	1970	MF	FT	10	-	-	-	10	-
		MF	PT	10	-	-	-	10	-
		MF	FTE	15	-	-	-	15	-
		F	FTE	-	-	-	-	-	-
BERMUDA[10]	1970	MF	FT	-	-	-	-	-	...
		MF	PT	9	-	-	-	9	...
		MF	FTE	4	-	-	-	4	...

ANNEX B

Chapter Four

Appendix 26-43 From Robert Morgan (Principal Investigator) The Role of US Universities in Science and Technology for Development Mechanisms and Policy Options. Center for Development Technology. Washington University, St. Louis, Missouri. September 1978.

AID-FINANCED UNIVERSITY CONTRACTS AND GRANTS

ACTIVE DURING THE PERIOD 04/01/77 THROUGH 09/30/77 +

TYPE OF ACTIVITY	NUMBER OF COUNTRIES	NUMBER OF U.S. UNIVERSITIES	NUMBER OF CONTRACTS /GRANTS	AMOUNT IN DOLLARS (*)
TECHNICAL ASSISTANCE TO HOST COUNTRIES				
LATIN AMERICA	9	11	12	$5,683,373
NEAR EAST	7	12	12	12,985,293
AFRICA	13	14	20	25,260,112
ASIA	2	11	12	15,124,811
SUB-TOTAL	31	48	56	$59,053,589
GRANT SUPPORT	---	48	66	$58,281,774
TRAINING	---	96	107	16,769,132
CENTRAL RESEARCH	---	55	111	55,587,145
TECHNICAL SERVICES TO AID	---	42	68	43,724,671
SUB-TOTAL		241	352	$173,866,722
TOTAL	---	289**	408	$232,920,111

NEW CONTRACTS/GRANTS AND AMENDMENTS EFFECTIVE 2ND HALF FISCAL YEAR 77

CONTRACTS/GRANTS	82	DOLLAR AMOUNT	$ 16,095,127
AMENDMENTS	734	DOLLAR AMOUNT	31,110,308
TOTAL	816		$47,205,435

* FUNDS ARE CUMULATIVE AND REPRESENT TOTAL DOLLARS OBLIGATED OVER THE LIFE OF THE CONTRACT/GRANT.

** COLUMN TOTALS 289 BUT THERE ARE ONLY 127 UNIVERSITIES ENGAGED IN CONTRACT/GRANT ACTIVITIES, SINCE SOME UNIVERSITIES ARE OPERATING IN MORE THAN ONE AREA OR TYPE OF SERVICE.

\+ From AID Report.

TABLE 39

U.S. SPENDING ON R & D FOR DEVELOPMENT

Rough AID Estimates for FY 1972

(Reported by Moravcsik)

	Millions of Dollars
1. R & D explicitly for benefit of developing countries:	
a). AID	100
b). U.S. Contributions to Multinational Organizations	70
c). U.S. Foundations	40
SUBTOTAL	210
2. Other R & D in Developing Countries	
a). Through Other U.S. Governmental Agencies	90
b). Private Industry	20
SUBTOTAL	110
3. Other R & D of Potential Short-Term Benefit to Developing Countries	
a). Governmental Agencies	500
b). Private Industry	30
SUBTOTAL	530

TABLE 20

Disciplines of the University AID Contract Staff Members, Total Agricultural and Related Sciences

Rural Development Contracts

Discipline	All Staff Number	All Staff Percent
Animal science [a]	232	17
Agronomy	223	16
Agricultural economics [b]	140	10
Agricultural engineering	84	6
Agricultural extension	86	6
Agricultural education	72	5
Agricultural administration	55	4
Horticulture	45	3
Plant pathology and entomology	48	3
Home economics	43	3
Forestry	34	2
Botany, other basic plant sciences	21	2
Range management	11	1
Bacteriology and food technology	7	1
Other non-agricultural disciplines [c]	271	19
Discipline unknown	27	2
TOTAL	1,399	100

[a] Include veterinary medicine

[b] Includes rural sociology

[c] Non-agricultural disciplines were grouped together for this study. This group represented a variety of talents including basic biological and physical scientists, English teachers, and librarians.

Source: Thompson, William N., "AID-University Rural Development Contracts and U.S. Universities." (Washington D.C.: AID, 1968).

TABLE 40

NATIONAL SCIENCE FOUNDATION BUDGET SUBMISSION
TO THE CONGRESS FOR INTERNATIONAL ACTIVITIES, FY 1979

NATI NAL COOPERATIVE SCIENTIFIC ACTIVITIES
AM UBACTIVITY $10,600,000

Obligations by Program Element

Pr ram Element	Actual FY 1977	Budget Request FY 1978	Current Plan FY 1978	Estimate FY 1979	Difference FY 1979/78
ve Scie	$5,054,517	$5,400,000	$5,530,000	$6,100,000	$570,000
Organi ions and	2,504,687	3,100,000	2,862,981	3,300,000	437,019
Science and ogy fo velopment	—0—	1,200,000	1,200,000	200,000	-1,000,000
Tra	537,340	500,000	500,000	600,000	100,000
Special Center	289,544	300,000	320,250	400,000	79,750
.....	$8,485,088	$10,500,000	$10,412,231	$10,000,000	$103,769

SPECIAL FOREIGN CURRENCY

PROGRAM ACTIVITY SUMMARY

PROGRAM TOTAL $6,000,000

Subactivity	Actual FY 1977	Budget Request FY 1978	Current Plan FY 1978	Estimate FY 1979	Difference FY 1979/78
ch & Related Activities	$3,959,009	$4,900,000	$4,934,055	$4,900,000	$565,945
Information	443,037	1,100,000	1,100,000	1,100,000	—0—
Total	$4,403,426	$6,000,000	$5,434,055	$6,000,000	$565,945

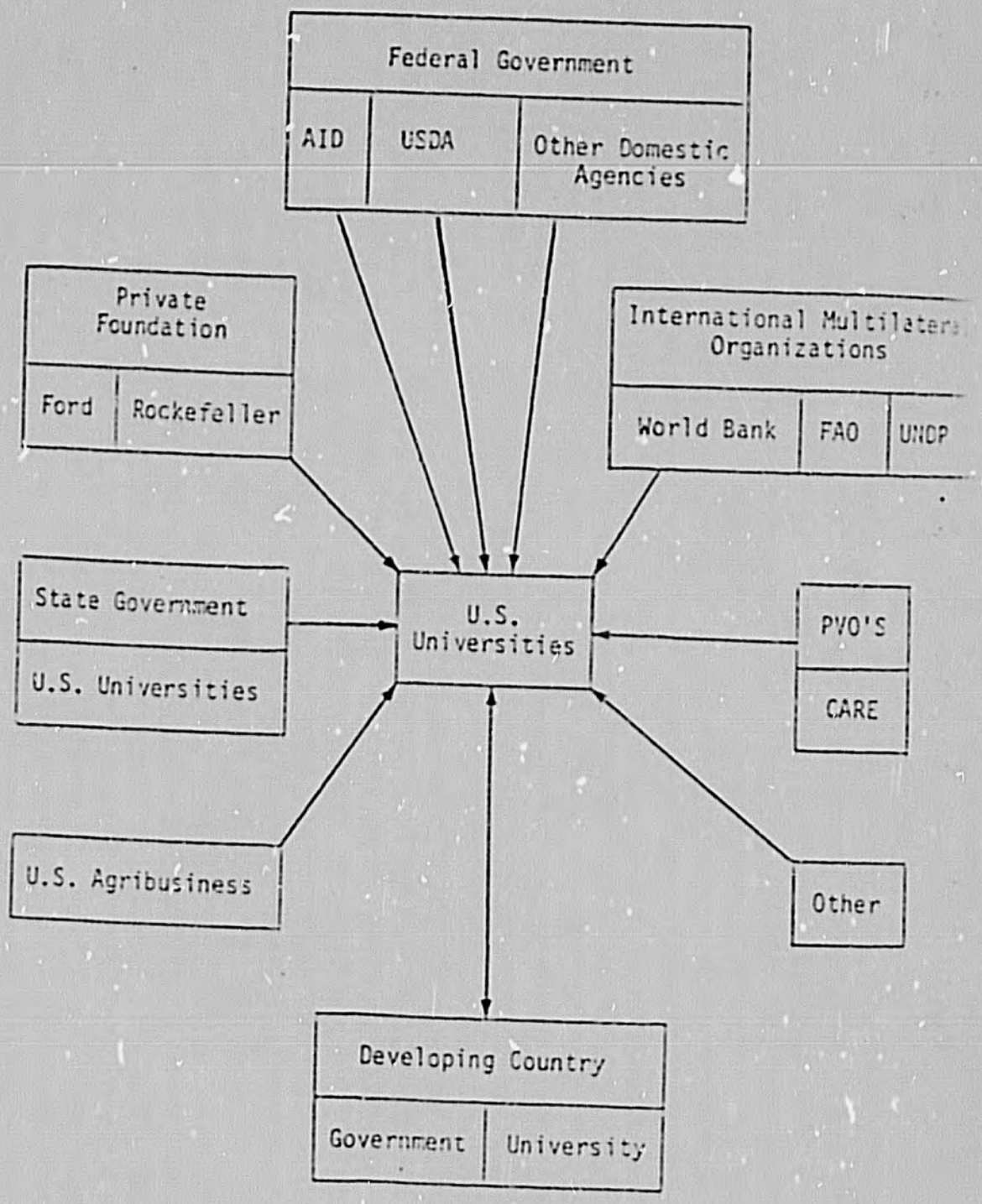


Figure 5

Schematic of Flow of Funds to U.S. Universities for Involvements in International Agricultural Activities

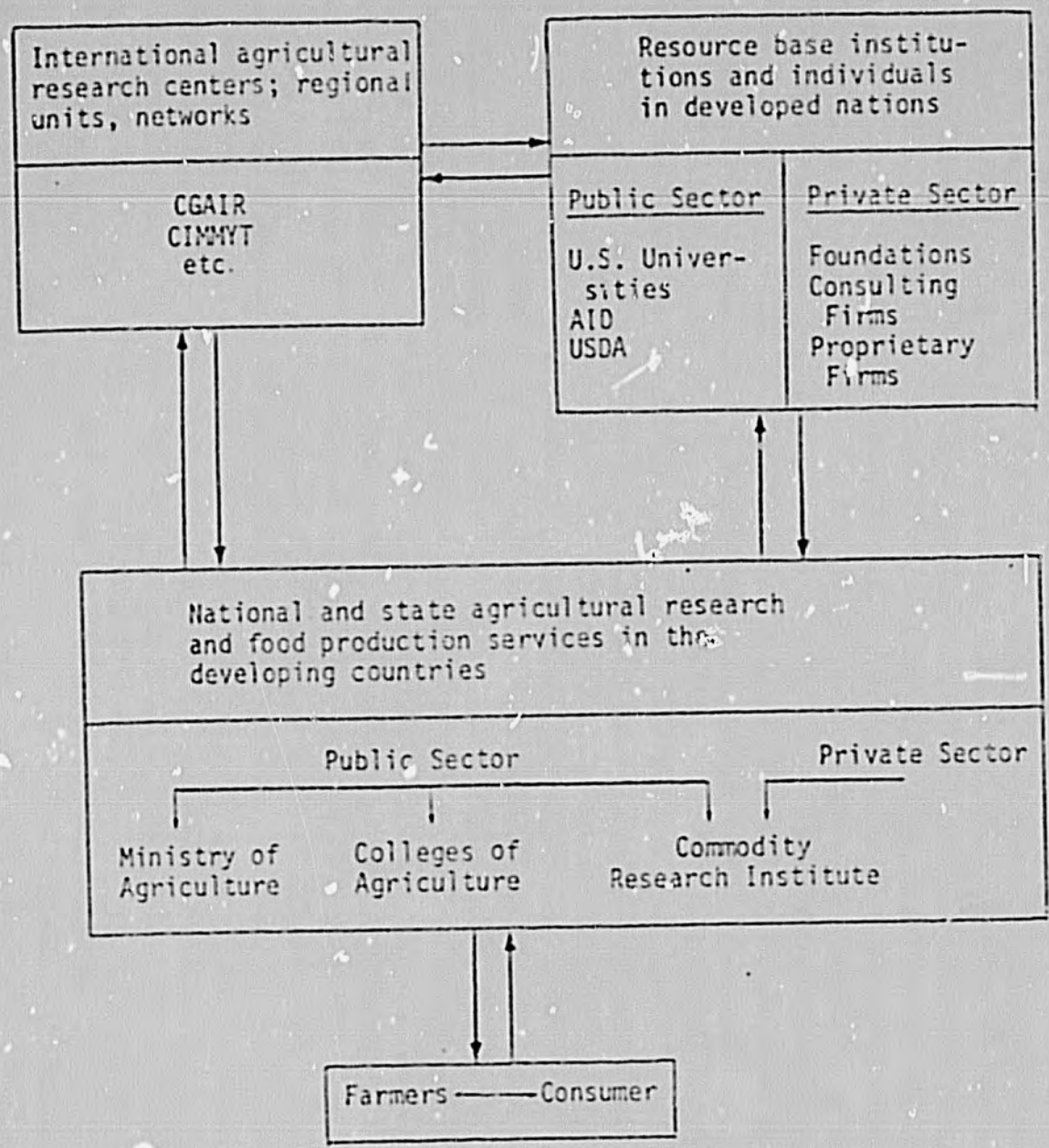


Figure 2

Generalized Structure of International Agricultural Research for Developing Nations

Adapted from Supporting Papers: World Food and Nutrition Study (35).

TABLE 5

SOME LEGISLATION PERTINENT TO THE ROLE OF U.S. UNIVERSITIES IN SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

Name and Public Law No.	Significance
Foreign Assistance	
Foreign Assistance Act of 1961 PL 87-195	Reorganization of aid programs; creation of AID Title II - Section 211 pertaining to technical assistance.
Foreign Assistance Act of 1966 PL 89-583	Amendment to Title II. Section 211(d) added which provides for strengthening international capabilities of U.S. universities.
International Development and Humanitarian Assistance Act of 1971 S 1656, S 1657, never passed	Proposed reorganization of AID, creation of International Development Institute and International Development Corporation.
Foreign Assistance Act of 1973 PL 93-189	"New Directions" in policy. Emphasis on basic needs, poorest of the poor.
International Development and Food Assistance Act of 1975 PL 94-161	Amended FAA of 1961 with Title XII, involving U.S. universities in decision making on agricultural projects. Also, Section 107 makes funds available for new programs in "Intermediate Technology".
International Development Cooperation Act of 1978 S 2420 - not acted upon	Proposed Reorganization of foreign aid programs
International Mandates for Domestic Agencies	
PL 90-407; 1968	

Table 5 (cont.)

Name and Public Law No.	Significance
International Mandates for Domestic Agencies	
Anti-Nuclear Proliferation Act of 1978	Authorizes Department of Energy involvement in international small-scale energy activity.
Food for Peace Act of 1966 - Section 406	Authorizes U.S. Department of Agriculture to enter into contracts or agreements with U.S. universities to conduct research on agriculture related to developing countries (funded in 1974).
Food and Agricultural Act of 1977 PL 95-113	Authorizes U.S. Department of Agriculture to strengthen U.S. universities for working in international development (not yet funded).
Education	
International Education Act of 1966 PL 89-698	Provided broad mandate for involvement of U.S. universities in international education (never funded).
National Defense Education Act of 1958 PL 85-864 amended by International Education Act of 1966	Created international institutes for secondary school teachers. NDEA also authorized U.S. Office of Education to support foreign area studies and language programs.
Immigration	
Immigration and Nationality Act of 1952 PL 414 as amended	Created special categories for non-U.S. students and professors.

Table 25

Brief Summaries of Selected International Projects Involving the College of Agriculture and Natural Resources of Michigan State University from June 1977 to June 1978

a) Livestock Feeds Research Project; Belize; Departments of Animal Husbandry, Poultry Science (MSU), and colleagues from the University of Minnesota; financially supported by Michigan and National Partners of the Americas, Heifer Project International, MUCIA, local government agencies, CARE, and others.

b) Michigan Partners of the Americas; Dominican Republic and Belize; technical assistance, training, and exchange; Cooperative Extension Service (mostly 4-H) and animal science departments at MSU; supported by the Partners, Michigan and Belizan institutions and organizations.

c) MUCIA-Indonesia; interdisciplinary; institutional development; AID funding.

d) MSU Brazil-MEC; interdisciplinary; support to graduate education; institution building; supported by AID loan to Brazil and Government of Brazil.

e) Peace Corps Intern Program; Philippines, Thailand, Malaysia, and Nepal; financed by ACTION- Peace corps.

f) MUCIA-Somalia; Department of Crop and Soil Sciences; research and training; financed by FAO.

g) Better Understanding of Poor Rural Households - technical change and income distribution in LDC's; research and technical services; oriented to West Africa; Department of Agricultural Economics; AID financed.

h) Female Participation in West Africa; research; Department of Agricultural Economics; AID financed.

i) Sahel Secretariat and Documentation Center; Department of Agricultural Economics; consulting services, applied research, seminars, translation of research results; AID financed.

j) Master's Degree Training for 26 Students from Sahel, Africa; Department of Agricultural Economics; AID financed.

k) Agricultural Economics Services; African Sahel; applied research and consulting services on priority projects; Department of Agricultural Economics; AID financed.

l) Integrated Rural Development, Upper Volta/ORD; technical assistance; Department of Agricultural Economics; AID financed.

m) Agricultural Economic Analysis, Niger: design of agricultural research program as part of Niger's National Institute of Agricultural Research; Department of Agricultural Economics; AID financed.

Source: Highlights - International Activities of College of Agriculture and Natural Resources (June 1977-June 1978): Michigan State Univ.

Starting in 1960, a network of international centers was established for agricultural research, training, and outreach assistance to governments.
In 1974, eight centers are operating.
These eight centers are listed below, and are located (by the same numbering) on the map below:

Key	Center	Year	Crop or Research Emphasis
1.	IRRI (International Rice Research Institute) Los Baños, Philippines.	1960	Rice and farming systems for rice.
2.	CIMMYT (International Maize and Wheat Improvement Center) Mexico.	1966	Maize, wheat, barley, rye, triticale
3.	IITA (International Institute for Tropical Agriculture) Ibadan, Nigeria.	1967	Farming systems for lowland humid zone including work on maize, rice, tubers, legumes.
4.	CIAT (International Center for Tropical Agriculture) Cali, Colombia.	1968	Farming systems for the tropics with emph. on beef, swine, cassava, maize, rice and bean
5.	CIP (International Potato Center) Peru.	1972	Potatoes
6.	ICRISAT (International Crop Research Institute for the Semi-Arid Tropics) India.	1972	Sorghum-millets, food legumes and farming systems for semi-arid tropics.
7.	ILRAD (International Laboratory for Research on Animal Diseases) Nairobi, Kenya.	1973	Diseases of African Livestock.
8.	ILCA (International Livestock Center for Africa) Addis Ababa, Ethiopia.	1973	Production of African Livestock.

Revised February

Source: Robert D. Osler, This is CIMMYT, CIMMYT, 1974.

Figure 4

Network of International Agricultural Centers

Table 16

Some International Centers of Research Excellence
(excluding agricultural ones
est. before 1974*)

1) International Center for Agricultural Research in Dry Areas (ICARDA), Cairo, Egypt, est. 1976.

2) Asian Vegetable Research and Development Center, Taiwan. (AVRDC)

3) International Center for Insect Physiology and Ecology, Kenya (ICIPE).

4) International Center for Living Aquatic Resources Management, Philippines (ICLARM).

5) Central Food Technological Research Institute, Mysore, India. (CFTRI)

6) Institution of Nutrition of Central America and Panama, Guatemala City. (INCAP)

7) Nutrition Center of the Philippines, Manila

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*See Figure 4 for agricultural centers.

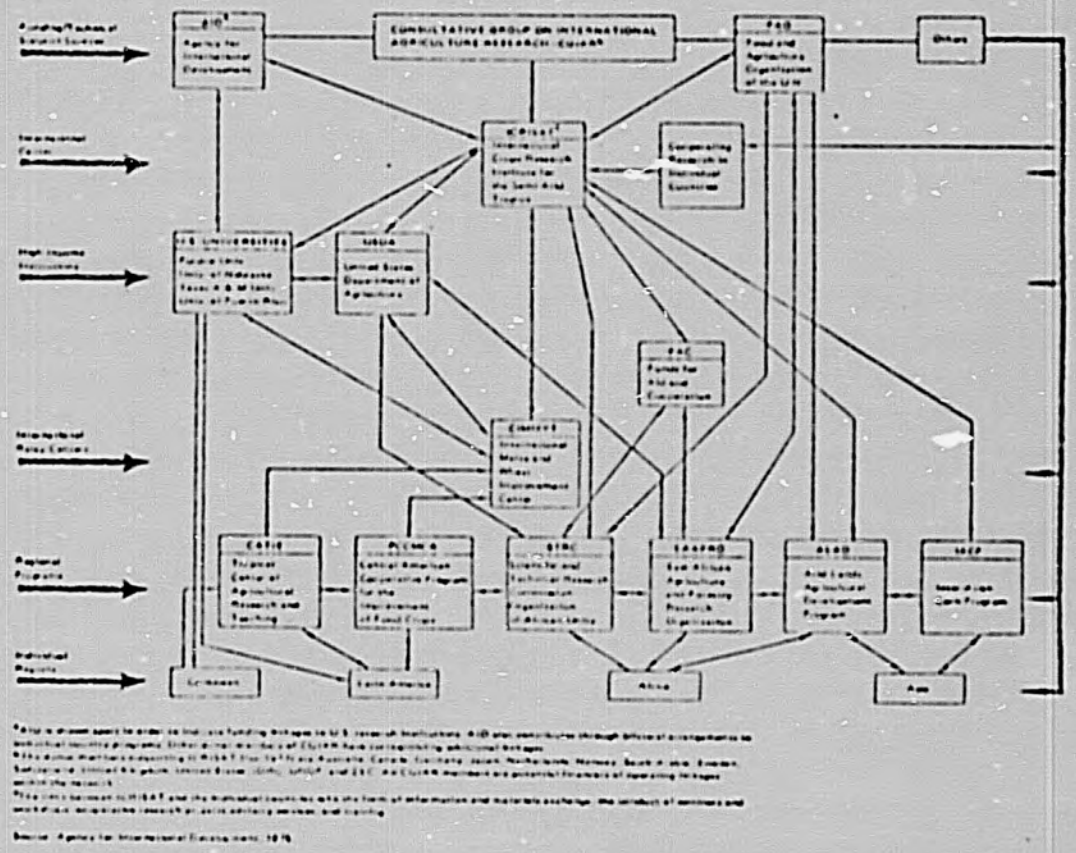

Figure 3

International Sorghum Research Network, Major Linkages

Source: Supporting Papers: World Wood and Nutrition Study (35).

Table 24

Major Contracts for INTSOY Program*

1. U.S. AID. Research Contract (AID/CM/ta-C-73-19)
   Total Funding: $980,000
   Contract Period: April 1, 1973 - March 31, 1976
   Title: Development of Improved Varieties of Soybeans.

2. U.S. AID. Research Contract (AID/ta-C-1294)
   Total Funding: $2,085,855
   Contract Period: April 1, 1976 - March 31, 1979
   Title: Development of Improved Varieties of Soybeans and Supporting Cultural and Marketing Practices for Production in the Tropics and Information Delivery Systems.

3. U.S. AID 211(d). Grant to U. of Illinois (AID/CM/ta-g-73-49)
   Total Funding: $500,000
   Grant Period: October 1, 1973 to September 30, 1978
   Title: A Grant to Strengthen the Institutional Response Capabilities of the University of Illinois in Improvement of Soybeans for Tropical and Subtropical Areas.

4. U.S. AID 211(d). Grant to University of Puerto Rico (AID/CM/ta-g-73049)
   Total Funding: $500,000
   Grant Period: October 1, 1973 to September 30, 1978
   Title: A Grant to Strengthen the Institutional Response Capabilities of the University of Puerto Rico in Improvement of Soybeans for Tropical and Subtropical Areas.

5. Rockefeller Grant
   Total Funding: $100,000
   Grant Period: August 1, 1974 - July 31, 1975
   Purpose: To support tropical soybean production research centered at Puerto Rico including seed storage under tropical conditions.

6. Food and Agricultural Organization of the United Nations, UNDP and UNICEF/CARE
   FAO/UNDP Funding: $862,000
   Period: 1975-1978
   UNICEF/CARE Funding: $454,000
   Period: Mid 1977 to 1978
   Purpose: Soybean Development in Sri Lanka.

7. Soybean and Maize Development in Peru
   AID Funding: $652,000
   Period: November 1977 - October 1979

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*Source: "A Brief Outline Summary of Progress 1973-1978: The International Soybean Program (INTSOY)."

The problem of appropriate education for students from less developed countries in science and technology affects all fields. However, the magnitude of the problem has become most visible in the field of engineering where in excess of 50 percent of those being educated in this field in the United States come from Third World countries. It is for this reason that the curriculum of engineering schools has received relatively more attention. However, the problem of appropriateness needs to be considered in terms of many other fields. Refer to Appendix 40-43.

Table 11

Foreign Students in Engineering in the U.S.: Home Region and Academic Level, 1973-1974

Region	Undergraduate		Graduate		Total	
	Number of Students	Percent of Total	Number of Students	Percent of Total	Number of Students	Percent of Total
Africa	978	6.1	727	5.2	1,767	5.7
Europe	774	4.8	1,257	8.9	2,108	6.8
Far East	4,318	27.0	8,242	58.7	13,022	41.7
Latin America	3,064	19.2	1,230	8.7	4,430	14.2
Near and Middle East	6,132	38.5	2,029	14.4	8,530	27.3
North America	379	2.4	222	1.6	616	2.0
Oceania	63	0.4	54	0.4	124	0.4
Stateless	43	0.3	28	0.2	73	0.2
Country Unknown	214	1.3	271	1.9	517	1.7
TOTAL	15,965	100.0	14,060	100.0	31,187*	100.0

*Note: Totals do not equal sum of Undergraduate and Graduate because of "other" student category.

Source: Institute of International Education. Open Doors. New York: IIE, 1974, pp. 20-27

Table 9

SUMMARY OF PRESENT AND FUTURE OPPORTUNITIES FOR U.S. ENGINEERING SCHOOLS TO RENDER DEVELOPMENT ASSISTANCE*

The chart below summarizes major program areas where U.S. schools of engineering can act now and in the future to broaden and improve development-related education and research in this country and the LDCs.

Program	Conducted in: U.S.	Conducted in: LDCs
1. Undergraduate Engineering	Basically sound; continue to offer broad, balanced flexible programs. Suitable for students interested in development	Continue to upgrade quality
2. Engineering Technology	Well-established; suitable for students interested in development	Promising applicability; need to establish in LDCs
3. Graduate Engineering	Continuing influx of LDC students; good, long-term impact	Create more regional graduate centers of high quality
4. LDC-oriented Graduate Education	New courses, more experimentation to match specific LDC needs; cooperative efforts with LDC universities	U.S. provide assistance in developing advanced programs; develop applied research; provide faculty training at regional centers
5. Industrial Extension Service	Develop additional models	Develop new university-based centers for transfer of technology
6. Contract Special Training	Potential for expansion, both for schools of engineering and engineering technology	Potential activity at regional centers
7. LDC Faculty Upgrading	Workshops and courses at appropriate U.S. universities	Short courses at regional centers and LDC universities
8. Seminars on Special Subjects	Provide professors, experts	Conduct for students/faculty at LDC universities and regional centers
9. Short Courses for LDC Engineers	Develop courses; provide visiting professors	Conduct at LDC schools and regional centers
10. Continuing Education	Technical assistance in developing courses for use in the LDCs	Facilitate development and application. Need permanent activity in continuing education
11. Research (wherever possible cooperative between LDC and U.S. universities	Development methodology and processes; development-oriented technical research; management techniques; energy; natural resources, etc.	LDC faculty work on products and processes; marketing; technology applications; housing; energy; natural resources

*From NAS-NAE Report on Role of U.S. Engineering Schools in Development Assistance.

Table 12

Primary Sources of Funds for Foreign Students Studying in the U.S. 1976-1977

Primary Source of Funds	Percentage
Personal/U.S.	7.6
Personal/Foreign	44.4
College or University	12.7
Home government	13.5
U.S. government	5.0
Private sponsor/U.S.	2.6
Private sponsor/Foreign	3.9
On-campus employ./part-time	4.2
Off-campus employment	3.9
Employment of spouse	0.4
Other	1.9

Source: Institute for International Education. Open Doors. New York: IIE, 1978, p. 27.

TABLE 30

Some Recommendations for Science Development
by Michael Moravcsik

Education

a) Measures must be taken to ensure that exorbitant and discriminatory substantial tuition does not make it impossible for foreign students to be educated at U.S. universities.

b) The selection of students from LDC's who are to be admitted and permitted given financial aid at U.S. universities should be improved [illegible] programs like the Physics International Project.

c) Revolving fund should be established for foreign students to be able to repay the travel expenses from their countries to the U.S. [illegible] where they will be [illegible]. Loans are to be repaid from [illegible] or teaching assistantship salaries such students receive once they are in graduate schools.

d) Summer seminars should be established for students from LDC's studying science in U.S. universities. The seminars should deal with auxiliary aspects of science of great importance to the LDC student upon his return to his country.

e) Measures should be taken to improve the training of students from LDC's studying science at U.S. universities, and their collaboration with their professors during their education and after it when they return to their countries.

f) Students from LDC's studying science at U.S. universities should be given opportunities for (i) [illegible] employment in scientific institutions in the U.S., (ii) in scientific institutions in their own countries.

g) Public communication media in the LDC's should receive cooperation and assistance to enlarge and improve their programs dealing with science. Particularly important is material dealing with why and how scientists work and what of their thinking and attitudes can be of direct use in the everyday activities of the average citizen.

BEST AVAILABLE DOCUMENT

ANNEX C

Chapter Five

Appendix 44 UNESCO SPINES: Data Exchange System on Science and Technology Policy

SPINES: Data exchange system on science and technology policies

Within the framework of the SPINES Programme, Unesco is publishing during the first semester of 1976 the English source version of the *SPINES Thesaurus*. The *Thesaurus*, constructed with the assistance of numerous consultants and according to UNISIST guidelines, is a major achievement in the field of information relating to science and technology policy-making, as well as to the management, transfer and assessment of science and technology, and their application to development. It contains some 12,000 terms, 9,000 of which are authorized descriptors, and more than 100,000 relations. It will be published in three forms: (a) an alphabetically structured list; (b) thirty-four terminological graphic displays; and (c) a series of subjects facets. Its general coverage is shown below in the form of a *Global Graph of Graphic Displays*.

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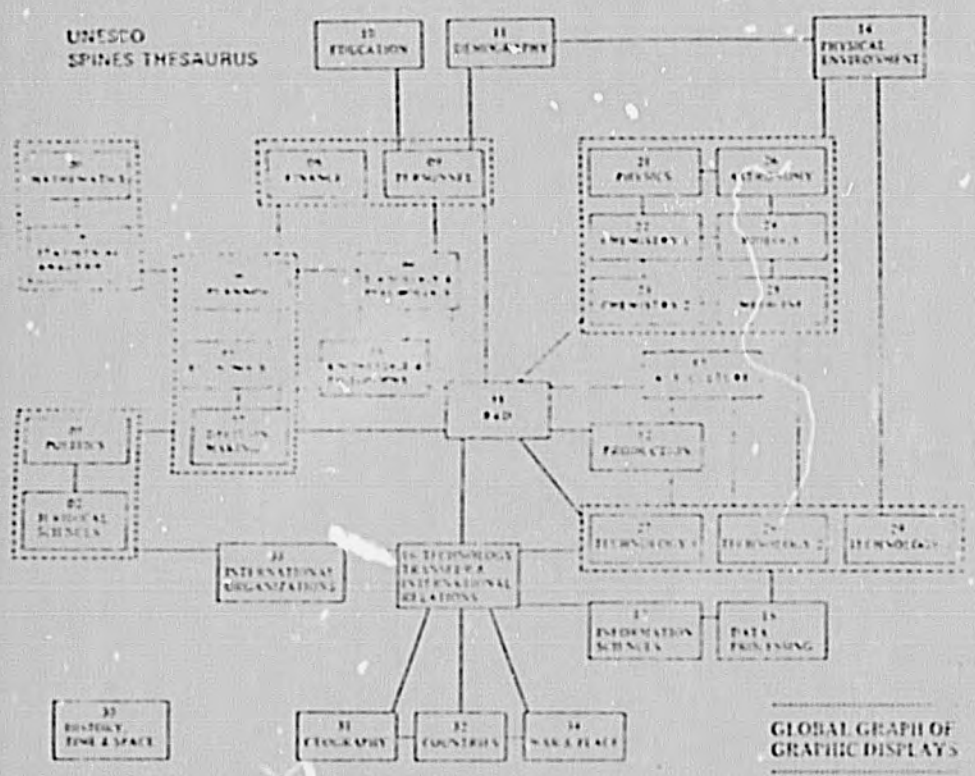

ANNEX D

Chapter Six

Appendix 45-52 Review of AID Research. TA/Res Revised Draft November 11, 1977 (US Government Memorandum)

TABLE 1 Funds Allocated To Identified Research Activities By Regional Bureaus For FY 1977 And FY 1978
(in thousands of dollars)

BUREAU	Research Component	Research Institution Building & Training	Research Extension	Total Identified Research	Bureau Total Grants	Research Percent of Total Grants
Africa						
FY 1977	16,715	7,906	2,253	26,874	125,000	21.49%
FY 1978	30,555	11,936	4,190	46,681 21,041	196,800	23.72
					Omits Sahel Development Project	
Asia						
FY 1977	12,350	1,699	489	14,538	66,000	21.73
FY 1978	11,259	17,626	1,434	30,319 27,361	168,600	17.98
Near East						
FY 1977	2,650	1,310	-	3,960	20,200	19.60
FY 1978	5,866	2,479	4,285	12,630 ~~[illegible]~~ 4,369	42,790	29.52
Latin America						
FY 1977	10,423	3,227	265	13,915	49,900	27.88
FY 1978	8,403	2,922	-	11,325 ~~[illegible]~~ 11,283	67,400	16.76

TABLE 6 Number of research projects by crop studied and bureau, FY 1977.

CROP	TAB	Latin America*	Near East**	Asia	Africa***
Sorghum	4	1	2	1	8
Barley	1		1		
Millet			1	2	7
Maize				2	3
Corn	1	1	1	1	1
Rice	1		1	3	4
Wheat	1		1	4	
Beans	1	1	1		
Soybeans	2		1		
Legumes				1	5
Oil Seed				2	2
Groundnut					3
Cassava	1				1
Potato			1		
Sweet Potato			1		
Yams					1
Cocoa					1
Coffee					1

* 5 projects covering "various food crops"
** 2 projects covering "various food crops"
*** 7 projects covering "various food crops"

Note: Number of crops sum to a total larger than total number of research projects since some projects are investigating more than one crop.

PROJECT TITLE	COUNTRY	CROP(s)
Lake Chad Livestock and Mixed Agriculture	Sahel	Various food crops
ORSTOM-Mauritania Dieri Soil Crop Research	Sahel	Various food crops
North Cameroon Seed Multiplication	Sahel	Groundnut Sorghum
North Cameroon Livestock and Agricultural Development	Sahel	Various food crops
Seed Production Center	Sahel	Various food crops Oil seed
Guinea Agricultural Production and Training	Sahel	Various food crops
Mali Crop Production	Sahel	Sorghum Millet Rice
Niger Cereals Production	Sahel	Millet Sorghum
Crop Production and Marketing	Botswana	Sorghum Millet Legumes
East Africa Food Crops Research	East Africa	Maize Rice Sorghum Millet Legumes
Rice Research and Production	Africa	Rice
Semi-arid Food Grain Research & Development	Africa	Sorghum Millet Maize Cowpea Groundnut

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Dryland Agricultural Development	Pakistan	Wheat Maize
Small Farmer Income and Production	Philippines	Rice
AFRICA		
Pulse Diversification and Improvement	Ethiopia	Various pulses
Agricultural Research	Sierra Leone	Maize Millet Sorghum Benisseed Groundnut Rice Cassava Sweet potato Yams Legumes Cocoa Coffee Oil palm
Seed Multiplication	Tanzania	Various cereal Legume Crops
Agricultural Research	Tanzania	Corn Legumes Sorghum Millet
IRERA Support	Zaire	Legumes Various food

PROJECT TITLE	COUNTRY	CROP(s)
TAB		
Sorghum Protein Content and Quality	Interregional	Sorghum
Sorghum Yield Physiology	Interregional	Sorghum
Sorghum Pest Resistance	Interregional	Sorghum
Tropical Adaptation of Sorghum	Interregional	Sorghum
Improvement of Nutritional Quality of Wheat	Interregional	Wheat
Maize Protein Content and Quality	Interregional	Maize
Improvement and Tropical Production of Beans & Corn	"	Beans Corn
Improvement of Soybeans for the Tropics	"	Soybeans
Development of Improved Varieties of Soybeans		Soybeans
Inheritance and Improvement of Protein Quality of Barley	"	Barley
Cassava Pest Management	"	Cassava
Upland Rice Physiology	"	Rice
LATIN AMERICA		
Intensive Small Farm Management	El Salvador	Various grain & vegetable Crops
Food Improvement and Nutrition Improvement	Guatemala	Corn Beans Sorghum
Agricultural Development and Support	Panama	Various food Crops
Food Crop Production	Caribbean Region	Various food crops
Soil Fertility	ROCAP	Various food crops
Small Farm Cropping Systems	ROCAP	Various food crops

TABLE 4

Number of Projects and Identified Research Costs by Years in Project Life by Fiscal Year and Region

LIFE OF PROJECT - Years

N Year	1 or 2 years		3 or 4 years		5 or more years		10 or more years
	No. of Projects	Identified Research Costs	No. of Projects	Identified Research Cost	No. of Projects	Identified Research Costs	No. of Projects
77-							
ica (58)	6	3,089	16	6,309	36	17,472	5
a (33)	0		19	4,495	14	9,743	7
in America	4	410	26	6,884	8	6,621	4
r East (12)	2	599	5	1,864	5	1,497	2
78-							
ica (52)	0		8	4,377	40	35,449	4
a (24)	1	550	7	4,300	14	25,023	3
in America (40)	1	283	18	3,596 (14)	20	11,481 (19)	3
r East (19)	2	50 (1)	5	5,800	11	6,789	1

TABLE 3 Average Number of Years in Life of Project by Field of Research, Fiscal Year and Region

REGION	FIELD OF RESEARCH							
	All Projects	Rural Dev.	Crops	SDA	Ag. Gen.	Livestock	Ag Economic	Health
FY 1977								
All Regions	5.1(149)	3.4(8)	5.3(30)	3.4 (8)	4.5(12)	4.7(9)	5.1(10)	5.4(13)
Africa	5.1(59)	4.0(5)	5.7(15)	3.3(3)	3.0(2)	4.7(7)	4.0(4)	4.5(6)
Asia	5.4(38)	3.0(1)	5.2(6)	5.0(1)	5.5(4)		3.5(2)	6.1(7)
Latin America	4.6(41)	2.0(1)	4.2(6)	3.0(4)	4.0(4)		5.3(3)	
Near East	5.6(11)	2.0(1)	5.3(3)		5.0(2)	4.5(2)	12.0(1)	
FY 1978								
All Regions	5.6(140)	4.9(12)	6.2(33)	3.7(6)	4.7(16)	4.9(5)	6.6(9)	6.0(10)
Africa	5.7(66)	5.2(7)	6.5(20)	5.0(1)	4.6(7)	5.4(4)	6.0(5)	5.7(3)
Asia	6.1(22)	4.0(1)	7.1(3)	4.0(2)	5.0(2)		6.0(1)	11.5(2) Cholera)
Latin America	4.9(37)	3.0(1)	4.9(5)		4.6(5)		5.0(2)	5.0(3)
Near East	4.9(18)	5.3(3)	6.0(5)	3.0(3)	5.)(2)	3.0(1)	13.0(1)	2.5(2)

Note: Number of projects in brackets.

TABLE 2 Number of Regional Projects and Amount of Funds in Projects With Interregional Application

Bureau	Regional Application: Number of Projects	Regional Application: Funds (millions)	Interregional Application: Number of Projects	Interregional Application: Funds (millions)	Interregional Application: Percent of Identified Research
Africa					
FY 1977	45	18.764	14	8.110	30.17
FY 1978	56	33.414	10	6.412	16.10
Asia					
FY 1977	31	9.945	9	4.593	31.59
FY 1978	17	20.348	5	9.972	32.88
Near East					
FY 1977	11	3.600	1	.360	9.09
FY 1978	17	10.775	1	1.855	14.68
Latin America					
FY 1977	38	12.606	6	1.309	9.40
FY 1978	32	14.441	5	919	5.98

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