SCIENCE FOR DEVELOPMENT IN AFRICA

edited by
Thomas R. Odhiambo
and
T. T. Isoun

ICIPE

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Proceedings of the Consultation on the Management of Science for Development in Africa

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CONSULTATION ON THE MANAGEMENT OF SCIENCE FOR DEVELOPMENT IN AFRICA

SUMMARY OF RECOMMENDATIONS

PREAMBLE

African governments and their societies unanimously support the global objectives of rapid industrialization and technology development geared towards increasing national productive output and developing dynamic and self-reliant economies. There are, however, ineffective mechanisms to realize these objectives as evidenced by the minimal investment made by African nations (0.1 to 0.15% GNP) on research and development (R&D) and for the training of skilled human resources to sustain scientific creativity and technological innovation.

This Consultation on the Management of Science for Development in Africa, brought together distinguished policy-makers, administrators, university academics, research scientists, development bankers and financiers, and industrialists and entrepreneurs, largely from Africa, to deliberate on these issues and to initiate a mechanism for sponsoring and sustaining the processes for managing science. The participants recognized: the dominance of scientific activity in industrial infrastructure; the need to make international technology and financial transfer to flow both to and from the developing countries; and the importance of investment in science-driven agriculture and agro-industries to ensure food self-sufficiency as a start for industrialization. These actions are so fundamental to the improvement of the living conditions of the people in Africa that the strategy of governments for financing R&D should be to place science and technology on a war-footing in Africa. African governments must make a policy decision on the promotion of science as a means of bringing technology into the mainstream of national development and to fulfill their obligation to finance the necessary R&D through all means - national, regional, international, private banking and industry.

Further, the participants were aware that people will finance research if the benefits are close to them. In this regard, scientists particularly, must take the initiative of dealing with both transnational corporations and the informal sector; scientists must have honesty of purpose, safeguard ethical and cultural considerations in science, and promote standardization and quality control; scientists must encourage the components of the technology triangle - policy-makers, entrepreneurs and scientists - to work together in Africa and to develop national institutions. In turn, governments must (a) create incentives for the development of an environment conducive to science in Africa so that motivated scientific personnel can function, and (b) utilize scientists as advisers, if not members of their cabinets, for assuring that high priority is given to science and technology (S&T) in national development planning.

The Consultation focused its attention on three major themes:

1. **Creating an enabling environment for R&D, focused on African development**

2. **Mechanisms for creating an interface between science, industry and government; and**

3. **Financing of R&D in both private and public sectors.**

The participants acknowledged and endorsed the action of the African Academy of Sciences (AAS) in implementing mechanisms for promoting S&T in Africa:

- AAS has established the Network of African Scientific Organizations (NASO) to bridge the gap between science/technology, industry, and governments.

- Together with the International Centre of Insect Physiology and Ecology (ICIPE), AAS has instituted a series of seminars and conferences with national, regional, and international organizations to develop patent laws and commercialization systems for Africa, for the protection of innnovations and the rights of scientists and industrialists in Africa.

- In consultation with other agencies, AAS will carry out a detailed study of the problems of brain-drain from Africa and the possible ways of arresting the situation;
- In collaboration with Third World Academy of Sciences (TWAS), AAS has launched a peer reviewed multidisciplinary journal that will enhance communication between scientists and other segments of society within Africa; and

  AAS is planning to launch, in collaboration with the Association of African Universities (AAU) and interested donor organizations, a human resources programme (under its programme of Africa Brains Trust). It is also, under the same auspices, developing a Referral Data Base Centre.

  Consultation participants urged the Academy to carry on with expanded activities in these programmes and to undertake study of the need for the establishment of a Technology Commission for Africa (TCA) and an African Technology Group (ATG) as an industrial/commercial enterprise owned by scientists, technologists and industrialists.

SPECIFIC RECOMMENDATIONS

Multifactorial problems of development on the continent require that all interested organizations rally to these causes. The participants, therefore, directed specific recommendations to some of these organizations as discussed below.

THEME ONE: CREATING AN ENABLING ENVIRONMENT FOR R&D FOCUSED ON AFRICAN DEVELOPMENT ON A SUSTAINABLE BASIS

1. That the Association of African Universities (AAU) should play a leading role in evolving new approaches to S&T which emphasize practical involvement of university faculty and students with:

- agriculture in support of food production
- local industries and occupations; and
- local entrepreneurs including the informal sector.

2. That training at university level should be designed to incorporate into the scientific and engineering programmes, courses that cater for the entrepreneurial development of future generations. The curricula should be modified to include courses in management, politics, and economics.

3. That the AAU should endeavour to change the evaluation and reward system of university staff to encourage cooperation with the informal as well as agro-industries and the industrial sector.

4. That there should be close collaboration between universities, research institutes and national planning agencies; this collaboration should emphasize R&D geared towards socio-economic goals which are target-oriented. Furthermore, technology triangles should be established as a means of converting knowledge into wealth for the improvement of the human condition.

Theme Two: Evolving Mechanisms for Creating an Interface Between Science, Industry, and Government

5. Information Data Base.

- The African Academy of Sciences (AAS) should examine the existing national and regional information initiatives and sources from outside Africa for the establishment of data bases for possibilities of networking. The participants noted that this is already a programme of the Academy and welcomed Academy assurance that it will cover the collection of past and current R&D findings in Africa so as to constitute a comprehensive referral data base centre.

- The information data base should be created for use by scientists/engineers, industrialists and policy-makers.

- The data base should be a multilocational network with centres in various strategic parts of Africa and elsewhere in the world.
- The services of the data base should be commercialized and paid for by all users.
- The services provided by the data base should cover technological research findings, possible applications of existing technology, products of technological innovation and text books.

6. Teaching Materials. The AAS should organize a programme to promote the publication, popularization, and distribution of technical books to facilitate the extension of S&T to the general public. The participants welcomed the information that the Academy intends to make this one of its major activities through NASO.

7. Sensitization of Institutes of Technology.

    - University and research institutions should play a promotional role in the development and growth of small-scale industrial operations.
    - Universities and research institutes should initiate and operate industrial consultancies. They should model themselves to provide service on the basis of their expertise to the government and industry as a source of income. At the same time, industrialists should seek greater advice from professionals in the universities and research institutions and participate in refresher courses.

8. Scientists as Entrepreneurs.

    Individual scientists should be encouraged to go into industry. They should start small-scale industries initially but with the vision of developing their businesses to large-scale economic levels.

Theme Three: Financing of R&D in Both Private and Public Sectors

9. The African Development Bank (ADB), as the primary African development and lending institution, should be involved as a partner in this enterprise of initiating and promoting R&D and in the mobilization of necessary resources for its implementation in the near and long term.

10. There is urgent need for industry and the private sector in general to get involved in financing of R&D enterprises. In this respect, African governments have a critical role to play in establishing incentives, such as tax-exempt contributions by industry, to R&D that would promote and bring about the involvement of industry.

11. The Future Actions Committee whose secretariat will be coordinated by the AAS and the ICIPE, should appoint specialized task forces to identify critical scientific problem areas with potential for R&D of benefit to the African continent in times of crisis. The task forces should be responsible for developing plans for their implementation:

IMPLEMENTATION PLAN

In order to implement the strategy of the programme, the participants in the Consultation:

- Established a Future Actions Committee to act as the continuing organ of the Consultation Meeting. The Future Actions Committee is a small group consisting of experts in science, technology, geopolitics, management, banking and industry. Its current Chairman is the soldier and statesman, General Olusegun Obasanjo.

- Noted that the Future Actions Committee will operate under the aegis of the ICIPE and AAS, which will coordinate and implement actions arising from the Recommendations of the Consultation Meeting.

- Decided that the Second Consultation Meeting will be held in two years time at which the Future Actions Committee will report progress.

- Directed that the Future Actions Committee to (a) constitute a delegation to address the O.A.U. Heads of State and (b) organize a meeting of Heads of State with scientists and industrialists (possibly as part of the Second Consultation indicated in (3) above), to focus on Science and Technology objectives to be achieved by Africa by the year 2000:
    - Self-sufficiency in basic food production for Africa
    - Self-reliance in transportation and basic equipment for land and in-land water-ways and agriculture.
    - Self-reliance in production of basic educational materials and equipment.
    - Self-reliance in energy supply, particularly intra-conti-nental gridding of hydro-electricity and distribution of fossil fuels.
    - Production of 50% of drugs and medicaments required in Africa.
    - Entrepreneurs to (a) re-invest or give grants and donations of not less than 10% of their profits to research and development and (b) make scientists their close allies in indigenizing their production and products. Investment or grants to research and development should be made tax deductible by governments.

That the Future Actions Committee will comprise the following individuals and agencies invited as observers:

MEMBERS

General Olusegun Obasanjo (Statesman, Entrepreneur and Chairman, Africa Leadership Forum) — Chairman, Nigeria

Professor Lydia Makhubu (Vice Chancellor and Head of Chemistry Department, University of Swaziland. — Vice Chairman, Swaziland

Professor C.C. Mjojo (Professor of Chemistry, University of Malawi) — Member, Malawi

Mr. Madatally Manji (Industrialist and Executive Chairman, House of Manji) — Member, Kenya

Dr. J.M. Kordylas (Consultant, Arkolyds FoodLaboratory for Research and Development of Tropical Food Products) — Member, Ghana

Professor P.N. Nkwi (Chief Adviser to Ministry of Higher Education) — Member, Cameroon

AGENCY OBSERVERS

U.N. Economic Commission for Africa (ECA)

African Group Development Bank (ADB)

SECRETARIAT

Professor S.Gombe	Scientific Secretary, AAS
Professor T. T. Isoun	Editor, AAS
Mrs. R.A. Odingo	Chief Planning Officer, ICIPE, Convener
Dr. V.O. Musewe	Station Manager, ICIPE

The Proceedings of the Consultation will be circulated widely in African countries and to the international community.

A Declaration in English and French highlighting issues of concern and the commitment of African scientists will be prepared by the Future Actions Committee and circulated to all Heads of State in Africa and the Secretary-General of the OAU.

The Secretariat will liaise with ECA, ADB, and UNDP on the role these institutions will play in the programme.

The Secretariat will draft terms of reference, membership and time-tables of the various task forces and circulate them to the Future Actions Committee.

The Future Actions Committee will meet in Nairobi for two days in the second half of July, 1989.

Welcome and Introductory Address

Thomas R. Odhiambo

The rise of modern industrial economies in the last century or so has demonstrated again and again that the path to national economic prosperity relies on three crucial interacting factors:

First, the creation and nurturing of an enabling environment for scientific discovery and technological innovation. Such a productive political and social environment enables the full potential of the brainpower of the scientist and technologist to be released to wonder, to explore, to tinker, and to find fulfilment.

Second, the development of a national culture which recognizes that science is an integral part of human culture, and not simply a tool to be taken up or purchased as part of the national accoutrement for development.

Third, there must be a continuing two-way interfacing between the science enterprise and the political economy enterprise (consisting of agriculture, industry, the health institutions and the financial community).

These three same ingredients are prominently demonstrated in the newly industrialized countries of Asia and Latin America, including those with few natural resources to boast about (such as Singapore and Hong Kong).

In the last three decades of Africa's political independence, we have moved in a contrary direction: we have erected stifling barriers and constraints that have all but snuffed out any emerging growth points in science and technology; we have strenuously attempted to build up an African culture from which the vital component of science is divorced; and we have kept our small struggling science enterprise in a separate compartment from all other factors necessary for economic development.

This week's Consultation on the Management of Science for Development in Africa is a serious attempt, probably for the first time in this century, to present a forum for leading wisemen in Africa to consciously create a long-term vision for Africa, in which the social and economic development of Africa will be science-led. We realize that what we will be able to do in four short days is simply to paint the broad strategic strokes of this vision; the detailed picture will be completed through many subsequent sessions of planning, dialogue, and advocacy. It is precisely in anticipation of this implementation-oriented post-conference activity that the conference organizers - the International Centre of Insect Physiology and Ecology (ICIPE) jointly with the African Academy of Sciences (AAS) - have suggested that this conference appoint a Future Actions Committee in the course of its deliberations. It is our expectation that the Committee will ensure that Africa keeps faith with itself in beating a new transforming path of science-led development by acting on the long-term vision that this week's conference will help to create.

The Academy has, since its inception almost exactly three years ago, focused its efforts on the mobilization of Africa's scientific talent and on sensitizing African governments to the great potentials of science for national development. The ICIPE, on the other hand, has - besides its principal mandate of creating a knowledge base for the development of sustainable management of insect populations in the tropics, especially in Africa - a crucial concern about institutional building and human resource development in the field of science and technology in Africa. In convening the Consultation on the Management of Science for Development in Africa, the joint organizers entertain high hopes that the talented and experienced group of African personalities whom they have brought together this week will spend most of their time talking and thinking broadly, strategically, and in a transdisciplinary mode so as to fashion out the long-term vision I referred to earlier. In order to assist this process, we asked a leading new-generation scientist in Africa, Professor Olu S. Adegoke, a geologist based at the Obafemi Awolowo University in Nigeria, to prepare a comprehensive background paper for the conference as a whole.

It is satisfying that all those whom we invited responded so well to our invitation to take part in this important task of creating a new science management vision for Africa. We are indebted to the Canadian International Development Agency (CIDA) who have given us the financial means and intellectual freedom to pursue unfettered, our dream, at this important juncture in the geopolitical history of this continent.

Opening Speech

G.M. Ndotto,
Minister for
Research, Science and Technology, Kenya.

Distinguished Delegates, Guests, Ladies and Gentlemen:

On behalf of the scientific community and the people of our beloved country, Kenya, I am greatly honored to have the pleasure of welcoming you to Nairobi. You have convened here to deliberate on the very important issue of the application of science and technology to the development of countries of Africa, whose socio-economic development has, for many years, eluded the enforcement of purely economic policies.

Historical Background.

The title, *Consultation on the Management of Science for Development in Africa,* calls to my mind the deliberations of the United Nations World Conference on Science and Technology (UNCSTD) which was held in Vienna in 1979. That pivotal meeting evolved the current world awareness of the importance of science and technology to the development of societies, which is summarized in what we now call *Science, Technology and Society*. Even at that early stage, it was noted that to successfully apply science and technology to development, would require not only expertise and supportive government policies, but also a **determined pooling of political will to develop national potentials in science, technology, education, research and infrastructure in developing countries.**

It is now very clear to us that the widening gap in economic growth observed between the developed and developing countries is closely linked to the increasing imbalance in scientific and technological capabilities and it seems appropriate that we in developing countries should re-dedicate our efforts to minimize that disparity with all the means at our disposal.

KENYA'S EFFORTS

Let me reiterate the commitment of our country and also that of my Ministry to the establishment of science and technology as a basis for national development. During the past decade there has been a rapid expansion of the nation's capacity for higher education at universities. The pre-university education system in this country has been re-focused to give more emphasis to technological self-reliance. We have restructured the research system in Kenya for better management and effectiveness. Our country is hosting the largest number of international resarch institutions and development agencies in the African region. The Government of Kenya has politically, morally and financially supported the Nairobi-based ICIPE, an African conceived international research institution whose main mandate is the control of insect pests of crops and vectors of live-stock and human disease. We have encouraged ICIPE to enhance scientific capabilities of the continent through high level training in insect science research in order to provide the necessary leadership in Africa. We are also hosting the African Academy of Science which is committed to the mobilization of science for national development and the sensitization of African nations to the imperative use of science and technology for modern development and to the vital part that indigenous scientists must play in this process. We are confident that, with continued political peace in this country, the research and training activities of these national and international institutions will develop the requisite manpower and technologies that are required for economic advancement of the African continent.

RELEVANCE OF SCIENCE FOR AFRICA'S DEVELOPMENT

Whether or not the manpower and technologies generated at national and international institutions will remain relevant and applicable to the African situation, is the factor critical to the sustained technological development required. You, as high level representatives of Africa's policy makers, the scientific community, the industrial sector, and funding agencies, are charged with the responsibility of providing guidelines on the actions necessary to ensure that science and technology remain relevant to Africa's sustained economic growth.

Allow me to make one or two observations on this issue of the application of science and technology to national development in third world countries. First, the need for science and technology in development is not a new philosophy. It has been discussed at various levels of government in many African countries. Indeed, most countries are in the process of establishing or implementing strategies aimed at enhancing their technological bases. A meaningful discussion of this subject must not fail to take stock of the achievements and experience gained so far by developing countries. What is now required is to harness and apply that information to development, while at the same time attempting to make improvements on the existing technologies.

Secondly, we should be able to learn from the experience gained by industrialized countries which have successfully applied science and technology to their economic development. Experience has shown that four basic elements are essential to the development of a technology-based economy:

- The political machinery should be able to institute supportive policies and create a social environment that is sensitive to technological advances and that will facilitate and increase production for development.

- There must be a commitment to the development of human resources and, particularly, manpower to create and manage technology.

- The strategy should focus on the end-users of technology, and incorporate their needs into the design of the objectives and the implementation process; and

- There ought to be a sustainable source of funds to finance the high costs and risks associated with the development of suitable technologies.

A discussion of the application of science and technology should examine these four elements in the context of Africa's economic situation and the culture of its peoples. I am pleased to note that the themes selected for this workshop, namely,

- Creating an enabling environment for research and development (R&D) focused on African development;

- Mechanisms for creating an interface between science and industry;
- Financing of R&D in both private and public sectors; and
- Long-term vision of special opportunities for Africa,

will touch on all four elements, in an attempt to review the process in which policy-makers, entrepreneurs and researchers can work together for sustainable techno-economic development in Africa.

CONCLUSION.

The task before you for the next four days or so, is enormous for several reasons. First, your committee is charged with the onerous responsibility of preparing tangible and concrete recommendations for the African continent. Secondly, the recommendations you make, when implemented, will affect policy decision-making in many nations and change the living standards of millions of African peoples whose interest you must represent effectively.

I hope you will, therefore, apply your vast professional skills and experience in:

- Carefully reviewing the state-of-the-art of the application of science and technology for development in the continent.
- Identifying bottlenecks to, and requirements for, the enhancement of a science culture among African communities; and
- Using the benefit of hindsight of past experience as well as success stories from developed countries to formulate recommendations, including flexible plans of action that may be adaptable and acceptable to individual countries of Africa. In your potential problem analyses, you should pay special attention to the possible problems that may be created by science and its applications in the African setting. It is my sincere hope that the output of your meeting will clearly

spell out the important roles and contributions that must be expected from the principle players in technology generation and utilization i.e., the policy makers, the industrialists, the scientists and the ultimate consumers of technology.

I believe you will join me in expressing our appreciation to ICIPE, AAS, and CIDA for facilitating this meeting.

I also wish you all successful deliberations and a pleasant stay in Nairobi. **May I now take the opportunity to declare the Consultation on the Management of Science for Development in Africa, officially opened.**

PART TWO

BACKGROUND PAPER

Management of Science for Development in Africa

O.S. Adegoke

Summary

1. There is a strong yearning in all developing countries of Africa for rapid industrial and technological development aimed at increasing national productive output, alleviating poverty, and establishing strong, dynamic, and self-reliant national economies.

2. These efforts are plagued by problems whose historical roots are found in the partitioning of Africa and the resulting dependence of the African economies; unsuitable national development policies and plans; the high level of illiteracy; and the non-adoption of a science culture.

3. The major manifestations of the unenviable situation in Africa are the excessively high population growth rate (over 3.1% per annum) which places considerable pressure on existing resources and services; food shortages; the crippling debt burden that leaves virtually no funds for development; the continued dependence on declining revenues from raw material exports

with virtually no manufacture value added (MVA less than 1%) and the escalating expenditure on imported finished consumer goods. The situation is further compounded by the frequency of natural disasters, especially floods, erosion, desert encroachment and pest invasions.

4. Despite the enormity of the problems, African nations make the least investment (0.1 to 0.15% of GNP) on research and development and the training of skilled manpower. The continent has the lowest number of research and development scientists and engineers per capita in the world (0.3% of world total).

5. An environment conducive to technological development should be created by :

   - inculcating a science culture into the African society;
   - intensifying high level skilled manpower training;
   - creating a network of scientific associations and communities to ensure optimal utilization of existing material and manpower resources.
   - ensuring effective dissemination of scientific research results;
   - instituting effective policies at government level geared towards rapid technological take-off; and
   - providing facilities, infrastructure and the right motivation and incentives for scientists.

6. Technology development centres should be created at national and regional levels to stimulate the pace of technological development on the content.

7. There is need for interface between scientists and the industrial sector. Both should play a complementary role. Scientists should respond positively to the research needs of industry. Industry on the other hand, should support research and development efforts actively.

8. Technology triangles in which scientists from universities, acting as entrepreneurs, collaborate with industry and the fi-

nancial institutions to develop and market new products resulting from the effort of the researchers, should be established in Africa as they have been in developed nations.

9. In order to build successful technology triangles, African scientists must learn to develop the entrepreneurial spirit. The supporting educational institutions must have strong academic programmes in engineering, mathematics, basic sciences, computer science, agriculture, veterinary medicine, biotechnology and business management. Government must provide the right policy measures and infrastructure.

10. The primary responsibility of providing funds to support research and development rests with the governments of each African State. This should be done through annual budgetary provisions. The multinational companies and the private sector should also be made to pay compulsory research and development levies. Such contributions should, however, be tax deductible. Large multinational companies should be encouraged to establish research and development facilities locally.

11. The continued support of African research and development efforts by international donor organizations should be encouraged.

12. Venture capital as risk money provided specifically for tracking, examining, initiating and funding of new businesses or products. Despite the high risk, the objective is to obtain unusually high returns on the investments.

13. There is need to adapt the venturing concept to the African situation such that high demand consumer products for which the production technology already exists and for which Africa has a large market, should be developed side by side with new products arising from inventions, and innovations.

14. Agriculture and health must form the highest priorities of the technology development drive of Africa.

15. Venture funds can be generated through mobilization of rural credit, formation of cooperatives, and mobilization of both national and regional venture capital.

16. Because of its unique position as the leading African development finance institution, the African Development Bank

(ADB) is identified as an institution capable of spearheading the effective mobilization of venture capital funds on a regional basis.

17.An effective way of accelerating the pace of technological development throughout Africa would be to form an African Technology Development Group (ATG)., This requires that African scientists come together to jointly promote the development of their own ideas, and products. The goal is to create a high level network of leading African scientists and technologists as an "African Technology High Command", within which they would work together with purely commercial and entrepreneurial objectives. Its formation would promote free communication and ensure optimal mobilization of indigenous skills. The pooling of resources would widen the internal venturing base and guarantee greater success of the venturing effort.

18.In order to ensure that technology development receives priority attention and a sustained momentum throughout Africa, a Technology Commission for Africa (TCA) should be set up. Its duties should be to make a periodic overview of the continent's science and technology needs, prepare realistic master-plans and ensure their effective implementation by harnessing Africa's material and human resources.

19.The governing board of the TCA should include Africa's leading scientists, politicians, military men and civil servants. One of their primary tasks should be to sensitize African governments so that scientific and technological development is given the priority attention that it rightly deserves.

20.The overall objectives of this African technological development should be:

- to reverse the role of Africa as the supplier of unprocessed raw materials and net importer of consumer goods, to one of a major producer of finished goods, competing effectively with developed nations for its share of world markets;

- to bring illiteracy to an end and ensure total adoption of a science culture through an aggressive science popularization programme;

- to accelerate the pace of technological regional cooperation, reversal of brain drain and mobilization of existing institutional structures (such as the regional economic and common service groupings, the natural resources development organs, the training and reasearch institutions, the financial institutions, the Academies of Science and professional societies, as focal points for the technology development effort.

MANAGEMENT OF SCIENCE FOR DEVELOPMENT IN AFRICA

DEVELOPMENT INDICATORS

Introduction

It is generally accepted that the developed nations of the world are readily distinguished from the developing or underdeveloped nations by their higher level of scientific and technological development. In Third World developing countries, the rate at which science and technology (S&T) are applied for development is low. There is poor awareness within the populace of the intricate relationship between the total adoption of a science culture and progress in both the economic and industrial sectors.

In all these nations, there has been a strong yearning to attain rapid industrial and technological transformation, a yearning that has been articulated in most development plans and policy statements.

The desire for rapid industrial and technological change has as its basis the desire of the national governments "to increase national productive output, alleviate poverty and establish their respective nations firmly as united, strong and self-reliant nations, with great and dynamic economies, and as lands of bright and full opportunities for all citizens " (Nigeria's 4th National Development Plan).

The adoption of this development stategy is informed by the obvious prosperity of the developed nations and the fact that their economic and politcial dominance over the other nations, is sustained by their higher level of technological development.

In their effort to bridge the gap between themselves and the developed nations, developing countries have made massive investments in the commercial, industrial, and manpower development sectors. They have pursued, on priority basis, the implementation of gigantic and expensive heavy industries, usually designed and constructed on a turn-key basis. Considerable funds have also been devoted to agricultural projects and rural development. The primary objective has been to attain rapid industrial transformation and lasting economic development through the process of technology transfer.

True scientific, technological and industrial development implies a certain level of independent mastery and control of the materials as well as the means of production. That is, it implies a certain high level of scientific and technological self-reliance.

The disparity between the economies of developing and developed countries, has been depicted using several economic indicators. In the following brief review, a number of such indicators which highlight the backward position occupied by Africa relative to developed and other developing countires, are considered.

Population

The influence of population growth rate on the economy of any country cannot be over emphasized. Unlike the industrialized countries, where the annual population growth rate is about 0.5%, Africa is characterized by a mean annual population growth rate of 3.1% with at least one country recording a rate of 4.1% (Appendix 2). In simple terms, this means that the population of the continent will double itself every 25 years.

The effect of rapid population growth in Africa is multiple. First, there is serious environmental damage, arising from excessive pressure, to many parts of the continent. Secondly, there is a rapid depletion of grazing and and arable land required for food production, leading to the well known food shortages. Available World Bank data shows that 26 of the 37 least developed countries of the world are in Africa. Twenty-four of them do not produce enough food to support their populations. Thirdly, an uncontrollable population growth leads to rapid and irreversible losses of renewable resources. One glaring example is the pressure on the forest to produce fuel wood for cooking and the resultant encroachment of the desert on Africa (Appendix 3).

A high population growth rate also puts pressure on available facilities such as water supply, medicare, electricity, education, and shelter. Moreover, populations are skewed toward the young. The disproportionate percentage of the population under the age of 15 places considerable and often unanticipated strains on the health and resources of the adult population. Thus, approximately 46% of the population of developing countries is under the age of 15 years as against 23% for the developed world; one youth is being catered for by at least three adults in developed economies but one youth is being catered for by only on adult in the developing world.

Food and agriculture

Another result of the relatively large percentage of children is that while an increasing number of the young are being fed, fewer adults are available to grow the required food. The problem is compounded by the fact that food production in Africa is still labour intensive and based largely on traditional methods.

In most cases, African countries depend on exportation of raw materials for foreign exchange. Where such commodities are non-agricultural products, there is the tendency to abandon the agricultural sector altogether as has happened in Nigeria. Where the exportable commodities are agricultural products, the production of food by the exporting countries is secondary to the production of cash crops. As a result, there is acute shortage of food in Africa and money that should be used for industrial development is spent on importation of food. Where money is not available the 'starving' country depends on aid. With the exception of a few countries, African countries generally have a negative annual growth rate in food production (Appendix 6). In fact, 24 African countries do not produce enough food to support their population and 21 of these are on the World Bank's list of low-income countries.

Economic indicators

Various parameters indicate that the economies of African countries are among the most undeveloped in the world.

For example, while many developing and developed countries have been having annual real growth in their GNP per capita, Africa has consistently shown a negative annual growth rate (Appendix 4). According the the World Bank, 21 countries in Africa are among the "low income countries" that is, the GNP per capita is less than US $400. It is generally accepted that substantial capital accumulation is a prerequisite to rapid economic development. That is to say, high saving ratios are good for economic growth. Africa however, has the lowest saving ratio in the world (Appendix 8); it is therefore not surprising that 26 of the 37 least developed countries in the world are in Africa.

Another indicator of development is the amount of value added to manufactured goods (MVA). While Africa is responsible for the production of a significant proportion of some of the world's mineral and agricultural products (Appendix 9), its percentage of the world's MVA is pathetically low (Appendix 10). While the MVA in the industrialized world is as high as 65%, that of Africa is a mere 1%.

Environment and institutions for economic growth.

In Africa, economic growth is often hampered by natural disasters, such as drought, desert encroachment, flood, pest invasions and erosion. While such disasters occur in other developing countries and to some extent in the industrialized countries as well, due to many factors, their effect is more calamitous in Africa.

First, African countries do not usually have the technological know-how nor possess the facilities for predicting the occurrence of such disasters. Consequently, they are always caught unawares. Second, even when they are warned against an impending disaster, most African countries do not have the human, financial and material resources to plan for solutions. They therefore have to depend on foreign aid for survival.

In addition to natural disasters, economic development in Africa is plagued with the twin menaces of government instability and changing policies. Everyone agrees that rapid economic growth cannot be maintained without a stable government and security of life and property. Most African countries are characterized by political instability, military coups and revolutions. At the same time, African countries are also characterized by continuously changing economic policies, dictated by successive governments and often, by foreign governments.

Debt burden

African countries are importers of manufactured goods and exporters of raw materials, especially agricultural products and mineral resources. However, over the years, there has been a steady decline in the export output of African countries. Furthermore, the prices for most export commodities have decreased (Appendix 11). As a result of the decline in ex port output, and collapse of prices of export comodities, African countries have, over the years, suffered huge trade deficits and incurred heavy foreign debts. The level of the foreign debt of Africa can be appreciated from the fact that in 1987, the ratio of debt to GDP and ratio of debt to exports for Africa were 0.70 and 2.95 respectively (Appendix 12). The situation has not improved since. In 1987, the debt ratio for the continent was 35.8. The effect of such high debt ratios is that most African countries are spending the money that should be used for development on debt servicing. Furthermore, most countries are experiencing a foreign exchange squeeze and are accumulating arrears with the result that they are becoming less credit-worthy and are thus unable to procure fresh loans needed for their recovery process.

Technology and education

The technological advancement and development of any nation, depends on an educated and skilled labour force. Regrettably, most African countries are still plagued with a high rate of illiteracy (Appendix 13).

It is also a matter of concern that Africa is not investing in the training of the skilled manpower needed to make adoption of modern technology effective. For example, available data (Appendix 17) indicate that from 1970, Africa has always spent less than 0.4% of her GNP on research and development (compared to 2.23% in developed countries) Consequently, Africa has the lowest number of scientists and engineers per capita in the world (Appendix 16).

SCIENCE AND TECHNOLOGY DEVELOPMENT IN AFRICA: THE PROBLEMS

Four major obstacles to the economic and social development of Africa were identified by the Second Conference of Ministers Responsible for the Application of Science and Technology to Development in Africa (CASTAFRICA II):

- The partitioning of the African continent
- The dependence of the African economic system
- The unsuitable development policies and plans
- The educational situation and the handicap of illiteracy.

One of the greatest advantages of the science debates is the creation of greater awareness among African nations of the importance of research and development as well as science and technology for true development. Each country has, therefore, been made to feel the urge to establish its own scientific base rather than rely on the importation of turn-key industrial projects that are based on technologies that are ill-suited to the African environment.

Lack of progress in the scientific and technological sphere is all- pervasive, as it affects the affluent and economically more advantaged nations of Africa as much as it does the less endowed nations. Much of it has been attributed to lack of political will arising from the colonial history of the African nations, the political instability and the erroneous belief that the economic problems confronting the nations can be solved through fiscal and economic measures only. There is need to embark on a deliberate policy that will uplift the status of scientists, as well as that of S&T throughout the continent and increase the productive output of the populace.

The basic problems related to scientific and technological development and which require solutions are summarized below:

• Need for national science and technology policy-making bodies in Africa.

Until recently, most African nations did not have a S&T policy, nor did they have a clearly designated S&T policy-making body. There has been considerable improvement since 1979, as more and more countries are establishing ministries or agencies for coordinating science (Appendices 14, 15).

• Inventory of African scientific and technological potential

Despite the importance of accurate and current data for planning, there is no reliable data on the scientific and technological potential of Africa. Available information indicates that African scientists and engineers devoted to science are grossly inadequate - constituting only 0.4% of the world total (Appendix 5).

• Creation of an environment that is conducive to scientific work.

Conditions conducive to scientific creativity and technological innovation must prevail in order to attain economic development. There is need to organize scientists into functional communities in order to enhance their productivity.

• General educational level of the population and scientific and technological development

There is need to increase the level of awareness of the populace through campaigns in education and the media.

• Need for regional cooperation

The reluctance to participate in regionally based training programmes or projects must be overcome as a means of conserving scarce resources.

• Common problems

Common problems encountered in the development of S&T on the continent are summarized below (CASTAFRICA II):

- Absence in some countries of a national science policy-making body and the inadequate mandate accorded to such bodies when they exist;
- Inadequacy of the financial resources allocated for national R&D efforts in S&T (Appendix 17);
- Shortage of well-trained and experienced science technology personnel and inadequacy of the plan for human resource development;
- Weakness of research infrastructure and services, particularly science information, extension services and research result utilization;
- Lack of special status for scientific workers;
- Ineffective mobilization of African scientists to tackle problem-related research; and
- The inappropriateness of S&T education.

THEME I: CREATING AN ENABLING ENVIRONMENT FOR RESEARCH AND DEVELOPMENT FOCUSED ON AFRICAN DEVELOPMENT ON A SUSTAINABLE BASIS

Introduction

It has been argued that the greatest constraint to the development of S&T in Africa is the absence of a conducive environment. A conducive environment must foster productive research and development activities on a sustainable basis and lead ultimately to self-reliance in all sectors. To do this, the entire African population must be mobilized to adopt science as a way of life. A synthesis of data presented at various national and continental conferences and workshops show that the following issues must be addressed:

- **Adoption of a science culture in Africa**
- **Production of a corps of well trained indigenous technological manpower**
- **Networking of scientific communities**
- **Establishment of S&T policies**
- **Motivation and incentives for scientists**
- **Provision of incentives (tax rebates, tax holidays etc.) for companies investing in local R&D efforts**
- **Involvement of scientists in national planning**
- **Establishment of a viable R&D base for selecting, adapting and developing technology**
- **Establishment of the institutional framework for developing and adapting technology**

- **Provision of avenues for the effective dissemination of scientific research results.**

- **The role of governments**

Adoption of a science culture in Africa

The rate at which S&T are applied for development in Africa is low. Science is not yet a part of the culture and the populace is not fully aware of the importance and impact of technology in their daily lives. Religion and superstition still dominate the thinking of most Africans. There is thus need to actively re-orient the populace toward the adoption of science as a way of life (Adegoke 1985, 1988). As observed by M'Bow (1985), **development's "only chance of succeeding is if it is espoused by populations who are fully aware of the need for it, ready to act and determined to do so."**

Some of the most effective ways suggested for stimulating the scientific consciousness of the populace include:

- intensification of the teaching of science and technology in the formal educational system. Integrated science should be taught at primary school level where the natural inquisitiveness of the young can be optimally stimulated and developed.

- the development of science and technology museums. Museums that are properly laid out serve as an invaluable educational tool for both educated and less educated people alike. Good examples are the various natural history and technology museums found in all developed nations.

- propagation of scientific and technological information using the multimedia approach especially through radio and television. It is essential to stress that the programmes have to be prepared and presented in a stimulating and convincing manner by an interdisciplinary team of experts in the sciences and educational technology.

  The approach must not be pedagogic. Each programme should be laid out in such a way that the underlying scientific principle is presented and linked to practical everyday applications. A good example is the science popularization programme in Cote d'Ivoire. By contrast, some of the science programmes taught on television in Nigeria can hardly rouse the attention even of a practitioner.

- utilizing the capability and expertise of the numerous scientific societies and associations present in each country by establishing a network of such societies. These societies should be organized and funded under the umbrella of the national Academies of Science and charged with the responsibility of propagating science to the entire nation.

- institution of a formidable extension service in S&T. The dissemination of scientific information through extension services was developed in the United States and Europe. It played a significant role in the high level of development of agriculture in those countries. In Africa, extension was introduced as part of the educational package in agriculture. Its success has been considerable. African farmers are generally aware of the higher productivity associated with the adoption of improved farm techniques such as the use of fertilizers, improved seed stocks, pesticides and herbicides, irrigation, etc.

  There is need to extend extension services to the S&T fields. Extension workers should understand the principles of sociology in addition to having competence in interpreting, simplifying and presenting technological innovations in a language that the layman can understand and appreciate.

  A properly thought-out national S&T policy should, therefore, give pride of place to information service and the establishment of a data bank for the easy storage and retrieval of vital scientific data. This is because the society cannot be re-oriented technologically unless there is free flow of information between the scientists/researchers and the consumer populace.

Production of a corps of well-trained indigenous technological manpower.

The most important constraint to rapid scientific and technological take-off in Africa has been the inadequacy of competently trained and experienced indigenous manpower. In order for S&T to take root, a critical number of scientists engaged in R&D must be present. These will transform the problems of production and application into feasible, technological solutions.

The inadequacy of skilled scientific manpower in Africa is basic; and has its roots in the culture, education, science and training policy of the member nations.

Statistics published by UNESCO in 1986 (Appendix 16) show that the number of African scientists engaged in R&D work is lower than the mean for developing countries. It represents only 0.4% of world total as against 11.2% for all the developing countries. The "density index" for scientists and engineers engaged in R&D per million inhabitants are: 49 for Africa (excluding Arab member states), 129 for all developing countries, and 2,986 for developed countries.

The problem of inadequate skilled manpower is compounded by the fact that expatriates execute most of Africa's high technology projects, thereby depriving Africans of opportunities to gain experience.

The message for the continent is clear: it is not possible to attain true scientific, industrial and technological self-reliance without the total involvement and commitment of indigenous scientists. Africa is presently at the same stage in which Europe, Japan and the USA found themselves during the post World War years. In order to sustain the scientific and technological impetus, and notwithstanding the general depression, those countries pumped massive funds into initiating and expanding training and research facilities. Each country encouraged its nationals to pursue research in existing institutions as pre- and postdoctoral students. In this connection, the following is recommended:

- Introduction of formal training in science and technology into the curriculum at all levels.
- Inculcation of a scientific attitude into the populace.
- Compelling industries to provide exposure to trainee technicians and technologists.
- Provision of adequate funding for establishing research support facilities and infrastructure in all institutions of higher learning.
- Creation of avenues for the re-training and skill improvement of employed scientists and technologists through short in-service courses, participation in conferences, workshops, etc.
- Ensuring the free flow of books, journals, etc.

- Creation of centres of excellence for critical subject areas in various institutions so that such centres can become focal points for attaining excellence in the designated fields.

Networking of scientific communities

In order to create an environment conducive to cooperation and to optimize the use of available resources, the scientific and technological community of Africa must be organized, on a firm and formal basis. It is within each organized group that development problems can be debated by high quality researchers who are capable of innovating and creating.

Much of the progress recorded in technological development efforts in Asia and Latin America during the past decade has been largely attributed to the enthusiastic activities of these science communities which are organized as federations, associations and networks which collaborate between themselves and with international funding agencies. This approach should be discussed and the mechanism for operationalizing it should be articulated by this Consultation.

Establishment of science and technology policies

There is need for all African governments to set up the appropriate institutional framework for accelerating the pace of scientific and technological development. A policy document clearly outlining government's goals and the guidelines for achieving the stated goals should be published and distributed widely. The policy document should address itself to the peculiar problems of Africa with respect to the culture and beliefs of the people, and seek to change these through a carefully planned system of mass mobilization and political control. The policy should also carefully articulate how the various arms of government will complement each others' roles in order to achieve the stated goals.

Setting up a national science and technology advisory council

Each nation should set up a supervisory body to control and nurture the national technology development effort (Adegoke, 1988). This extra-ministerial body should be multidisciplinary in composition, autonomous in its operations, national in outlook and should be directly advisory to the respective African heads of governments. Its composition should include all the government ministries that are essentially science-based as well as a few carefully selected scientists from higher institutions and the community at large.

By placing the council under the direct supervision of the heads of government, competition for control and the usual inter-ministerial squabbles would be eliminated or reduced.

Recognition, motivation and incentives for scientists

There is need to set up an acceptable system of reward, motivation, recognition and other incentives for scientists, if they are to accept their calling as full time career scientists. They have to be adequately remunerated and in addition, extra incentives must be provided to keep them glued to their work.

Examples abound to show that scientists work best under an acceptable reward system. In order to promote Soviet scientific effort in the mid-1940s, despite the shattered economy, Stalin increased by 300% the salaries and emoluments of all scientists and researchers connected with the Soviet Academy of Science.

There is little doubt that the salary and reward system for scientists is poorest in Africa where, in most cases, scientists are rated and paid less than their contemporaries who studied the humanities and are engaged in administration.

Involvement of scientists in national planning

Despite the realization of the fact that technological development is the key to Africa's production problems, national planning in most African States is exclusively in the hands of economists and adminstrators. It is becoming abundantly clear that the present depression cannot be managed through economic and fiscal manipulations only. The economy can be turned around only when, through a technological and industrial revolution, the continent is changed from a consumer group that exports raw materials to a self-reliant producer of finished goods that are able to compete favorably with other nations for a share of the world market.

In order to achieve this objective, African nations should involve scientists and technologists in the planning and execution of national development plans.

Establishment of a viable R&D base for selecting, adapting and developing technology

Research and development activities on the continent should be directed towards areas that will promote industrial activities as well as facilitate the adaptation of imported technology for local use (Adegoke, 1980, 1985; Makanjuola 1983). In this regard, the current style of repeatedly purchasing advanced technology on a turn-key basis, has to give way to a well planned system of copy technology (Oladapo 1987), followed by adaptation and innovation. The recent examples of Japan, India and China - countries that have moved from underdevelopment to the implementation of technological policy objectives - should be to involve indigenous African technologists in all phases, from planning to execution stages of all major industrial projects and to insist, as a matter of deliberate policy, that only the first generation of plants and equipment for any industry would be purchased from outside. Subsequent replacement and repairs should be fabricated locally through indigenous effort. This is the only way to save the continent from perpetually exporting unprocessed raw materials in exchange for processed consumer goods, plants and machinery. It is the only viable way to attain technological self-reliance. African governments should, therefore, be persuaded to:

- compile an up-to-date directory of scientists and scientific research infrastructure and results within their country, in order to have on hand information on available expertise;
- screen inventions and discoveries, both local and foreign, that have local application and pass these to indigenous developers;
- provide massive funding for goal-oriented researchers;
- encourage greater linkage and cooperation between scientists and technologists in the universities, polytechnics, research institutes, government ministries, and parastatals and the industrial sector (UNCTAD, 1981);

- create a favourable financial climate to encourage the provision of risk funds for pilot plants as well as the industrial development of viable and relevant research results.

Establishment of the institutional framework for developing and adapting technology

Based on a critical assessment of national needs, and drawing heavily upon the experiences of other countries previously in a similar situation, Africa's industrial and technological development strategy must encourage immediately (i.e. in the short run), the exploitation of innovations and adaptations of existing technologies. In this regard it is essential:

- to identify which existing innovation systems and inventions can work well and be readily adapted to our local needs;
- to identify the pool of indigenous personnel that have the capability to understand such systems, copy them and, in the process, improve on them;
- to ensure that a well managed production system is created'
- to review the nation's patent laws such that inventors and innovators will be well rewarded and encouraged to obtain patents for their inventions;
- to organize a responsive credit system to finance the risks of developing such innovations as well as the cost of marketing and distribution.

It is the general view, that success in this regard can be assured through:

- the organization and nurturing of an active private sector industrial activity (Adegoke 1985), 1988). Government's role must be restricted to initiating the activities and monitoring subsequent development in order to protect national interest;
- the sponsoring and nurturing of goal-oriented research projects through a well structured process involving the national

Academies of Science and the major inter-disciplinary and technological societies and associations, i.e. each nation's entire scientific and technological manpower resources; and

- the establishment of regional technology development centres (Adegoke 1985, 1988); UNCTAD 1981), whose objectives will be: to transform local raw materials into feed-stock for existing and planned industries; and to fabricate, assemble and test new equipment that is either developed locally or adapted for local application from a foreign invention. Such centres should ideally have:
    - an industrial geology division to intensify the search for local mineral-based raw materials
    - an industrial chemistry division manned by chemists and chemical engineers that would concentrate on the transformation of local raw materials into industrial feedstocks
    - a pilot scale production division to develop, produce and test at semi-industrial or pilot scale, the results of all laboratory discoveries, inventions and innovations
    - an agricultural technology division tackling the vital problems of agricultural plant design, fabrication and maintenance, food production, preservation storage, etc.
    - an industrial extension division, whose primary task is to act as linkage between scientists and the community at large, thereby ensuring effective dissemination of scientific and technological research results for the users (Adegoke, 1978a).
    - Apart from these divisions, others could be added, such as electronics or petrochemical divisions, depending on the locality.

The centres advocated will complement the useful contributions of national, regional, and subregional institutes such as the Federal Institute for Industrial Research at Oshodi (FIIRO) and PRODA at Enugu, the Nigerian Machine Tools Limited, Oshogbo, the recently commissioned ECA Centre, ARCEDEM in Ibadan, and other regional centres throughout Africa. Such centres would have to be better staffed and their activities well publicized. Proper linkage with the private sector must also be assured.

At various fora, attention has also been drawn to the intrinsic advantages of establishing research institutes close to or within universities as is commonly the case in advanced countries. This has the dual advantage of attracting good scholars to such institutes and encouraging free collaborative movement of indigenous staff within the host university and the institute. Experience both locally and elsewhere has also shown that extension services linking industry with the researchers are better co-ordinated as part of university-based activities.

Provision of avenues for the effective dissemination of scientific research results.

Dissemination of scientific research results achieved by the scientists and researchers to the consumer general populace is a vital aspect of creating a conducive environment.

The normal channels for the dissemination of scientific R&D results are largely through:

- formal education
- published scientific journals, periodicals, newsletters, etc.;
- participation at conferences, workshops, seminars, etc.;
- mass media coverage especially newspapers, radio and television;
- museums, exhibitions, trade fairs, etc.;
- extension and public awareness programmes; and
- libraries, data banks, and similar information storage and retrieval centres.

Use of these channels has not been consistent or effective, as applied in African societies. In fact, the advantages gained in past years, especially after the exodus of colonial research officers, are slowly being eroded as successive African governments, faced with mounting economic and political problems, devote less attention and funds to science, to research institutes and universities. Today, current books and journals are rare in most African libraries and too expensive when present in bookshops. Support for African scientists to host or to attend international conferences has dwindled to nothing. This is compounded by the absence of data banks, museums, referral and diagnostic centres, and unreliable statistics.

The effective diffusion of the results of scientific research is crucial for the technological and economic development of Africa. Participants in the task of dissemination must include the researchers at the apex of the pyramid, other scientists and industrialists in the middle, with the general populace (the ultimate consumers) at the base. Effective dissemination involves a process of dialogue in which all participants create and share information with one another in order to reach mutual understanding.

This Consultation should consider the following recommendations:

- setting up by African governments of the appropriate institutional framework for the fostering of science as a tool for national development. This could be in the form of a Ministry of Science and Technology (as in Nigeria and Kenya) or science and technology development agencies;

- establishment of data banks as repositories for scientific information;

- establishment of national history and technology museums;

- provision of special funds for the development of science books for all levels of the educational systems;

- provision of special funds for the development of science books for all levels of the educational systems;

- provision of up-to-date scientific journals;

- development of higher quality media coverage of scientific activities by the provision of intensive on-the-job training for science media practitioners.

- establishment within each country of model science and technology development centres. In this regard, the role played by such centres as the Babha Institute for Fundamental Research, on the rapid technological development of India, cannot be over-emphasized;

- development of extension services in all major scientific and technological fields.

The role of governments

It is often difficult to discuss development problems without discussing the role of governments. The tendency in all cases is to blame government functionaries for not providing adequate resources for development. Government functionaries on the other hand, quickly argue that it is not the duty of government to perform every task or to provide all the ways and means of stimulating all sectors.

In this Consultation, we shall assume that each national government is fully aware of its responsibilities and has allocated the maximum affordable resources to its institutions in the face of a horde of competing socio-economic priorities. We would focus attention instead on those non-fiscal functions of our national governments that are none-the-less vital stimulants to scientific and technological development. This is because true and lasting industrial and technological development cannot be achieved unless governments take seriously their functions to promote actively, scientific development in all its ramifications.

History has repeatedly shown that the direct intervention of presidents and heads of state in the task of assembling scientists and technologists, motivating them, and challenging them with vital national tasks and goals, to be achieved within a set time frame, has produced some of the most dramatic technological feats known.

The very rapid scientific and technological progress achieved by the US after World War II resulted largely from the policy involvement of successive presidents. However, the unique achievment of the USSR of putting the first satellite, Sputnick I in orbit in October 1957 and the attendant hurt to US national pride, compelled President Eisenhower to create immediately the Office of the Special Assistant to the President for Science and Technology. Through that office, he reached out to all scientists and gave space research a major boost. Finally, addressing leading US scientists about 1961, President J.F. Kennedy threw the challenge that man (i.e. the US) must reach the moon within the decade. He backed the challenge up with unlimited R&D funds and the feat was achieved well ahead of the target. Similar direct interventions by heads of state have produced similar remarkable feats with indigenous scientists in India, Pakistan, USSR, Brazil, and Japan (Adegoke, 1981).

Heads of government of African nations should be urged to show personal interest and commitment to science. They should promote technological and scientific changes in their domains by (a) providing adequate facilites for R&D, (b) giving adequate incentives to encourage scientists to remain in the laboratories and work towards national development; and (c) by establishing a national policy and appropriate advisory councils for S&T particularly in the critical sectors of energy, industry, agriculture, environment and health. Finally, each head of government should evolve a policy for reaching out to national scientists, listening to their advice and challenging them with vital national tasks. They should also foster the spirit of mutual cooperation and free exchange of technical and scientific experts among their respective countries in order to enhance the pace of development of the continent.

THEME II: EVOLVING MECHANISMS FOR CREATING AN INTERFACE BETWEEN SCIENCE AND INDUSTRY.

Need for interface between scientists and industry

In the developed countries, there is an inseparable linkage between the practitioners of S&T and industry. Both sectors see their roles as complementary. The scientists are seen as the generators of new ideas and innovations. The innovations and inventions resulting from their new ideas are the necessary stimulants that keep industry alive. Thus, there is free consultation between both, and industries generally approach research scientists for solutions to industrial problems.

In Africa, however, active contact between scientists and industry has rarely been a matter of priority. This has a historical basis. First, the introduction of higher education into most African countries had, as its primary objective, the production of technocrats and bureaucrats to service the administrative set-up of the colonial government. Thus, the practical orientation needed to make scientists relevant to the needs of the society and industry, were not considered necessary in the educational scheme.

On the other hand, the development of both agricultural production and mining were geared towards the production of raw materials to feed the industries located in the colonizing countries. Thus, emphasis in Africa was on the production of cash crops and mineral raw materials for export (Isoun 1987).

With awareness of the need to industrialize following independence, most African countries adopted import substitution as their industrial policy. The objective was to produce finished consumer goods to compete with, and ultimately displace, imports. This industrialization policy involved the wholesale importation of machinery on a turn-key basis. In most cases, the raw materials as well as the high level management and technical personnel were also supplied from abroad. Thus, in the entire industrialization process, there was no point at which African entrepreneurs felt the need for local input with respect to technical know-how or research support for the local sourcing of raw materials or product development.

There are obvious advantages in establishing an interface between research scientists and industries on the one hand and government on the other. Among these are:

- the promotion of goal- or mission-oriented research and its effect in making the research scientists more relevant to the needs of their nations;
- provision of a practical orientation for students through attachment experiences with industries.;
- creation of avenues for practical experience as well as exposure to problem solving by the scientists themselves who are involved in industrial work;
- reciprocal use of facilities (e.g. research laboratories, libraries etc.) between the scientists, and industries, leading to considerable savings in cost; and
- provision of opportunities for studies and self-improvement for workers willing to study in the institutions on part-time or day-release basis.

The economy also benefits from such an arrangement by:

- obtaining greater returns on the investment on scientists and their advanced research facilities;
- the greater efficiency accorded to economic objectives through the application of advanced research results; and

- the opportunities offered to optimally utilize the nation's human and material resources.

In considering the previous lack of close linkages between African scientists and industries, several questions have been raised:

- Are African scientists relevant to the needs of industry either in terms of training or through their research competence?
- Are African scientists sufficiently flexible to respond to the quickly changing needs of industry?
- Does industry consider money spent to support research scientists worthwhile investment?
- Will the research effort of scientist give quick return to the funding industrialist?

Critical evaluation of the results of over 25 years of romance with the idea of technology transfer has shown that it has failed to transform Africa industrially (CASTAFRICA II; Lagos Plan of Action 1980; Africa's Priority Programme for Economic Recovery (APPER) 1986-1990).

It is now generally accepted that what Africa needs is to develop strategies for technology acquisition.

The experiences of recently industrialized nations such as India and Japan show that a close working relationship must be forged between scientist and industry. The government has a crucial role to play by formulating policies that are deliberately designed to favour endogenous, over foreign, development of technical knowledge.

The technology triangle

The concept of the technology triangle is the new strategy adopted by the developed countries for promoting linkage between researchers and industry. The objective is to get technology out of the scientist's laboratories and into the hands of industry where it can be used to create new products, generate new companies and opportunities, and provide in the process, unlimited new jobs annually.

New centres of technology development are being deliberately planned in developed countries based on the success achieved at California's Silicon Valley and Boston's Route 128. Both areas are renowned for their production of advanced technology; and the high volume of business generated from the linkage.

In North America, the principle objective is to have new investments in four sectors:

- machinery and metal;
- plastics;
- electrical products and high technology; and
- pharmaceuticals and veterinary products.

California's Silicon Valley is today the home for one-eighth of the US electronic industry. Its success has its roots in the formation of a strong engineering department at Stanford University prior to World War II. The staff and students were not only innovative, but they also showed a spirit of entrepreneurship which resulted in the establishment of a large number of leading electronics and computer companies. It would be recalled that Hewlett-Packard Co. was established by two Stanford engineering students in 1939.

Similarly, the success of Boston's Route 128 is tied to efforts of the Massachusetts Institute of Technology and the Lincoln Laboratory's US government research group working on radar during World War II. The research effort at both the University and the Laboratory created interest in electronics and high technology. An entrepreneurial spirit was also generated. Soon, computer companies sprang up in the area.

A similar technology triangle is presently being developed around Waterloo, Ontario, Canada, seeded by research results of a professor of chemical engineering who developed a wet scrubber for use in industrial smokestacks. The effort is suported by the Ontario Ministry of Industries and several neighbouring institutions.

Experts suggest that four critical elements must be in place for a technology triangle to succeed. These include:

- Individuals (including research scientists) with entrepreneurial spirit. There has to be a critical mass (i.e. a viable minimum number) of well trained scientists and engineers, to support entrepreneurship and product development.

- Educational institutions to provide well trained employees and cooperative support.
- Venture capital.
- A manufacturing infrastructure to ensure that innovations can be produced.

Looking more closely at the Waterloo experience, it is clear that companies are attracted to the area because of the brain-power of the University of Waterloo and the University of Guelph. Both are renowned for their expertise in engineering, mathematics, computer science, agriculture, veterinary medicine and biotechnology. A third institution associated with the Waterloo development is Wilfrid Laueier University, noted for its expertise in business. Again. Vokker-Graig Ltd., a manufacturer of computer terminals was started by four University of Waterloo engineering students. In this, and other similar areas of high-tech development, there is cooperation between the scientists, industry and government. To date, more than 75 companies have been established in the Waterloo area - all associated with research conducted within the University of Waterloo.

What is the relevance of the above to Africa? What lessons can we learn from it?

For technology to survive in Africa, scientists must play a more vital role. Scientists must make the transition from being reservoirs of ideas to being participants in manufacturing and production.

Centres for Africa's technology triangles must be carefully selected and developed so that they are both centres of excellence for research and technological innovation as well as sites for manufacturing and production. The greatest problems that must be surmounted in Africa are the near total absence of manufacturing infrastructure and the poor state of development of materials (iron and steel as well as plastics). In most countries too, scientists and engineers have not attained the critical mass. Experts in business management are in short supply and their importance in technology development has hardly been realized.

An entrepreneurial spirit must be engendered in African scientists. They must learn to venture into the industrial sector as producers working hand in hand with industrialists.

Finally, African governments should play a supportive role in providing funds for the establishment of infrastructure and materials as well as for scientific and engineering facilities.

Suggestions for establishing an interface between African scientists and industry

In order to foster closer linkages between African research scientists and industry, there is need to:

- mount an enlightenment programme aimed at getting African scientists to develop the entrepreneurial spirit. They should be made to realize that they stand to gain and can actively participate in the commercial development of their own research results;

- inculcate into African research scientists the virtue of responding promptly to the research requests of industries. In this way they can make their services indispensable to industries;

- educate industrialists about the relevance of local R&D work to their activities;

- encourage local entrepreneurs to support the effort of local research scientists;

- organize regional workshops, seminars, etc. into which mini-science fairs are built. The primary objective should be to stimulate/promote contact and rapport between African scientists and local entrepreneurs. Such forums would provide a conducive atmosphere to discuss mutual problems and expose industrialists to the potential of local scientists;

- actively promote joint venture enterprises involving scientists, industrialists, finance houses and possibly government. Industrialists should be encouraged to value and accept the technical know-how of innovative scientists as equity participation in such ventures.

African governments should be urged to promote the effort of local scientists by selective legislation which favours:

- private sector support for local scientists and local R&D efforts through tax rebates;

- commissioning local scientists to solve technical problems especially the production of spare parts instead of referring such to foreign scientists and technologists;
- local manufacture of spare parts and accessories for existing industries and local production of the second generation of any industry established in Africa;
- provision of facilities, in leading African institutions for the training of large numbers of African scientists in disciplines known to advance the cause of technological development - especially mathematics, basic sciences, engineering, computer science, agriculture, veterinary medicine, biotechnology, and business administration, and
- establishment of extension services manned by trained scientists and social scientists who can translate local research results into forms that industrialists and entrepreneurs can digest.

THEME III: FINANCING RESEARCH AND DEVELOPMENT IN BOTH THE PUBLIC AND PRIVATE SECTORS

Problems related to the funding of scientific and technological development were exhaustively discussed during CASTAFRICA II. The summary presented below takes into consideration, but does not discuss in detail, the previously expressed views on traditional sources of funding. The new area of venture capital is also explored. Funding of technological development should be viewed from two perspectives, the funding of R&D activities and the financing and commercialization of discoveries and innovations.

National contributions by African States

Annual budgetary provisions. In most African countries, the federal or central governments constitute the primary, and often the only, source of funding for R&D activities. This is done through annual subventions to higher institutions particularly the universities, government ministries, and parastatals, as well as to the national research institutes.

Available data shows that the funds provided through this source have never been adequate, and have for most African countries, been on the decline.

For example, in Nigeria, R&D related funds declined from N 98 million in 1982 to an all time low of N 7.5 million in 1985.

Apart from the inadequacy of funds provided, there is the more crucial problem of ensuring the availability of funds on a predictable and sustainable basis. Irregular and unpredictable release of funds means that research programmes cannot be planned in advance or pursued consistently.

The level of funds provided for R&D activities expressed as % of GNP for developed and developing nations is 2-2.5% and 0.1-0.15% respectively. The developed nations, despite their near-total control of global technology still devote a far greater proportion of their GNP to R&D in order to maintain their lead position. There is need to persuade African governments individually and collectively to see the long-term negative effect of neglect of the scientific sector on the economy of their States.

In order to bridge the gap between African countries and the developed nations, African nations must make greater provisions for R&D. The recommended level is 2% of the GNP (APPER 1986-1990) or 5% of the annual budget of each nation.

Ultimately African nations must realize that they will need to vote more funds for R&D if they have the intention of bridging the technology gap between them and the developed nations.

State government provisions. The state (regional or provincial) governments of each country should also be urged to set aside 1.5-2% of their budgets to support the R&D effort. The thrust of the research should be to solve problems peculiar to the state and thereby compliment the effort of the national government.

Special research and development fund. Because of the indisputably backward position of Africa in technological matters, there is need to have in each country, a special Science and Technology Development Fund. The Fund should be sustained through contributions from all three tiers of government (federal, state, and local) as well as compulsory R&D levies based on percentage turnover imposed on existing industries, and government parastatals. One percent of turnover has been suggested for these. Voluntary donations from the private sector as well as bequests should be encouraged and paid into the fund.

Contributions at Regional and Subregional Levels

In order to ensure effective mobilization of all Africans for accelerated technological development, special R&D and S&E funds should be set up at both regional and subregional levels.

These funds should preferably be centrally managed in order to ensure coordination of the development effort on a regional scale.

Foreign donor organizations

International donor agencies are second to African governments in the provision of research fund support. Because they provide relevant experts and infrastructural backing as well, their contribution to research is sometimes more informed and more effective.

Funds provided by international, bilateral and multilateral donor agencies including UNESCO could be channelled to the central source or used to fund priority development projects identified by the suggested African Science and Technology Advisory Council.

The private sector

In Africa, the private sector (including the multinational companies) which is composed of the ultimate consumers of the products of S&T research, has rarely played a notable role in the funding of research activities. The indigenous private sector has learnt to look outside for the supply of equipment and raw material inputs for industries, and have thus rarely seen the relevance of local research effort in enhancing the productive output of their industries. The multinational companies by contrast, appreciate the importance of R&D but fully patronise R&D facilities established at their home bases rather than establish R&D facilities locally.

What then must we do if R&D is to thrive in Africa? The private sector, and the multinational companies should be mandated to support an R&D levy of 1% of their annual turnover to be paid to the S&T fund of each country. In addition, the larger multinational companies, whose work requires considerable R&D support, should be required to build R&D facilities locally and preferably in collaboration with existing institutions of higher learning. As an incentive, money contributed directly to support research could be made tax deductible.

Venture capital

The concept and rationale of venture capital. Because of the short-term, profit motive of most conventional development finance institutions (banks, etc.), they are not ideally suited to support technology development efforts which, by their nature, are high risk ventures with long gestation periods.

In the United States and Europe, much of the investment in technology development has come through venture capital. Venturing is the process for tracking, examining, initiating and funding of new businesses or products. A venturing decision is strategic and must be based strictly on clearly defined growth goals (Block 1982). Thus, the *raison de'etre* for venture capital has been the exploitation of innovative technology, often with high risk, but also, with the promise of unusually high returns from successful ventures.

Unfortunately in Africa, the innovative high technology base that nurtured the success of the venture capital concept as seen in the developed nations, is virtually absent. Nonetheless, there is, in Africa, a large population of consumers, with increasingly sophisticated demands for modern industrial goods. There is thus a rich market for some form of technological development especially that oriented, initially at least, towards the production of consumer and intermediate goods.

The key to venture capital in Africa, therefore, will have to rest on the ability of entrepreneurs/operators to identify areas in which large demand/supply gaps exist or where such demands can be "created" through the introduction of new, technologically more advanced, products into the economy.

Limitless opportunities exist, considering the low level of development in Africa. A large pool of technological innovations exist in universities, polytechnics and research institutes which are ripe for local processing and commercialization. Similarly, the local stock of researchers constitute a vital, though small group, that can form the nucleus of entrepreneurial ventures.

The operators of venture capital efforts will have to study the African situation carefully, map out the gaps in supply/demand from one sector of the economy to the other, prioritize them and ensure the positive channeling of the most promising of these previously developed ideas and innovations to the benefit of the economy. In view of the agrarian nature of the economies, and the low level of health on the continent, agriculture must rank highest in the list of priorities, closely followed by health.

Venture capital companies are organized in different forms in different parts of the world. Irrespective of their corporate structures, they all exhibit certain basic characteristics:

- **"Entrepreneurial" management.** Venture capital is usually undertaken by specialized institutions or within a specialized section of existing businesses. It is usually associated with what is now usually referred to as "entrepreneurial" management, that is, management which involves starting a new business in a continually changing situation, requiring learning and management which is effective in the presence of high uncertainty. Because venture capital is high risk, high returns are sought. Thus, all parties to the venture, i.e. the entrepreneur, the venture capitalist and other passive investors as well as the innovator, have one common objective, capital appreciation. Entrepreneurial management therefore calls for a great deal of intuition, making assumptions based on information and guesswork, and swift decision-making in an environment marked by little predictability. It is now generally held that entrepreneurial management is required to start and manage each new business while professional management is best able to manage the system once established, to track new businesses (Block1982). In virtually all cases, the primacy of the entrepreneurial management team in achieving success has been established.

- **Minority shareholding.** Various proportions of equity have been tried, from 100% owned, to majority owned joint venture, to 50-50 joint venture to minority interest. In the majority of cases, the best situations have been those in which the venture capitalist holds minority shares.

- **Link with management.** The venture capital company exerts considerable influence over the management of the business via a working partnership relationship sustained by board representation and by providing corporate finance and advisory services.

- **Long Term Perspective.** Venture capital investments have long gestation periods. Review of global trends shows that it usually takes between 3 and 8 years before significant results can be expected (Biggady 1979; VonHippel 1977; Block 1982). During this long period, money is required to pursue the activity. Some failure is inevitable (assessed at up to 60% in developed economies) and there is usually an initial period of negative results before success comes.

Venturing in the African setting: developing the entrepreneurial spirit. How can the venture capital concept be used to stimulate scientific and technological development in the African setting? Who is to provide the venture capital? How do we engender the entrepreneurial spirit among indigenous scientists? Can African development finance institutions be made to develop sufficient confidence in the effectiveness of the local scientific capability and risk its capital in developing their discoveries?

As discussed earlier, the development of an entrepreneurial spirit is a *sine-qua non* for stimulating technological take-off on an unprecedented scale. An aggressive campaign must be mounted among African scientists aimed at assisting them to "discover themselves" and to realize that they can attain material success by marketing their own scientific discoveries or innovations. Examples abound in the developed countries (see Technology Triangle). Local entrepreneurs must also be made to see the wisdom of looking inwards, not only for the sourcing of raw materials but also for the technological inputs. The tight foreign exchange squeeze presently being experienced makes it relatively easy to bring scientists and industrialists together.

Who is to bring together the venture capital?

There are a number of possibilities, such as:

- **Mobilization of rural credit.** It is possible for a group of local scientists to mobilize rural credit/loans and use these to fund the development of new products or technologies. Achievement to be expected from this move will be severely limited. Among the most glaring limitations are inadequate market opportunities for the new products; limitation of funds that can be raised locally; insufficient ideas for venture basing, and possibly, inadequate foresight, adaptibility etc. on the part of the rural investors;

- **Formation of cooperatives.** Cooperatives have been shown to be fairly successful especially in the small-scale rural agricultural sector and in trading throughout Africa. The interest of cooperative societies could also be extended to include development finance in the area of appropriate technology and new product development in agriculture and allied fields. In order to engage in venturing on a meaningful scale, the cooperatives may have to marshall funds from the financial institutions;

- **Formation of an African Technology Development Group.** The opinion has been widely expressed by some scholars that African scientists and technologists, must come together to promote their own ideas and products. This would require the creation of an African Technology High Command and the formation of a network of African technologists, working together with a purely commercial and entrepreneurial objective; such a network has some obvious advantages. Its formation would usher in an era in which African scientists and technologists have a forum for free communication of ideas. The pooling of their capabilities would widen the internal venturing base and provide almost limitless ideas and products for development. Thus, the chances of venture failure will be reduced to the barest minimum.

  The questions requiring answers are:

  - Is it feasible to achieve a continent-wide pooling of scientific and technological effort especially in the face of the poor communications plaguing the continent?
  - Does such a group have an entrepreneurial outlook?
  - Does such a group have any chance to attract the funding required for high risk venturing?
  - Does such a group have the management capability ("entrepreneurial management") required to make venturing succeed?

One possible way out is to define "scientist" and "technologist" in a very broad way to permit the registration or inclusion of "practitioners" in the group, even if such entrepreneurs are not scientists or engineers by training. Support for such action can be found in the fact that several national academies, especially in their formative years, admitted non-scientists who were influential and willing to act as promoters of science as full-fledged members. This group acts as promoters and could be vital in providing the link between the scientists and the financial institutions;

- **Mobilization of venture capital on a national basis.** In most African countries, there are now a few development financial institutions that are non-traditional in their outlook and which support national industrial development effort. Such support is, however, grossly limited by the fact that:

    - funds are usually provided to support the establishment of traditional manufacturing industries geared towards the production of common consumer goods, using known imported technology;

    - the funds provided for such industries usually cover only a percentage of the total investment required for the project with the result that most of these industries suffer interminable delays and rising costs as the promoters search for additional sources of funds.

    - the funds do not inlude provisions for risk venturing in new areas, no matter how promising

    Another major problem is the fact that virtually all the commercial banks in Africa have short-term, high return on investment objectives. They have no interest in long-gestation, high risk new ventures.

    The charter of a few of the new industrial and particularly the merchant banks, are sufficiently flexible and forward-looking that they can be readily attracted to provide venture capital for new products and processes. These can form the basis of mobilizing venture capital funds on a national basis that can support the development of ideas generated within each nation.

- **Mobilization of regional venture capital.** It is very unlikely that each African nation can independently support successful venture activity. In some, the number of trained scientists is inadequate. Other countries do not have the banks or markets to support commercialization of new products. Besides, differences in currencies as well as in other fiscal and economic policies and restrictions to free movement of citizens and goods, are all insurmountable problems facing the prospect of venturing on a national basis.

It is, therefore, worthwhile to critically examine the prospects of venturing on a regional basis. This would call for the cooperation of the leading commercial institutions in Africa working as a consortium under the lead of a regional development finance institution such as the African Development Bank (ADB). The consortium could pool together the kind of investment required to initiate new ventures in several areas simultaneously.

A critical examination of the industrial strategies of the ADB shows that the industrial emphasis is on resource-based industries i.e., those which utilize local raw materials to produce finished goods for local consumption or for export; or intermediate goods needed as inputs in other industries.

Based on the Lagos Plan of Action, the Bank emphasized development in eight priority areas that are essentially traditional industries. High on the priority list are: agricultural products, tools and spare parts; construction materials, textiles, chemicals, wood products; mining and processing of mineral resources; and service industries such as transport, construction, tourism, medical and health facilities and small-scale operations including handicrafts, trading and catering.

In Section 2.2.4.8. of its Industrial Policy, the Bank discusses the problem of ownership of private enterprises not owned by citizens of the region. It recognized the paucity of the entrepreneurial class as a hindrance to development at the desired pace. It therefore saw the need to link bilateral cooperation at government level with the efforts of the private sector. The bank decided to approach the problem of private ownership cautiously and flexibly in order to be able to accommodate the needs of member States.

Is it, therefore not possible or reasonable to urge the ADB to play a lead role in mobilizing venture capital development on a regional scale? There are some reservations, however. The Bank's Policy permits it to take equity participation not exceeding 10% in any organization. Besides, the evaluation of its equity in many projects was not particularly encouraging.

Generating Venture Ideas. From the foregoing, the most challenging problem confronting the managers of science and technology in Africa will be how to generate venture ideas. To provide opportunities for choice, venture ideas and proposals need to be stimulated, encouraged and sought. Sources relevant to our ongoing discussion include: venture basing exercises; newly developed products and technology; technology forecasting; new government policies; marketing and technical staff scanning; outside inventors; and outside entrepreneurs (Block, 1982).

However, the most effective ways of sourcing venturing ideas is to tap the fertile imagination of creative people working in an environment in which new ideas are sought, welcomed and rewarded. It is, therefore , our duty to create such an environment. This Consultation is, therefore requested to address this important problem.

One of the crucial facts to consider in this regard is the long-term benefits that will accrue to Africa when barriers to free movement and trade within the region are relaxed. Scientists will be able to move freely between technology development centres and the technology triangles. Banks of different nations will be able to cross national boundaries.

How Venturing Works. Venturing involves four major processes:

- Taking the decision to engage in venturing;
- Generating and collecting venturing ideas. This has to be based on well-established criteria. The available ideas and processes must be carefully screened in order to reduce the chance of failure to the minimum;
- Organizing and starting individual ventures; and
- Monitoring of the newly established businesses.

In deciding to go into venturing, venturing bases must be identified. Venturing bases are those characteristics of a firm or group (such as areas of expertise or knowledge, skill, technology, market position, distribution channel, etc.) which can serve as major resources for starting the planned ventures. This is **internal basing**.

In this regard, the questions to which answers should be found include:

- What is the nature of our collective competence?
- What are our special strengths or weaknesses? (biotechnology?, pharmaceuticals? genetic engineering? computerization? mechanical fabrications?)
- What new business(es) can we generate from the inventory of competency?

External basing involves screening the trends, needs and problems of the world around us, i.e. external to the firm or group of venturers. Venture projects can be planned around such basic problems as increasing crime, growing nutritional awareness, or increased interest in exercises and physical health, etc. The key here is "find a need and fill it". The types of questions posed are:

- What venture possibilities and needs exist in industries and the market?
- Which aspects of changing lifestyles in a society can lead to needs to be fulfilled?
- Finally, based on conclusions drawn from internal and external basing, we can ask:
- Are there venture possibilities that can utilize our internal basing strengths and external basing needs?

It must be emphasized that from the experience of developed nations, venturing is highly risky and fraught with failure. Recent assessment of several venturing projects started in North America and Europe show that, on the whole, only about 10% of venture businesses attain outstanding success. The overall success rate, where success is defined as venture survival with significant return on investment, is 20-30%. The important rule of the game is to keep losses low in cases of failure (Block 1982).

There are good reasons to believe that if venturing groups are carefully put together, the success rate may be generally higher in Africa. One possible reason is that activities will be concentrated on a mix of products, both well known consumer goods and new products. This optimistic possibility should be discussed in the light of the experience of the participants. On the other hand, a higher rate of failure may occur because of the limited availability of managers and venture entrepreneurs.

STRATEGY FOR IMPLEMENTATION

Africa as the most backward continent

A cursory view of Africa's efforts at technological development to date gives a very gloomy picture. Not only has the continent failed to make appreciable progress but the apparent gains made in the past seem to be losing significance. Available information shows that compared to most of the other developing countries e.g. Argentina, Venezuela, that were at the same technological level with Africa, Africa is, without doubt, the least developed continent of the world.

What are the possible ways out of this situation? Are there problems peculiar to Africa that make her completely unresponsive to the global technology change?

Conferences, workshops and seminars have been convened to discuss the problems. Copious solutions have been offered. Resolutions have been passed and action programmes have been prepared and launched. All have yielded little positive result.

Africa's seemingly intractable technological problem needs a radical solution. The following management approach is placed before this Consultation as one of several possible options.

Establishment of a Technology Commission for Africa (TCA)

In order to continue to give priority attention to the problem of technogical development in Africa, a Technology Comission for Africa should be created. It should have the same status as the Economic Commission for Africa (ECA).

Terms of reference of the TCA:

- To make periodic overview of the continent's science and technology needs.
- To prepare science and technology master plans and ensure effective implementation.
- To prepare an inventory of African scientists.
- To prepare an inventory of scientific and technological facilities that can be mobilized for development.
- To prepare an inventory of inventions, discoveries and innovations that can be applied towards development in Africa.
- To prepare a priority list of projects that are feasible, sector by sector, especially in the areas of agriculture, health and biotechnology.

- To prepare a realistic time schedule for implementing a phased programme of development.
- To mobilize African scientists for development by:
    - initiating awareness programmes to create the entrepreneurial spirit among African scientists. This can be done through workshops, seminars, etc;
    - organizing a network of African scientists and scientific institutions, coordinate them and encourage free exchange of experts among institutions.
- To promote awareness of the vital need for R&D by indigenous entrepreneurs and industrialists.
- To promote closer links between scientists and industry.
- To create awareness among African governments, through gentle pressure and persuasion , of the importance of S&T in the solution of economic problems.
- To persuade and pressurize African governments to provide special incentives for scientists in order to enhance their productivity and stop brain-drain.
- To persuade African governments to give S&T the priority attention that it deserves, and to fund R&D activities properly.
- To persuade African governments to reduce and ultimately eliminate dependence on foreign technology and personnel by extolling and encouraging indigenous creative capability.
- To organize venture capital for carefully identified technological development projects, products or consumer goods.
- To organize and channel international support for science development in Africa based on the identified priorities.
- To create avenues whereby each nation can actively upgrade the knowledge and competence of local artisans and craftsmen.

- To set up machinery for monitoring the successful achievement of these set goals.

The Governing Board of the Commission

The proposed Technology Commission for Africa should have a governing board composed of eminent African scientists, carefully selected and highly respected African citizen politicians, military and civil servants. There may be need to have a few representatives of international funding agencies.

All members of the governing board must be individuals known for their strong commitment to the cause of science and Africa's economic emancipation.

The normal duties of the Board will be the usual functions of governing boards for such high-powered international bodies.

However, the Governing Board would be expected to carry out a special task of a political nature. Members should constitute themselves into a powerful pressure group that will maintain close personal/physical touch with all African governments in order to ensure their cooperation in implementing all the objectives listed under the terms of reference of the TCA, as well as the scientific and technological aspects of the Lagos Plan of Action (1980) and APPER (1986-1990).

Divisions of the Technological Commission for Africa

The TCA should have eight functional divisions created around areas requiring priority attention:

1. Food and beverages (including agriculture)
2. Chemicals
3. Pharmaceuticals (including cosmetics)
4. Industrial mechanization
5. Electronics and electrical engineering
6. Raw material procurement and development
7. Extension and information services
8. Biotechnology

Each division would be encouraged to keep in close touch with all relevant African institutions, research laboratories and leading scientists within its area of expertise. The thrust of the activities of each department is to operationalize the ideas expressed in this document and support the local design and fabrication of machinery and other inputs needed to transform its sector throughout Africa.

cation of machinery and other inputs needed to transform its sector throughout Africa.

The first activities would be: to assess existing and on-going facilities, institutions and technical personnel; identify areas of strength as well as areas of weakness; upgrade facilities that are deficient; and harness available resources to leap-frog into a properly organized industrial situation.

It is important in this connection that existing industries be involved and used as a base for further development. For example, it should be possible to coordinate the demand for skilled personnel by existing and planned industries with the manpower training programme for each nation.

Technology packaging

Let us look at a few models for technological development that can be pursued by these divisions:

• **Food**. It is known that the biggest problem confronting agriculture in Africa is not one of productivity but that of conservation via prevention of post-harvest storage losses. That problem could be defined as Priority 1. Plans should then be drawn up to solve the problem over the next 3-5 years.

Scientists and engineers in the field would be required to design and build simple storage silos for use by the rural farm communities. These silos would be distributed widely to farms all over the country as has been successfully done in Kenya

Other simple but vital tasks that can be programmed for implementation within the same period include:

- canning of simple fruits, vegetables, fish, and meat products, etc; and
- preparation of local drink concentrates based on locally available wild or cultivated fruit varieties.

• **Agriculture.** Other areas where local resources can be readily mobilized so that results are produced promptly include production of irrigation pumps and pipes, agricultural machinery, fertilizers and other farm inputs.

• **Industry.** To tackle the problem of stimulating local productivity in the industrial sector, industries will have to be organized into genetic groups - eg. vehicle assembly and production. Here, fairly rigid regulations must be enacted aimed at increasing the local content of goods produced locally to 100%, over a specified period e.g., 15-20 years, as given in a model developed by Adegoke (1985):

Years 1-5:	Establishment of local subsidiary companies for the production of components from local raw materials;
Years 6-10:	25% local content achieved involving production of tyres, batteries, bulbs, etc.
Years 11-15:	50% local content including the moulding and fabrication of body frames, etc.
Years 16-20:	attainment of 100% local content e.g. moulding and fabrication of engines, motors, etc.

As each small, but carefully selected project is completed, the technology involved is mastered, duplicated and propagated. In this way, indigenous scientists and artisans will rapidly build up expertise and from there progress to handle more technologically complex tasks.

• **Time frame.** A more realistic time frame for the industrial transformation of Africa has to be prepared as previous projections of five years (e.g. Lagos Plan of Action and APPER) were predicated on excessively high expectations. It is noteworthy that in both cases, the 5 years projected for the industrial revolution went by without any country performing even the most basic tsks.

Based on the experience of other recently industrialized countries (e.g. Japan, India, Brazil), 25 years of sustained activity (one generation) can lead to appreciable success.

All the consultations and contacts needed to mobilize and harness local resources and personnel, and promulgate appropriate legislation, could be put in place before 1990. By that time, all enabling laws (the policies and guidelines for implementing the goals stated in the policy documents) must be on ground at the national level.

VISION ON SPECIAL OPPORTUNITIES FOR AFRICA

Review of the problem

In considering the topic: Vision on Special Opportunities for Africa, let us summarize the facts as they relate to the African continent:

- It is obvious that Africa has today, the greatest number of the least developed and poorest nations of the world.
- While other continents have recorded measurable improvements in both the economic and industrial sectors over the past decade, Africa has remained relatively dormant.
- In many of the African countries where infrastructural facilities and expertise were tangible a decade ago, such facilities have suffered decay and experts are fleeing to advanced countries where research opportunities are brighter.
- There has been a general decline in material and financial resources allocated to science throughout Africa.
- National disasters, especially floods, coastal erosion and desert encroachment, are increasing the economic burden of most African States.
- The accumulated debt and its servicing consumes virtually a third to half of the productive capacity of most African nations.
- Declining prices of the so-called international primary commodities continue to jeopardize permanently the prospect of economic recovery for African nations.
- Political instability and inefficient and bureaucratic systems of government, unresponsive to change, compound the problems.
- The population is growing at an alarming rate (estimated at over 3% per annum), beyond the capability of the continent's resources to sustain it.

Can these negative trends be arrested? How can Africa achieve positive growth despite the harsh global economic condition? How can African governments be made to realize that more and more of their diminishing resources must be ploughed into R&D in order to achieve lasting economic growth?

The tasks before Africa

The solution to Africa's seemingly intractable problems are strategic and political. Africa needs to make progress technologically. Its present role as a consumer nation that exports largely unprocessed raw agricultural and mineral commodities must be exchanged for a new role in which she must attain industrial productivity, and compete favourably with other advanced nations for a share of world markets.

To make such progress requires a conscious effort to succeed based on carefully articulated government policies and political will:

- The promotion of S&T must be viewed as a national priority enunciated in a Science and Technology Policy.

- The focal point (either Ministry of Science and Technology or a Science and Technolgy Development Agency) must be clearly charged with the responsibilities of implementing the forward-looking S&T policy.

- The Science and Technology Advisory Council, directly answerable to the Heads of Government, must be set up to oversee the implementation of the intersectoral aspects of the Policy.

- A continental Science and Technology High Command must be set up whose primary function will be to stimulate and coordinate technological development at regional and international levels. Its administrative unit should be the Technological Commission for Africa.

- The Science and Technology High Command should also seek solutions to specific problems confronting the continent such as erosion, environmental degradation, and desert encroachment.

- Leading African scientists should be recognized and honoured through annual merit prizes.

- A programme for the popularization of science must be mounted on a regional scale in order to inculcate the science culture into our people and increase their awareness of the importance of science in their daily lives.

- The usual sources of funds should be tapped at national, subregional, and international levels to support R&D and stimulate technological growth.

- New sources of funding, especially mandatory levies on multinational companies as well as the private sector should be explored.

- The greatest hope for rapid technological development is to encourage an interface between researchers, governments and the private sector.

- Venture capital should be established at national and regional levels to fund the development of new products directly.

- Close cooperation and sharing of facilities must be encouraged between institutions, private and public, in order to ensure optimum utilization of scarce and dwindling resources.

- The problems of brain-drain must be arrested. African scholars in foreign laboratories should be encouraged to return through adequate incentive packages.

- Africans must resist the continued foreign domination of their economy and development programmes by reviewing the roles of IMF, World Bank, etc. and their unfavourable structural adjustment plans.

- There is need to review critically Africa's vision with regard to technology acquisition as these policies will call for concerted effort and an unprecedented level of cooperation between African nations. Failure hoewever, will mean the total relegation of Africa to the background in world affairs.

Technology acquisition

The invention, design and construction of any equipment or production process is largely dependent on an interplay of human knowledge and skill. This is a dynamic function which involves the potential for invention and innovation as well as the ability to independently identify problems and find solutions to them. Technology transfer, by contrast, endows the recipient with only routine operational skills in a more or less static way (e.g. a refinery operator, a typist). It does not confer the ability to keep the system running on a continuous basis over time, nor the skill to diagnose and solve problems in case of a break-down (Farrell, 1987, Adegoke 1988).

Much of Africa's industrial and technological effort to date has guaranteed only the acquisition of operational skill. For example, despite the fact that oil exploration and production commenced in some parts of the continent over fifty years ago, less than 15% of the required technical skills reside with African operators. The same is true for technologies related to agriculture, mining, refineries, breweries, telecommunications, etc. The continent needs to reverse this unhealthy position by taking new and bolder initiatives that will ensure total technological transformation that goes beyond operational control of machinery, to the ultimate realm of manufacturing and fabrication. This should be achieved within a clearly stated time frame. The twenty-five year period between 1990 and 2015 should be declared as the period of technological transformation. Thus the appropriate machinery and infrastructure required to achieve the goals must be in place before 1990.

The major prerequisite is the awareness of the fact that national prosperity and sustainable development can only be attained when the innovative capabilities of African peoples are developed to the fullest. In this regard, the United nations Conference on Trade and Development (UNCTAD) Resolution 112(v) of 3rd June 1979 is recommended for Africa's developing nations. It urged each developing country to formulate and implement a comprehensive technology plan as an integral part of national development strategy consistent with overall economic and social requirements, development objectives and policies, with a veiw to achieving technological transformation. The national technology plan should:

- identify sectors of critical importance to the countries concerned and define technological policy objectives;
- co-ordinate national action in relevant areas of technology development and transfer;
- define the relationship between technology imports and the endogenous development of technology, sector by sector;
- establish and strengthen links and feed-back mechanisms between policy makers, planners, researchers and technologists and users of technology, especially in the area of production;

- formulate programmes concentrated on the generation of research and development and adaptation of technologies, particularly in areas of critical importance for the economic and social development of the country concerned and

- define goals and ensure their achievement through financial, personnel and institutional arrangements.

In order to achieve these objectives, there is need for all African governments to:

- formulate their national S&T policies and ensure their effective implementation;

- establish supraministerial S&T councils or agencies for the effective coordination of national activities;

- provide needed infrastructure, especially for energy, roads, water and communication;

- ensure adequate funding for the S&T acquisition effort;

- ensure "free" access of nationals to global technological information systems at affordable prices;

- establish national technology development centres at strategically selected regional locations where they can best stimulate and mobilize the technology effort. At the initial stage, emphasis should be on the most crucial areas: food, energy, pharmaceuticals, etc.;

- keep government policies under constant review in order to enhance the achievement of stated goals. In this connection, government bureaucracy must be reduced to the minimum and re-oriented so that indigenous scientists and technologists are recruited and challenged with the implementation of important national high technology projects; and

- adequate incentives must be provided in order to retain the continent's best research scientists and arrest the on-going brain-drain.

If this Consultation succeeds in creating modalities for attaining these modest objectives, it would have placed Africa on the path to true technological change.

FOCAL POINTS FOR THE FORWARD LEAP

This final section briefly reviews the positive intitiatives already in place and assesses their potential for development as focal points for the technological forward leap of Africa.

Regional economic groupings

In recent years, African States have experimented with the idea of regional cooperation by forming regional economic groupings. For example, in West Africa, we have the CEAO (Communite economique de l'Afrique de l'Ouest), the MRU (Mano River Union), the ECOWAS (Economic Community of West Africa), Sene-gambia, etc. In Equatorial and Central Africa, there are at least three economic communities, the UDEAC (Union douaniere des Etats d'Afrique Centrale), the CEPGL (Communaute' economique des Pays des Grands Lacs), and the CEEAC (Communaute' economique des Etats de l'Afrique Centrale.

Though these regional economic groups vary markedly in their objectives and viability, they nonetheless form useful starting points for cooperation and development on the continent. Most emphasize free movement and free trade among the member States. Their overall developmental strategy is, however, weakly articulated.

There is no doubt that integration can contribute to development as it expands opportunities for investment, helps to mobilize underutilized resources and through rationalization, ensures more equitable distribution of available resources, particularly to the lesser developed countries. It will be essential in future years to reinforce and build upon these positive indications. There will be need, among other things, to review the national currency and monetary exchange system, strengthen the infrastructure and foster greater inerface or cooperation between the various regional economic groupings.The OAU itself needs to have a very strong technical wing and ensure that decisions adopted at its summit meetings are implemented at national levels.

Natural resources development organs

These are the inter-governmental organs set up to ensure the rational use of shared natural resources. They include organs such as the river basin and lake commissions. These commissions have, wherever they existed, contributed in no small measure to the rapid economic development of the collaborating countries, especially by ensuring rational use of common resources and in mainimizing inter-State conflicts.

Cooperation can be further strengthened by exploring the possibilities of whole-basin development as well as joint industrial development as this will optimize the use of scarce material, human and financial resources. For example, rational policies for sharing oil, and strategic industrial minerals (e.g. potash, phosphates, uranium etc.) can be worked out.

As Africa faces greater problems from the menace of natural disasters (desertification, erosion, floods, locust and other pest invasions, etc), collaborative control measures will foster endogenous development and reduce the external dependence of African States to the minimum.

Common services organizations

One of the major objectives of the regional economic groupings is to establish common services. For example, the principle achievement of ECOWAS has been the creation of the institutional framework for a customs union. The ECOWAS tariff nomenclature has been adopted by all member states. The CEAO has similarly made substantial progress towards emplementing its treaty provisions in customs affairs. It has adopted a common customs and statistical nomenclature, and introduced measures for trade liberalization. With the common currency, there is a certain measure of inter-group trade and economic integration. Further gains can be made by systematic integration of the industrial production process.

Financial institutions

Though still at a stage of infancy, the sharing of common financial institutions can act as a catalyst for technological development throughout Africa. The positive role that the ADB can play in providing venture capital for new technologies as well as conventional high demand consumer products has been discussed earlier.

Apart from the ADB, there are a number of existing funds, the disbursement instruments of which can be reviewed in line with the new vision of technological opportunities for Africa. These include:

- The African Development Fund, a fund held by the ADB in association with some States and used to finance projects and programmes which further the economic and social development of the territory of members;
- The Nigeria Trust Fund held in trust by ADB on behalf of Nigeria as a means of channeling assistance to the less favoured African countries, especially those most seriously affected by unpredictable catastrophies;
- The ECOWAS Fund that can be used for promoting positive integration, development and balance in the West African region; and
- The Africa Fund which is presently used to fund action for resisting invasion, colonialism and apartheid, but could have its scope broadened to include intensification of S&T efforts.

Research and training institutions

Some of the research and training institutions existing in Africa that have contributed immensely to the development of S&T (e.g. ICIPE, IITA, various universities and government research institutes) need to be identified. To these should be added research centres funded by ECA, OAU and other international donor organizations (e.g. IFC, ARCEDEM, etc.) Their resources should be integrated and coordinated by the establishment of networks and scientific community links and made available for training of Africans from all States. It is such institutions that should be the focal points for the new technology triangles that will help accelerate the pace of technological development regionally. African States should all accede to a protocol that encourages free inter-institution movement among research scientists.

National Academies of Science

The Academies of Science of African States can form a network with similar bodies such as the African Academy of Science and the Third World Academy of Science. This network can be a formidable think-tank and forum for the accelerated technological development of Africa. For example, it could assume the role of the African Science and Technology High Command discussed earlier. By down-stream linkage with national scientific societies/associations on the one hand and a network of R&D laboratories and institutes on the other, it can ensure the total mobilization of African R&D resources towards the achievement of stated goals.

Other intitiatives

There are a large number of successful national R&D experiments in scattered African countries especially in the fields of agriculture, food and beverages, biotechnology, medical sciences, etc. Literature on these few and laudable achievements is scanty and dispersed. They are not, therefore, amenable to treatment in this paper. Because the experiences gained in attaining these successes can be shared, adapted and used as a basis for stimulating further development, it is recommended that they be made a special theme for detailed documentation. Similarly, there is need to undertake an in-depth study of the various State institutions (both financial and academic) and organs discussed above. The study should focus on how they can be mobilized to perform the task of stimulating technological development by acting as nuclei of the proposed technology triangles.

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PART THREE

CREATING AN ENABLING ENVIRONMENT FOR RESEARCH AND DEVELOPMENT FOCUSED ON AFRICAN DEVELOPMENT ON A SUSTAINABLE BASIS

Integrating Higher Education and Scientific Research in Africa with a View to Maximizing the use of Available Resources for Greater Productivity: the Cameroon Example

Paul Nchoji Nkwi

Introduction

What does a developing country need to know in order to articulate concrete and appropriate policies for establishing the necessary indigenous capability in higher education and national science and technology systems for maximizing its industrial development and productivity capability?

Many years have elapsed since Cameroon first set out to seek answers to this question, and like most African nations, Cameroon has come a long way from its humble beginnings of S&T activities both in the broad area of higher education and scientific research as well as in the relationship between its R&D institutions and the industrial sector. But much is yet desired to strengthen the bond of cooperation between R&D results and the manufacuring sector, without which these nations will not be able to transform themselves from rural and technologically deficient societies to industrial and technological ones. In short, to transform them from dependency to independent and sustained development.

This paper attempts to present summary perspectives on the management of S&T activities. The current economic recession brings into sharp focus the urgent need for an integrated S&T and management policy. The paper is divided into two parts with the first part dealing with research policy in a historical perspective; and the second with the issues of university education and international organizations.

S&T AND RESEARCH POLICY IN HISTORICAL PERSPECTIVE

The political fragmentation of most African nations, including Cameroon, translates itself into a policy of fragmentation in S&T activities. Colonial rule perpetuated the non-emergence of a concerted policy approach. Scientific research and industrial development were never bed partners; each sector sailed on its own stormy seas. This is true of most Francophone countries.

A need arose after independence for the incorporation of science, research, development and technology into the industrial economic development of the country to foster production. It required a harmonious linkage of research activities and results with the productive sector, to produce capital goods, improve agricultural ouptut, and improve the distribution system. Let us look at a specific case, Cameroon.

The first move in this direction was the articulation of article 5 decree 59/102 July 1, 1959 appointing a Secretary of State responsible for scientific research. This was followed by decree 62/DF/364 October 1962 creating a Council for Scientific and Applied Research. Since Cameroon achieved independence, attempts were made to build economic and social development on a more solid base. Giving scientific and technological research top priority became a major government concern. Emphasis was laid on applied research, controlled by the Vice President of the Federal Republic, whose responsibilities were to ensure that the operational research structures implemented government policy by handling problems the new emerging nation was facing, in the areas of agriculture, education, health and animal industries.

In his inaugural speech on July 10, 1964, the Head of State noted the fundamental role of science and technology:

"Scientific and applied research is the key to human progress through the prestigious economic and social flight which enables us to live a better life in this century. The remarkable results obtained in every domain of contemporary life are the

fruit of the hard work of generations of researchers of all nations who patiently brought their contribution to the progress of science" (Ngatchou 1982:12.)

The establishment of the University of Yaounde in 1962 added a new impetus to the progress of building up the scientific and technological potential of Cameroon. Fundamental research became one of the major objectives of the new university. Designed to operate virtually in isolation from the research institutions inherited from the colonial rulers, higher education developed independently. The research institutions established outside the framework of university traditions continued their independent existence until five years ago.

A federal law of May 22, 1965 established the National Office for Scientific and Technical Research (ONAREST). This was a major move to nationalize foreign research organizations (ORSTOM, GERDAT - later CIRAD) which had continued to operate autonomously. ONAREST was responsible for orienting, coordinating and controlling scientific and technical research throughout the nation. Strangely, there were only three nationals (and these from the Anglophone part of the country) working in the existing research institutions. A special convention with France permitted French research institutes to train senior scientists. For more than nine years the law on science and technology remained a dead-letter. Although scientific research policy was being controlled by a department in the Ministry of Planning, higher education (universities and certain professional schools) was being run from the Ministry of National Education. Decree 74/358 April 17, 1974 set up the Council for Higher Education and Scientific and Technical Research (CESRST). This was the first attempt to bring higher education and scientific research together. This was rather superficial and not far-reaching enough to maximize the potentials of the two sectors for productivity. CESRT, because it was a body presided over by the President of the Republic, was only concerned with the definition and orientation of government policy in higher education, scientific research and technology development. The appointment of the Vice Chancellor of the University of Yaounde to head ONAREST was meant to bridge the gap and link higher education and scientific research. For various reasons, the isolation continued. Lack of implementation tools led to the tranformation of ONAREEST into DGRST (General Delegaton for Scientific and Technical Research) in 1979. DGRST was entrusted to a man who was not only an ex-minister but also a staff of the University. He enjoyed cabinet rank and could effectively enforce scientific policy.

Realizing the gap between higher education and research, he elaborated a protocol agreement which permitted university staff and scientists of the research institutes to work together on common problems facing the nation. It is interesting to note that another degree 2/465 October 4, 1982 amended the functions of CESRST, taking away from it any powers that could permit it to define and orient policy in the specific areas of higher education and invested those powers in the Head of State. The President of the Republic was therefore empowered to take final decisions concerning higher education, science and technology. CESRST became a mere advisory board. The supervision of policy execution in the two sectors remained entirely in the hands of the Ministry of National Education and DGRST. Although the first meeting of the Council had called for the promotion of scientific research within enterprises, and for scientists both at the University and research institutes to work together to solve problems facing socio-economic development of the nation, none of these policies became effective.

In order to establish the linkage (or remove the dichotomy that had persisted for more than two decades), decree 84/158 April 18, 1984 brought higher education and scientific research under one ministry. This ministry, that of Higher Education and Scientific Research (MESRES) was therefore charged with the responsibility of

- implementing government policy in the domain of S&T,
- coordinating and supervising all research activities,
- the projection of research results,
- promoting and developing endogenous technologies and appropriate technologies, and
- setting up teaching and research units, and associate research teams within the university institutions and in scientific research organizations.

MESRES was also empowered to coordinate all technical and scientific cooperation with foreign, national and international agencies. Thus, the new Ministry focused its attention to addressing and facilitating collaboration between the various research institutes, the ministry and the industrial sector.

Over the past few years, there have been apparent differences of opinion within the system and its institutions about the exact role of MESRES in defining and interpreting science policy in terms of guidelines for R&D, industrial production and research. As many officials still have strong attachment to the traditional dichotomy, a major management challenge and priority issue area for MESRES was to bring about the functional integration of its research and educational institutions and to provide the linkage for the research activities with the industrial sector. Such a collaboration is a necessity for the scientific, technological and industrial development of African nations.

The future economic prosperity of Africa lies in its ability to effectively generate, disseminate and utilize new technologies and to build an infrastructure responsive to rapid technological change. That ability would ultimately lead our countries to success in other markets particularly within the sub-region of Central and West Africa and the continent in general.

It is through a concerted coordination of higher education, the work force, and the country's commitment backed by its geopolitical advantages within such organizations as UDEAC, ECOWAS, and ECCAS, that it can effectively launch a serious offensive in S&T and industrial activities in the region. This however, requires the identification of critical issues by developing priority-setting methods; and such priority-setting requires explicit consideration of national development goals. All national goals must have an over-riding global objective of increasing the socio-economic well-being of their citizens.

Achieving the goal of satisfying basic human needs for all requires an integrated approach to higher education, scientific research, technological development and management with the ultimate ojective of maximizing the productivity capacity of the society. It is within this perspective that Cameroon has tailored its policy approach through the Department of Scientific and Technical Research (DRST) and the Sub-department of Valorization and Technology Development.

Playing the linkage role between higher education and scientific research, DRST was charged with the responsibility of supervising, controlling and coordinating, and implementing scientific and technical policy and research activities and other functions of the Ministry in the area of research. The Sub-department of Valorization and Technological Development provides services in articulating policy attempts to promote technological development, and in exploiting and valorizing research results. It is also responsible for assisting the institutes to promote and disseminate their research results and for assuring the legal protection of these results.

Government input in the processes of mutual intercourse between higher education, scientific research and industrialization continues to receive great impetus from the country's five year National Development Plans. For example, the Sixth Five Year Development Plan (1986-1991) contains explicit policy commitments on research objectives and programmes for the different research institutions. The execution of such programmes is expected to pool the human resources of the research and university institutions. Even though this policy statement is not based on a thorough analysis of projected long and short term perspectives of over-all national needs and priorities, it does show government concern for getting the country out of the doldrums of technological, scientific and industrial backwardness.

Effective mechanisms for research priority-setting and planning are particularly important for manpower resource-deficient countries. African countries cannot effectively undertake research in all sectors at the same time. Since research priority choices have a significant impact on socio-economic development, there is an urgent need for R&D strategies to be clear in their priorities in order to effectively steer the allocation of scarce resources to the generation and adoption of new technology for maximal industrial productivity.

The lack of a clearly articulated and stable research policy often results in fragmented research programmes only superficially linked to development objectives. Government efforts in future should focus on redressing this deterrent to progress.

Position of Universities and Institutions

The maximization of a country's industrial and productive capacity depends to a large extent on its manpower potential. The university plays an important role in building such manpower potential. The structure of higher education and research in a national system has to reflect the potential building capacity and the need for redressing the S&T deficiency of the country.

Attention has been focused in this area through the creation of the University of Yaounde and other university colleges or centres (Dschang, Douala, Ngaoundere and Buea) together with other related institutions such as the Advanced School of Engineering.

The educational system of the country is being structured to convince people that a mastery of S&T will ensure independence and progress. However, the increase in the number of university students, particularly in the areas of engineering, does not yet satisfy the acute needs of the society. More engineers, scientists and technicians are required to meet CASTAFRICA recommendations.

The university remains the power-house for nurturing talents capable of creating, addressing and solving the immediate and potential problems facing the country. Unfortunately, campus, institute, and industry collaboration remains weak. The industrial contribution to academic research is still insignificant. and this poses problems for research and innovation for industry. The major issue is whether such collaboration will prove fruitful and hasten the development of new products and processes. Government efforts in this collaborative venture come in the form of various input incentives (financial) and dissemination of information as for example, in the sponsoring of the Seminar on the Valorisation of Research in View of Industrialization of Cameroon (March 1988); the establishment of a Fund for the Promotion of Small and Medium Sized Enterprises (FOGAPE); and in the support of other auxiliary organs to foster industrialization of the country, and improve productivity, output and quality of products.

The resources of any system can never be enough, particularly in the systems of developing nations. However, making the best use of available resources is the key to management. Universities should strive to be models for maximizing output from limited resources; and the society must not misuse human potential. The misuse of human potential has contributed to the massive exodus of qualified manpower in many developing countries. Government efforts in Cameroon directed toward decreasing this exodus, include the recent recruitment of over 3000 university graduates. An equally important problem is to put this newly recruited manpower into useful duties directed to national development.

It is anticipated that the collaborative efforts of MESRES in conjunction with other ministries and parastatals will go a long way in strengthening industry and academic intercourse for the optimal maximization of industrial productivity.

There is immediate need for all-purpose education. Educational policy must therefore be re-inforced to reflect the national good. Development has never coexisted with illiteracy and ignorance except with a policy of separate development that perpetrates the unacceptable disparity between the "haves" and "have-nots". Emphasis on science education even at the lowest educational level is vital and necessary for any meaningful scientific take-off in higher education and the emergence of a science culture.

The move by MESRES to institute a biennial technological week where research institutions and other organizations, private and public, are invited to present their results, constitutes a major opportunity for bringing research to its clients. It creates an appropriate atmosphere for the industrial sector to be adequately acquainted with the activities of researchers and research institutes, just as it exposes researchers/institutes to the glaring needs of the industrial sector. The popularization of these fairs is necessary and they should be made more accessible to the rual population and even more relevant to national problems and sectoral needs.

Meeting sectoral needs calls for cooperation between the research institutes and parastatals so as to enhance the productivity of the industrial sector. As an agricultural country, Cameroon's industrial take-off depends on the firm cooperation existing between institutes and parastatals like SODECOTON, CDC, SOCAPALM, CENADEFOR, and SODECAO. It also depends on the degree of support and other input from these parastatals and the research activities of individual scientists and their parent institutions.

Over the years, and until the advent of the current economic crisis, there has been a steady increase in financial support for universities and related institutes. But governments cannot continue to be sole financiers of research activities; support must also come from individuals and the private sector. The presence of the African private sector in universities and research is insignificant or non-existent. Hence the need for a concerted integrated policy approach within the framework of the country's national development plan.

International Organizations

African countries cannot meet the challenge of development in isolation. The need for building bridges across national frontiers, taking into serious consideration the country's S&T underdevelopment is (more than) imperative, but cooperative activities should not lead to increased dependency. They should form the anvil for self-reliant technological development.

Given the continent's constraints, it is even more important to ensure the constant inflow of information and know-how to harness endogenous capability for the scientific and technological take-off of African nations.

It should be recalled that S&T activities and the research system in Africa have evolved from institutions created during the colonial period. Linkages with the research organizations of the former colonial powers (especially Britain and France) are still much in evidence. In the case of France, these links are propelled through the Centre for International Cooperation in Agricultural Research for Development (CIRAD) and the Institut Français de Recherche Scientifique pour le Developpement en Cooperation (ORSTOM). In the case of Britain, the Overseas Development Agency (ODA) plays a significant role. Other organs like USAID (USA), IDRC (Canada) and others have been instrumental in promoting S&T and industrial activities.

Since independence and particularly from the 1970's, some African countries have forged additional strong links with other nations such as Germany, Japan, USSR, and Israel; and with international agencies such as the United Nations and its agencies, and the Organization of African Unity. Sub-region and regional economic groupings have in different ways been instrumental in promoting the scientific and technological re-awakening of the continent.

CONCLUSION.

The tap-root of the problems of industrialization of African countries is not technology. Rather, it is the correlated problems of organization and management (in government and industry) and the nature of the educational systems - problems which have been seriously ignored. A more realistic approach to integrated development, through a concerted higher education policy incorporating the industrial sector, offers the most promise for maximizing productivity and accelerating manufacturing processes and capacity of African countries.

Cameroon is trying this approach through the encouragement of S&T education at various levels and through the promotion of infrastructure and provision of job opportunities to students and manufacturers. Human resources planning is an important component in this direction. Hence, increases in the number of scholarships, educational institutions, and other infrastructures for human resources building, should be considered as critical.

The management of science for development requires long-range planning and political commitment from the custodians of state power. The need for strategic skills remains an integrated component in the maximization of industrial productivity. Given the African environment, the importance of leadership and competitive strengths cannot be under-estimated.

It is absolutely fundamental that any educational system and S&T policy take into account what might be termed the culture of the country; rather than conceive and implement policies that attempt to impose exogenous cultural beliefs, values and strategies to which the country has to conform. This has been the greatest dilemma facing the management of science for Africa's socio-economic development.

The commitment to thinking strategically must come from the top, but the bottom or grass roots must also be adequately informed, involved and actively participate in the execution of strategic decisions. That is the greatest challenge facing the generation and management of science and research in Africa today.

Creating an Integrated Approach to Higher Education and Research in National Systems with a View to Maximizing Productivity

Donald E.U. Ekong

Universities in Africa are vital institutions and their role has been crucial for the development of the region. Their most important contribution has been to provide the human resources that were urgently required in senior positions, for the administration of African countries as they attained independence, and for service as administrators and teacher-trainers and as teachers in the secondary level of the education system of the countries. It is for this reason that most African governments have given a high priority to the establishment of universities as an essential infrastructure for development in spite of the high cost of the institutions. Yet, more and more in recent years, the adequacy of the contribution of the universities to development has been questioned. The principle mandate of the institutions and the public expectations from them comprise, besides providing personnel for administration and teachers for the school system,

- training of persons with the skills and expertise to formulate, implement, and manage development projects;
- research into the problems of the region and development of applicable technologies to address them; and

- public service to governments and the community as a resource for information and expertise on public and development issues.

It is in these latter three functions that there is at best, public unease about the achievements and contributions of the universities. Consequently most African governments, to the frustration and disappointment of the African intellectual and academic community, feel obliged to continue to turn elsewhere for the expertise and the technology needed for development in their countries. I shall highlight what the constraints are in the universities to achievements in the areas related to the three functions named above and will propose for our discussion, action programmes that could enhance the effectiveness of the contribution of universities and other sections of national systems to development through these three functions.

The functions of training in skills and expertise for training, research and development, and public service are in fact closely related and it is hardly possible to attain a high level of effectiveness in one without capability in the others. The fundamental basis for all of them is research, especially fundamental research, which provides the knowledge base for development of applicable technology, for training, and for public service. Unfortunately most African countries appear to consider research, especially fundamental research, as a luxury that they cannot afford at this time in the development of their countries. This is an erroneous conclusion as has been demonstrated by the experience of others worldwide not only in the technologically advanced countries, but also in the developing countries that have begun to take off towards self sustaining economic development. Consequently in many African universities, effectiveness in R&D is constrained by factors such as:

- inadequacy of the physical infra-structure to sustain the requirements of research. This relates to reliable supplies of electric power, water, transportation, and telecommunication.. No doubt this may be merely a reflection of the state of such facilities in the country and a general consequence of underdevelopment. Yet its effect on research productivity is significant;

- inadequacy of research facilities. This relates to equipment, instrumentation and materials essential for present day R&D which may be either non-existent, in a poor state of maintenance, or not in sufficient or regular supply;

- gross underfunding of research as a result of the combined effect of the economic problems of the countries and the low priority given to research. Whenever there is a reduction in funding, the allocation for research is almost always the first to be affected since research is regarded as a luxury and therefore accorded a low priority;

- poor or non-existent support services for research, some of which are frequently not even recognized as important. This relates to the services of technical support staff, research assistants, and library resources;

- inappropriate structure for reward, motivation and recognition of research workers. Salaries are unimaginatively linked to civil service salaries with no incentives to encourage scientific productivity. Consequently there is a high rate of brain drain from research functions to others within more lucrative sectors;

- non-existent or poorly functioning structures and modalities for involving scientists and other researchers in national planning or in strategies to achieve national goals. As a result, university researchers are generally not well informed about national priorities which they could address in their research and training programmes;

- weak linkages between research findings and applications in production systems. Thus there is lacking the encouragement and motivation of the research results being seen and recognized as significant for the national economy; and finally,

- lack of the critical mass in human resources, materials and facilities for the research output to have any significant impact.

This is the environment in which much of the research is being conducted in African universities Such research can hardly, therefore, provide the basis for much effective contribution to development.

Besides the university, many African governments operate other research establishments, several of which are devoted to similar fields as those in which the universities also have departments and programmes. Thus, along side university research and training facilities in agriculture, medicine, applied sciences and technology for example, there are also government operated research establishments in the same subjects. The problems of these government institutions are not much different form those earlier highlighted in respect of the universities. In some cases, the situation is even worse in the government establishments which are often operated under civil service procedures unsuited to encouragement of scientific productivity. Neither these establishments nor the universities have the critical mass in any subject to achieve any significant impact. There are, on the other hand, a number of African countries where the universities are regarded not as autonomous bodies outside direct governmental activities and control, but rather as an integral part of the national system of research and training establishments. In some of these countries, (especially some of the smaller Francophone countries) there are no research institutions separated from the facilities provided in the universities. Thus, some of the university department are assigned roles and responsibilities, such as inspection, certification, and production, roles normally performed elsewhere by separate national research establishments. Even with such cost saving integration, the centres being in small countries with limited human resources, rarely attain the necessary critical mass to ensure significant impact.

It is clear that unless there are significant changes in the present arrangements, local R&D will continue to make little contribution to African development. Some of the proposals for change are well known. One is the merging of some of the institutions and research establishments to form centres to serve large areas including sub-regional centres serving more than one country. There have been such sub-regional centres before which were, however, disbanded as a result of political rivalry following independence. To set them up again would require political will and action by the controlling political authorities, and would be effective only if the arrangement led to much greater resources and facilities being allocated to the centre, than were available to the individual institutions and establishments. Another proposal frequently made is for institutions and research establishments to specialize, each being assigned responsibility for a specific field or a branch of a subject. Such arrangements could involve not only universities but also government research establishments and would enable each to concentrate its resources towards achieving high standards and a critical mass of expertise in its chosen branch. Because each field or branch of a subject requires support from related disciplines, cooperation and mutual understanding between institutions are essential to achieve and sustain such arrangements. The participation of research establishments in some of the training functions of universities and the involvement of universities in the routine service duties normally performed by government research institutions would also be required in such arrangements. The result would be generally beneficial to all concerned. Yet another proposal often discussed, is the setting up of networks of collaborating institutions. Several networks already exist and their impact depends on the commitment of their members to clearly defined goals as well as on the will to set aside resources to sustain the operation of network.

Whichever of these or other arrangements which may be adopted, depending on the circumstances of the institutions and the controlling political authorities, will require cooperation and mutual understanding not only between institutions (especially between university and non-university institutions) but also between government departments and national science policy bodies. As the vital role of S&T in development is acknowledged, Africans need to confront these issues with realism and take bold action to break the vicious circle whereby inadequate resources are being devoted to R&D because of the poor economic situation of the region and at the same time there is economic stagnation because inadequate resources are devoted to R&D.

PART FOUR

EVOLVING MECHANISMS FOR CREATING AN INTERFACE BETWEEN SCIENCE AND INDUSTRY

The Scientist as an Entrepreneur

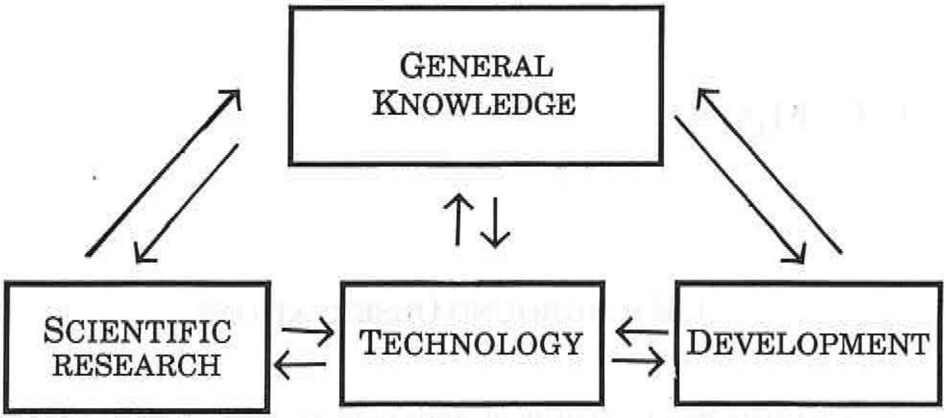
C.C. Mjojo

I. Background Observations

- Scientists on the continent appear to be developing a clearer picture of the strategies to be taken for technological development of Africa.
- One Harvard school of thought - "technology and not capital is the primary driving force for accelerated development" - is now taking root in Africa.
- The technology gap between Africa and the industrial world will not be bridged by fiscal and economic measures only.
- Scarcity of consumer products and escalating prices, particularly for those imported, are creating politically dangerous situations for Africa with ever-increasing levels of perceived relative deprivation for the masses.

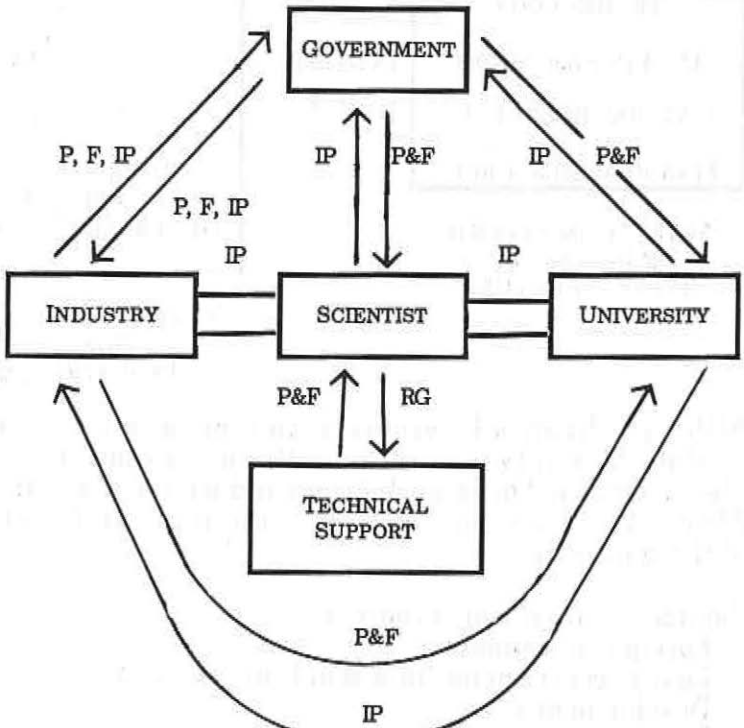
These observations suggest that the scientist must be involved in the development process as an entrepreneur. The following diagrammatic and outline presentations illustrate the proposed relationship between the various sectors of the economy, analyze the components of industrial infrastructure, and suggest means for implementing scientific involvement in the industrial sector.

II. Action-Reaction Types of Interactions within Research and Development systems



- Extensive inductive effects between all the sectors in an R&D system associated with S&T.
- Working concepts generated by scientific research lead to an application package constituting technology.
- Both scientific research and technology contribute to the domain of specialized knowledge.
- Technology, as the operational form of science, generates systematic development.
- There is an apparent correlation between the level of development and general scientific literacy in any given country.

III. The central position of the scientist in an ideal instutional framework for R&D in science and technology.



P&F Project solicitation and funding
IP Intellectual property, a term used in order to impart a connotation of monetary value to knowledge.
RG Research grant

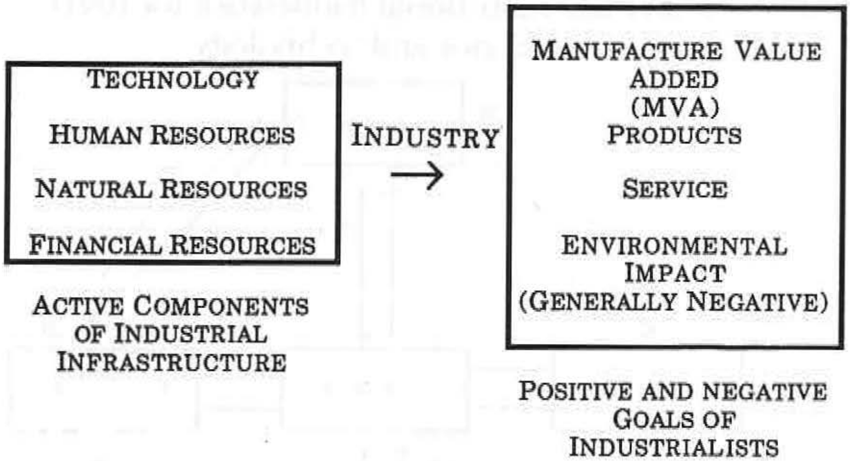
Developed world:

- Strong partnership between government, industry and university.
- The scientist/technologist occupies a key position in the dynamic R&D system.

Developing World:

- Scientists only interacts with his/her own institution.
- Weak (or even unhealthy) interactions between the three powers (government, industry and university)
- Weak technical support for the scientist.
- Industry contributes very little to R&D work.

IV. Components of industrial infrastructure



- Although financial resources can be a serious constraint, the ability to harness all the active components is also a critical bottle-neck to an industrial take-off for Africa. This latter aspect defines the industrial climate of the continent.

- Sources of financial resources:
  Foreign investments
  Loans (concessional and non-concessional)
  Development aid
  Special venture capital loans from donor countries
  National development banks

- Modes of technology transfer
  Turn-key projects with their associated export credit
  Guarantee facilities
  Joint-venture operations
  Multinational operations
  Direct importation

V. Indices for industrial infrastructure

N_P = WEC

PRIMARY INDEX

WATER (W)

ELECTRICITY (E)

COMMUNICATION (C)

$N_P > 0.99$
For developed world

$N_P < 0.99$
For developing countries generally

$N_{OVERALL} = 0$

OVERALL INDEX

- $N_{OVERALL} = 0$ in African countries.
- Generally I,H and S have critically small values making $N_S = 0$.
- All quantities are measured in terms of independent probabilities for simplicity.
- Banking includes financing.

N_S = BMITHS

SECONDARY INDEX

BANKING (B)

MARKETING (M)

INFORMATION (I)

TRANSPORT (T)

ENTREPRENEURIAL HUMAN RESOURCES (H)

TECHNICAL SUPPORT (S)

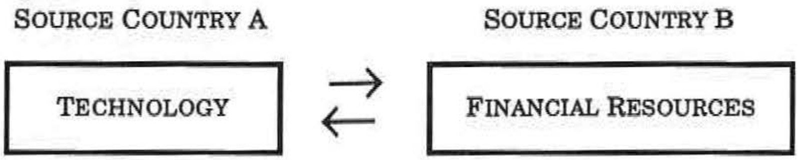
- Machine tool rooms
- Service Units
- R&D units

RAW MATERIALS

- Raw materials not included in the calculation because this sector is not generally a bottleneck and does not have to be localized.

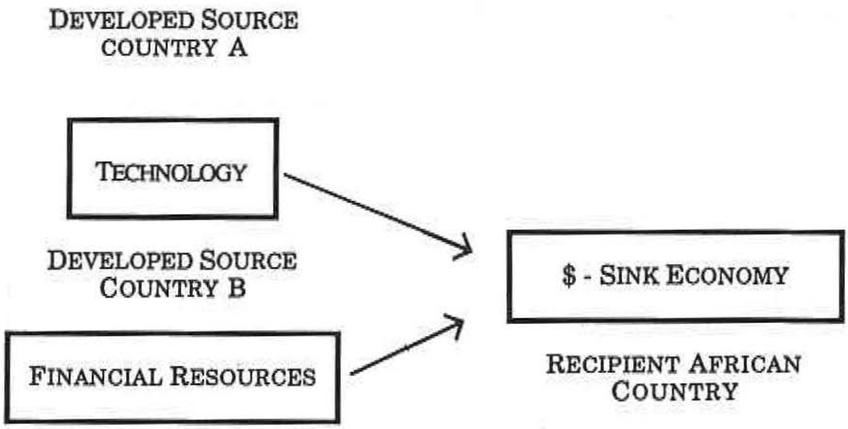
VI. International technology and financial transfers.

DEVELOPED WORLD



- Technology and financial resources flow in opposite directions between two collaborating countries.

AFRICA



- Both technology and financial resources may flow in the same direction toward the recipient developing country.
- Most practical mechanisms for enhancing such transfers is through investments (multinational operational); but the lack of one-stop agencies at which to make industrial negotiations is a discouraging factor for foreign investments in African countries.
- For sustained development, the recipient African country must become a $-source economy; i.e. export economy.

VII. The Scientist as an entrepreneur

Modes of entrepreneurial activities:

- Organize consultancy companies to serve both government and industry.
- Institutional participation in R&D work for industry which may be in the form of contracts or university-industry collaboration.
- Organize manufacturing companies within own field of competence.

Promotion of university R&D work for industry:

- Clarify:
    - benefits for each party
    - contributions from each party
    - ownership of the intellectual property.

    Clarify:
    - parties to the agreement (can be difficult for univer sities)
    - intellectual property to be protected
    - period of the agreement.

Possible benefits to the university:

- Provision of research scientists from industry might lead to reduction in teaching loads.
- Project might enhance relevance of the university to the economy of the country.
- Project might motivate staff to engage in research work
- Participation in project might bring additional income to university and participating scientists.

Possible benefits to the participating industry.

- Project when successful might increase the firm's ability to meet product demand with the competitive edge.
- The team of scientists in the university engaged in the project, consitute a local base for back-up services for the company in the new product line.
- Postgraduate students participating in the project constitute a pool of human resources already familiar with the technology of the company from which it can recruit.
- Collaboration enhances a positive image for the industry in the promotion of national self-reliance in the field of technology.

Parallel benefits can also be constructed for university-government and industry-government interactions.

XIII. Proposal for an effective action programme

This Consultation on behalf of its various constituencies, should:

- Stop preaching and adopt an operational example for Africa.
- Create the African Technology Group (ATG) as an industrial company.
- Create ATG as a multinational company wholly owned by eminent African scientists with a keen interest in developing the continent, as shareholders with venture capital from donor countries.
- Mandate ATG to specialize in high-tech products.
- Distribute operations (indluding ancillary industries) equitably between participating member countries.
- Negotiate for preferential tariffs for MVA products between participating countries to facilitate export within Africa.

IX. Advantages and objectives of creating ATG will:

- Give us opportunities to practice what we preach.
- Become a catalyst for technology-led development across the continent by selling successful ventures.
- Create ideal working environments for scientific and technological personnel in Africa.
- Deliberately attract back high level African scientists/technologists currently working in the industrial world, and halt international and inter-continental brain-drain.
- Promote advanced R&D work in S&T in Africa to service the operations of ATG, using universities.
- Allow some of us to become rich for a change!

The Scientist as an Entrepreneur: An Industrialist's View

S.M. Ita

I have been asked to give an industrialist's view of the scientist as an entrepreneur - within the broader theme of a search for an evolving mechanism for creating an interface between science and industry in Africa.

It is common knowledge today, that linkages between scientists, industrialists and entrepreneurs contributed immensely to the economic and industrial development of OECD countries, such as India and Korea.

Yet attempts in the last twenty-five years to transfer technology to Africa in a move to transform African economies industrially has failed to yield the intended results.

It is against this background that this forum of the Consultation on the Management of Science for Developmnent in Africa, organized by ICIPE and AAS and sponsored by IDRC, has selected its theme for discussion.

Before us, there are several suggestions on how the interface between scientists and industry can be encouraged in Africa. Among these is the strategy of encouraging scientists themselves to become entrepreneurs, and to get out of their laboratories to the production factories to produce new products based on their research and to market them. This approach has succeeded elsewhere in the world and it would appear that it has a chance of succeeding in Africa.

An industrialist's view of the scientist as an entrepreneur in Africa, must begin with a summary analysis of the environment within which African scientists will take up the challenge of being entrepreneurs. African scientists have, until now, remained somewhat passive to the needs of industrial and social economic development of their countries, thus creating suspicion about their competence and reliability. They must prove themselves reliable and useful to industry and society. This is beginning to be achieved through a number of successful scientific and professional consultancies established and managed by Africans. Africans must get more involved in consultancy work to expose themselves to to the entrepreneurial spheres of operation.

Most operative entrepreneurs in the modern sector of African economies are non-indigenous and depend largely upon scientific and technological inputs supplied from outside Africa. The majority of African entrepreneurs are in the informal sector running small activities backed by their professional, technical and scientific skills. It is interesting to note how these small scale African entrepreneurs manage their operations to minimize local conditions. Their activities have:

- a high degree of flexibility
- a minimum of regulation or no regulation at all
- a high degree of discipline (imposed by the fact that their activity is the source of their livelihood)
- small size, and a low level of overhead
- market-oriented products and services
- concentrated on a selected mix of products and services
- needs which can be supported on the basis of technical strength.

This is not an exhaustive list, but suggests that a scientist entrepreneur must be highly disciplined and ready to take risk on the basis of often scanty information. It may be appropriate for scientists to be trained in business management skills to enhance their opportunity-analysis and marketing skills.

African governments have a major role to play in creating an environment in which scientists/entrepreneurs can play their role fully in the development of their economies.

Research and Development in Africa Must be Based on African Cultural Capabilities

J. Maud Kordylas

AFRICA - A CONTINENT IN A DILEMMA

The state of a nation is the state of her people. People without proper direction and without a philosophy, produce a nation in confusion. Africa is in a state of confusion because her people are in a state of confusion. Like a child lost in a dark tunnel, Africa is groping along looking for a way out. Voices reach her from all directions with outstretched hands full of well meaning intentions. She does not know which helping hand to grasp to lead her out of the darkness and her confusion.

Please, please, she yells in frustration. give me some quiet and peace to evaluate my position to determine in which direction lies my salvation.

INTRODUCTION

Failure of African research institutions to bring about the needed thrust for socio-economic development is not an isolated phenomenon; it is a part of a complex fundamental issue which permeates through all socio-economic development efforts of the continent. The fundamental philosophy underlying efforts being made, or the basis for development, is erroneous.

To help clarify this assertion, I quote Schumacher's example of a visit to a refinery, which he used to explain the "evolution of development":

"Imagine a visit to a modern industrial establishment, say a great refinery. As we walk around in its vastness, through all its fantastic complexity, we might well wonder how it was possible for the human mind to conceive such a thing. What an immensity of knowledge, ingenuity, and experience is here indicated in equipment. How is it possible? The answer is that it did not spring ready-made out of any person's mind; ...it is the concrete evidence of a collective accumulation of knowledge, skills, expertise and experiences derived over centuries. It is a show of the cultural capabilities of the society that built the equipment."

Schumacher then went on to explain that this had started quite simply, then one thing was added and another modified. Gradually and systematically, this went on till eventually, the whole thing became more complex.

"What is actually seen in the refinery," he went on, "is only the tip of the iceberg. What is not seen is far greater than what is seen; multitudes of consignments of refined products properly prepared, packed and labelled; and the most elaborate distribution system, for example, are not seen. The intellectual achievements behind the planning; the organization; the financial investments made, the marketing; and finally, the great educational background which is the pre-condition of it all, extending from primary schools to universities, and specialized research establishments without which, nothing of what is actually seen would have been there, are all part of the invisible."

"It is, therefore worthless" he continued,"for an alien society to import and erect such a refinery with the hope that its presence will cause development to happen. If the invisible aspects of the refinery are not supplied, then the refinery becomes a foreign body, which has to depend, for most of its life, upon the society which produced it."

This was what Schumacher gave as his definition of evolution, or development.

Africa has, since independence, based her development efforts on such a premise. Foreign structures have been brought in without the necessary cultural capabilities to sustain them. This action has led to the creation of a "dual economy" - a modern sector where 15-20% of the population live in relative affluence, and a rural sector, where the majority live in poverty. Modern sectors have been set up in cities all over Africa. With help from international agencies and donor governments, it has been hoped that the dynamism of this sector would generate wealth and improve the condition of the entire society.

Unfortunately, this cannot happen, because the more important, larger, invisible part of any foreign transplant needed to make the transplant self-sufficient and sustainable, cannot be **created**. Besides, the cultural base: social, structures, historical experiences, cultural heritage, environment and acquired skills which were accumulated to make the imported visible part, is completely different from those of Africa. **No nation can hope to develop without going through a process of evolution.**

The choice left to Africa, therefore, is (a) to try to acquire the invisible foreign capabilities, which is an impossible task; or (b) to turn to her own cultural capabilities as her evolutionary base. There is no short-cut to development: development has to go through a process of evolution and evolutions take time. The process, however, can be accelerated if deliberate and judicious attempts are made. Japan did it in our generation and so did India. Africa can, therefore, also do it.

Supporting the visible modern sector without generating the requisite evolutionary part has been a very expensive proposition for Africa. For this foreign sector to prosper, it has remained isolated and at the direct expense of the traditional sector, which directly or indirectly finances the investments and subsidies required in its upkeep. Africa's government policies, educational systems, scientific institutions, financial institutions, agricultural production, trade and commerce, foreign exchange, and political arrangements - indeed, her whole socio-economic development efforts and resources, are all geared towards the support and maintenance of a foreign way of life in this acquired foreign transplant; the modern sector. As the population grows, poverty and unemployment also spread.

Africa has spent the last 25-30 years of her post-independence era building and supporting such modern sectors, without evolving any realistic system of generating wealth for the benefit of the whole society. Despite massive national and international efforts, what is seen in Africa today is unemployment, poverty, hunger, migration to cities and other countries, food crises, foreign debts, and stifled economic growth. These problems are only shadows of worse yet to come. If Africa continues to spend all her resources to support the import of the culturally-based technologies of foreign countries, the prosperity of those nations will lead to destruction of the continent. Unintentionally, Africa is also delaying the inevitable: the start of her own evolutionary process.

In the light of Africa's present situation, she cannot afford anything else, but to turn to her traditional sector in search of her cultural capabilities - the starting point of a genuine evolutionary process. Fortunately, such capabilities do exist in that sector. Traditional systems exist for trade and commerce, marketing, agriculture, food processing and preservation, law and order, banking, government, art, wood-work, textile production, religious orders, house construction, medicine, and technology. Africa does have cultural heritage. A heritage that has been serving the needs of the majority of her people, and which has come about through centuries of evolution. The systems evolved are small scale but cost efficient. They need less infrastructure (roads, water, power, etc.) and less capital to make them functional and productive. They are physically dispersed and do not need to be concentrated in cities. A majority of the people understand them and therefore can participate in the evolution of economic development.

With the post-independence policies enacted for development, Africa has acquired a great number of highly trained manpower with requisite knowledge and skills in modern techniques and technologies. With the will to do it, a little effort and serious study, areas in the traditional sector which could benefit from injection of appropriate modern techniques to make them more productive can be revealed, turning this sector into the evolutionary base which would give Africa the thrust needed for genuine socio-economic development. Africa does not need to invent the wheel; others have already done so. Appropriate modern equipment and techniques that would be in harmony with functional traditional systems do exist all over the world. Research is needed to identify and assemble the potential combinations. Systematic selection, addition, modification, etc. would eventually produce the right type of visible structures which Africa needs to set her on the right path to socio-economic development.

The African scientific community could spear-head such an evolutionary process. It does not need high financial investment to do so; neither does it need any government policies to be enacted in the initial stages. Cultural capabilities existing in the traditional food sector are used to illustrate the point.

TRADITIONAL EXAMPLES OF FUNCTIONAL CULTURAL CAPABILITIES WITHIN THE FOOD SECTOR

Natural ecological constraints

Africa's diverse ecological zones demand that a variety of land management schemes be evolved.

In the equatorial and tropical zones, rainfall is high and the peak of biological activities on farms usually coincides with periods of maximum rainfall. However, the intense convection rain storms which occur at the beginning and end of the rainy season result in problems of excess soil moisture and cloud cover.

Towards the northern and southern extremes, the amount of fainfall received is the most important constraint to agriculture. Soil moisture conservation and supplementation through some form of irrigation, and erosion control are the most important land management issues.

In the intermediate zone of wetter savannas and drier forests, all these management issues also assume some significance, though at different times during the cultivation cycle. The soils of the intermediate zone are often of better quality.

Faced with these land management problems, African indigenous people managed through centuries of trial and error, to evolve some highly complex, diversified, and therefore risk spreading, sets of management strategies, which cope with, rather than over-ride, nature. Complex land-use combinations were evolved for agricultural production, such as multiple cropping and upland cultivation combined with valley bottom flood retreat cultivation. Attention devoted to various activities varied through the season to make maximum use of available labour. In addition, livestock often subsisting on farm and household by-products, acted as savings, and hunting and gathering constituted important buffers against periodic famine.

These indigenous farming methods were by no means as primitive or unproductive as agricultural scientists had hitherto supposed. They were skilled, detailed, and of considerable complexity in which quality was as important as quantity. Specific examples from agricultural practices of several African cultures follow, to illustrate the sophistication of the methods they have evolved.

J. Maud Kordylas

Indigenous soil classification systems: The Sissala

The Sissala people occupy a stretch of land lying to the east and north of the Kulpawn River in a territory divided by the Ghana-Burkina Fasso international boundary.

Grassland dotted with trees is the natural vegetation. The area is undulating with a general height of 1000 feet above sea-level. It is floored by ground water laterites which consist of pale coloured sand of varying thickness lying on top of generally sandy clay. Long years of cultivation and burning have made the vetation very open. Only trees of economic value such as the shea butter are found near settlements. The mean annual rainfall is about 1,250 mm; the rainy season is between April and October.

Traditional farmers living in the area have been well aware of differences in soil. They use indicator plants, soil colour and soil moisture relationships to identify the soil types, and to classify them into capability classes for agricultural use (Appendix 18). The soil types are often related to particular topographical sites.

Farmers combine bush fallowing with permanent cultivation of small plots of land immediately around their compound houses. Each farming unit cultivates three fields at different locations: the compound farm, the valley farm, and the bush farm. This system of land use is based upon the recognition of different types of soils at the different locations, and their suitability for the cultivation of particular crops.

These soils have been identified through the indicator plants they support. Wherever possible, preference is given to a particular soil for each of the crops grown. Old and experienced elder men of each farming unit are responsible for choosing the farm sites for the group. Sites for the next farming season are selected at the height of the rainy season between August and September when the vegetation is luxuriant. The choice of site depends not only on the presence of a particular indicator plant, but also on its density and luxuriance.

Steep slopes are normally avoided because of rapid soil erosion which occurs after the cultivation of such areas. Farmers who have to cultivate such sites for one reason or another, take measures to check erosion. They arrange stones along the contour and fill in erosion channels with small stones.

Slashing and burning are used extensively in the rain forest belt as a means of clearing the land for cultivation. Ash from the burning is disturbed as little as possible in the planting of crops. Maize or other cereals are planted into the topsoil with a digging stick without moving the surface cover. Once the first crop has developed, other crops are intercropped to cover the ground and to protect it.

Howard Jones, one time government mycologist in Nigeria, described in 1936, the initial reaction of the European visitor facing a West African forest farm:

"The whole scheme seems to him laughable and ridiculous and in the end he would probably conclude that it is merely foolish to crowd different plants together in this childish way so that they choke each other. Yet if one looks more closely, there seems a reason for everything. The plants are not growing at random but have been planted at proper distances on hillocks of soil arranged in such a way, that when rain falls, it does not waterlog the plants, nor does it pour off the surface and wash away the fine soil; the stumps of bushes and trees are left for the yams to climb upon and the oil palms are left standing because they yield valuable fruit, and although several kinds of plants are growing together, they were not sown at the same time, nor will they be reaped together; they are rather, successive crops planted in such a way that the soil is always occupied and is neither dried up by the sun, nor leached out by the rain, as it would be if it were left bare at anytime.

"This is but one of many examples that might be given that should warn us to be cautious and thorough before we pass judgement upon native agriculture. The whole method of farming and outlook of the farmer are so entirely new to us, that we are strongly tempted to call it foolish, merely from an instinctive conservation."

Usually the land is cultivated for one to three years depending on soil fertility. When yields begin to degenerate, the forest is allowed to regenerate (natural fallow). It takes 5-10 years for a forest fallow to become re-established. Originally, the forest fallow was 25 years but population pressure and demand for land have forced the farmer to shorten the fallow period or eliminate it altogether.

Cropping system in the Sudanese Zone: the Tallensi

Tale settlements occupy an area of some 200 square miles, immediately north of the White Volta River. The area is within the sparsely forested Sudanese Zone with scattered trees and occasional patches of low bush or low ranges of hills. Agricultural activities are controlled by the natural distribution of rainfall. The climate has two well-marked seasons: a rainy season and a dry season. The rainy season is the period of intense agricultural activity and lasts from April to October. The dry season is from November to March.

Tale food economy thus has a marked seasonal periodicity which links the supply of foodstuffs with their distribution and consumption. Good harvests and poor harvests succeed one another erratically, due to adverse rains and frequent locust attacks. Cultivation occurs in three different areas: the compound farms, bush farms and low-lying alluvial land or valley farms. Seasonal variations in the ripening of crops make it essential for each family unit to have a supply of every type of cereal, or face starvation at certain times of the year.

All productive men in the community of over 15 years who are capable, jointly cultivate the land. The women and children assist in sowing seeds and in such duties as scaring away birds from the growing crops. The head of each food production unit is entitled to as much assistance as is necessary for the cultivation and harvesting of his compound farms. He receives help from the junior men, his brothers, sons or nephews belonging to the extended family, and also from all the women of the unit, in sowing and harvesting.

The head is responsible for the supply of the seed and for most of the implements. At harvest, he supervises the sorting of the grain and is responsible for the selection and preservation of seed. He sees to the storage of the grain, storing seed separately and with much care, and storing grain for consumption in his granary. The head of each food economic unit has his own granary or granaries and he alone controls the distribution to the women of the joint family: all who helped him are entitled to share in the produce. The entire unit thus draws its main supply of grain, the staple foodstuff, from a common source. Every primary family however, has a degree of economic independence which is limited only by the obligations to the bigger unit.

The Tallensi always had sufficient food even in the leanest years. They have excellent storage structures and adequate techniques for storing all kinds of food crops. Grains and groundnuts collected from granaries or from storage baskets twelve months after being in storage, were found to be in perfect condition. Even root crops and legumes which are quite susceptible to humidity and weavils, respectively, could be effectively stored by the Tallensi for a year.

Cash crop production in a coastal region: The Anlo-Ewe of Ghana

Anloga is a town of about 15,000 people situated in the south-eastern coastal region of Ghana. The area is mainly of sandy soil located on a narrow strip of coastal land between the ocean and a large salt water lagoon. Rainfall is sparse. Drought and floods have been alternating seasonally as long as the people remember. Agricultural activities were practised in areas that permitted them, and the people kept cattle, pigs and fowl and fished in both the lagoon and the sea.

The soils are unconsolidated sand, clay and gravel, and the land is so low-lying that drainage is a problem; hence the frequent flooding occurring the rains.

During the early part of the twentieth century, the building of the road along the length of the coastal strip effectively divided the region into two cropping zones: the lagoon zone which grows progressively marshier as one moves from the roadside towards the lagoon; and the coastal seaside zone, a series of depressions some of which run for three to four miles. The people first experimented with the cultivation of sugar cane, and then with shallots in order to meet their needs for a viable cash crop. They adopted shallots because of its shorter growing time and higher profitability. Sugar cane requires ten months to mature; shallots require only two months, enabling farmers to plant several crops a year.

Farmland in Anloga has been the creation of the labour of men and women who reclaim the low-lying marshes through filling in beds with sand. Every year the beds have to be rebuilt. Maintenance of this land requires enormous input of human labour, which has accelerated over time as the farmers have increased the number of crops cultivated per year. Thus land in Anloga at any point in time, is the product of labour expended in the past.

Prior to the mid-1930's, shallots were apparently sown at any time of year, with farmers usually planting two crops per year. Market factors combined with disease control requirements, encouraged shallot farmers to develop more intensive methods of cultivation. As more and more of the area was planted to shallots, it became necessary to regulate the planting period in order to control the spread of the insect pest thrips which became an increasing hazard. By the 1950's, the farmers had established a cycle of three growing periods in a year, each lasting about three months. By 1978/79, many had moved to a four season farm cycle, prompted by their urgent need for cash.

The cropping system. The farmer divides his or her land into raised beds, usually of about 2 by 6 or 10 metres to allow easy weeding and watering of the crop. Beds are ditched on all sides to permit seepage of ground water and shallow wells are dug at intervals to allow for bucket watering during dry spells.

Preparation of beds immediately before sowing requires two or three hoeings depending on the condition of the soil. Cow manure, bat droppings or dried fish as is seasonally available is applied by hand as a fertilizer. Through long experience, farmers have developed planting skills. Seed shallots are spaced about 4-5 cm apart and planted to a depth calculated according to a number of variables, which include: size, expected rainfall for the season and whether the seed is old or new. Watering is done twice a day from the time of sowing to the time of harvest. Additional fertilizer is applied once or twice during the growing season. Farmers weed the beds between two and four times. As soon as the shallots germinate they are intercropped with a variety of vegetables which have the same growing period: okro, pepper, tomatoes or a two-month variety of corn. These vegetables are used in the household or sold to supplement income. The corn stalks are processed into green manure.

At least once a year, the long grass growing near the lagoon is cut, dried in the sun, and transported to the farm beds and inserted into the sides of the raised beds to protect them from erosion. In addition, sand is added to the beds at least once a year, or more if erosion has been particularly serious. Sanding involves intensive work of bringing sand from the seaside to restore farm beds which have been eroded away. Farmers use a combination of mechanized and human labour. They hire trucks to do the job or bring in the sand by headloads. The sand is dumped at strategic intervals up and down the roadside. Women then headload the sand from the roadside to the beds.

Organization of labour. In pre-colonial times, labour relations were essentially social in nature, based on kinship and characterized by personal dependencies within the household or community. With the growth in significance of shallots as a main cash crop, total labour increased markedly, necessitating a shift to greater use of contract labour. If the farmers had surplus labour, they, in turn, could contract it out for a fee.

Meanwhile, as agricultural practices have become more labour intensive, the division of labour between males and females within the household have appeared to become less strict. This is not surprising as familial survival strategies have become more and more dependent on the use of all available familial labour power. However, the division of hired labour between adult males and females remains very strict. Women are hired only for agricultural work involving sorting of the harvest, for head-loading pans of manure or sand into the fields, or for loading the harvest out to the roadside. Men are hired to perform all other tasks. School children have also entered the paid labour market and are particularly sought after for watering the crop. Without their valuable contribution, the present agricultural system could not be sustained.

Lately, women labourers have organized themselves into groups called companies, headed by a 'boss' who supervises the women and negotiates for work. These companies are formed according to the relative proximity of the member's households. They usually contract out to farmers living in the same area. Until the formation of the companies, women agricultural workers received a disproportionate wage to that received by men. The company bosses came together from all across the community, discussed the situation, and decided to refuse to work for less than the pay received by men. Farmers quickly complied with their demands. Most men, however, contract out on an individual basis.

Marketing. Shallot yields fluctuate with the season, the most significant controlling variable being the amount of rainfall. After harvesting, shallots are dried in the field for a day or two, provided the farmer is able to post guards against theft. Otherwise they are taken directly to the household. In this case, the crop is transported to the village by women hired for the purpose or by lorry. Once in the compound, the drying continues for about seven days.

After drying, the labour-intensive process of sorting out the bulbs to remove smaller ones for seed propagation begins. The larger bulbs are prepared for the market. Women tie the marketable shallots into a series of bundles. These are again woven together into larger bundles weighing about 25 to 30 kg containing between four to five thousand individual shallots. These large bundles are sent for marketing when the market seems to offer the best return, or when individual farmers need cash for their daily operations.

As the input of female labour on the land increased, the rights of women to use land diminished. Currently, women do not inherit land if they have brothers. This is a change from former inheritance rights and has limited women's ability to acquire land for use in cash crop production. To compensate for their loss of traditional access to productive land, the women have consolidated their control over the marketing of produce, virtually excluding men from this activity.

Marketing organization. Local trade in foodstuffs took place at roadside or lagoonside mini-markets in the region. By mid-1950's the shallot trade had so dominated the economy that cultural isolationism was forced to give way to economic pragmatism. A new market was established in town, operating on a four-day cycle. The effect of this new market was to make Anloga not only the growing capital of the shallot industry, but also the marketing capital. In the early years a number of problems arose in the marketing of the shallots. Periodically there was a glut of shallots on the local market which resulted in a greatly lowered price. Sometimes transport facilities were inadequate to convey the shallots to other parts of the country.

As farmers gained experience in marketing their crop for the best price, they eventualy reached an agreement to rotate the marketing through the four traditional divisions of the town. This was later compressed into a three-fold divisional rotation which more nearly represented the actual layout of their farms. This system, when enforced, facilitated the flow of shallots to the market. However, too frequently, farmers felt the need for cash when it was not their turn to sell. This became a recurrent problem until the late 1960's when the women, who did the buying and selling, devised another solution to the problem. They conferred among themselves and with market women leaders in Accra and Kumasi (two of the main regional markets in the country) and agreed to deal with traders from these cities on alternating market days. This system continues to work well. Although prices still fluctuate, the fluctuations are more in response to seasonal variations in rainfall, rather than to the releasing of more shallots than the market can bear.

Women traders have monopolized the buying and selling of shallots in the market place. Every male farmer depends on wives, sisters, or aunts, to market his crops. At the end of the market day, the woman entrusted with the responsibility gives an account of the day's transactions. She deducts transportation charges, food money, and a bit of compensation for her time, before handing over the cash received. Since men have been alienated from the marketing place, no man can know for certain the selling price of his produce on any given market day.

The most able and wealthy Anloga women formed a union, or "habobboh" about twenty years ago to provide wholesale services: buying shallots in bulk from farmer's wives and selling them to buyers from other towns country-wide. The prerequisite for joining the group was the possession of enough capital to be able to offer credit facilities to market women coming from elsewhere to buy. Honesty was an additional desirable qualification. These women represented the elite of the traders and were easily recognized because they sat together under a special shed in the market place.

Union members control the price of the shallots. About 10 a.m. on a market day, when other women assemble in the central market to discuss and inspect the produce, union members have already settled the day's opening offer for a buying price, usually about one third higher than the price which was negotiated with farmer's representatives. Various factors are taken into consideration in fixing the price: supply and demand; comparison with selling prices in Accra and Kumasi markets; and information gathered from outside traders as to what they consider an acceptable price. Early in the afternoon, union members meet with farmer's representatives to determine the final purchase price. These negotiations are highly formalized, for the union members are well aware that the wives and female relatives of producers are compelled to sell, since their immediate need for cash will not enable them to hold the produce in the hope of a better price later. Once the union members settle on a price with the producers, they repeat the negotiation process with the outside traders.

In this context, long-standing relationships are established between individual traders. Such relationships are characterized by congeniality, hospitality, mutual economic benefits, mutual trust and sometimes long-lasting friendship. Union members extend credit facilities to trading partners from outside, who in turn purchase preferentially from them.

These are but a few examples of the cultural capabilities which exist within the African traditional sector. The systems evolved by the people are functional, sustainable, and serve the needs of the society - more than any foreign based rural project which has been established with high capital input.

Evaluation of African land management and cropping systems

African traditional farmers have already evolved systems of farming which are in harmony with the environment and these systems cannot be bettered in principle, even if they can be improved in detail. As practiced in some areas, the farming scheme affords almost complete protection against soil erosion, soil structure injury, loss of soil fertility and maximum utilization of solar energy. A system of soil management, of shifting cultivation, minimum tillage, heaping, ridging and terracing, intercropping, mulching and application of soil conditioners are all parameters which could be considered intensive, and which help to deal with the intensive rainfall, alternate wetting and drying, seasonal water-logging, and dessication experienced by many tropical and sub-tropical soils.

Mechanization. Traditional farmers use hand tools designed by them to perform various tasks needed on their farms. They are right to avoid wheeled vehicles such as ploughs and tractors. Apart from their prohibitively high initial cost, and high running and maintenance costs, their usage is not in harmony with the tropical environment, nor do they fit into the cropping systems evolved by the people. Factors militating against their use include:

- Ploughing over-exposes tropical soil and injures soil physical characteristics for retaining nutrients and releasing them for plant growth under the impact of intense tropical rainfall.
- Heavy ploughing loosens the soil and prevents it from maintaining a penetrable but stable rooting medium to counteract battering of wind and rain.
- The passage of wheeled vehicles leads to impacted layers or tractor pans, which cause plant growth to be hindered and erosion rates to be intensified. A downward spiral may sometimes be initiated, ending in gulley erosion.
- There are many benefits to the commonly used intercropping technique, a technique incompatible with heavy mechanization.

Intercropping. Intercropping is the system evolved by traditional farmers, of planting several different species, and different varieties of the same species in the same location. Perhaps the greatest significance of intercropping is the scope it offers for a range of combinations to be made; individual needs can be matched in accordance with local conditions and changing circumstances which occur within each season and from season to season. Through intercropping, adjustment responses can be made to declining soil fertility, greatly extending the life of an individual farm plot in a rotational farming system.

Intercropping is one of the great glories of African science. It is contrary to the ethos of agricultural commodity production under capitalism. It is difficult to combine intercropping with mechanization and yet intercropping has been capable of producing remarkable results. It has obtained labour productivities, equal to, if not better than, plough agriculture in European peasand agriculture. And this has been achieved in the intermediate tropical zone, where conditions are dominated by intense, yet variable, rainfall, and limited sunlight at the height of the growing season. Intercropping must be seen to be in effect, at the heart of an African agricultural revolution.

Benefits of intercropping include:

- Minimization of exposure of the soil to erosive rainfall, especially where quick growing and slower maturing varieties are planted together or sequential planting is practised.

- Spread of pests and diseases is minimized since neighbouring plants are less likely to be of the same species.

- Use of available soil moisture and plant nutrients is minimized, since plants grown together (e.g. maize and cowpeas) have different complementary nutrient requirements and their roots are at different depths.

- Established crops approaching harvest compete with and suppress weed growth at later stages in the cropping sequence. Weeding is a major constraint in tropical cropping systems and more often determines farm size than labour constraints of clearing and cultivation.

- Plants with different growth characteristics, different heights, and with varied leafing patterns, are able to combine rather than to compete to maximize the use of available sunlight.

- Risk of crop failure is minimized, because farmers mix varieties and species with different speeds of growth, maturation, and moisture requirements. Although sub-dividing the farm into several monocropped sections might achieve a similar result, intercropping offers significant operational advantages. Insurance crop varieties are sown in the same operation as the main crop.

- Gaps in the farm caused by the failure of some individual seeds to germinate can be plugged by adding a hardier variety at a later stage.

- Combinations of plants can be varied to match variations in soil conditions up and down planting slopes.

- Data collected suggests that farmers' returns may be more reliable with intercropping. Maize yields in an experimental study in cowpea/maize intercropping in Western Nigeria, were more than double those from an equivalent number of stands of monocropped maize. There was improvement in cowpea yields as well.

- Risk minimization is generally a more important criterion for small farmers than profit maximization. Thus although irrigated monocropped rice farms may double rice yields, they don't produce any intercrop. In addition, they require greater labour input. Several recent studies have suggested that 'improved' irrigation farming in Sierra Leone enjoyed no clear advantage over intercropped upland shifting cultivation.

Use of natural irrigation systems. Dry season flood retreat and valley farming systems which use residual moisture for cultivation have been practiced traditionally throughout Sub-Saharan Africa. They are the basis of valley cultivation of rice in northern Sierra Leone, and the inland delta of the River Niger; estuarine rice production on the upper Guinea coast and Zambezi valley; and specialized seed yam production of the Anambra Valley.

In many other areas, however, it is common for shifting cultivators to combine upland, and swamp or valley bottom cultivation. Hydromorphic soils in valley bottoms are especially useful for raising a reliable new season crop. Yam farmers in the Nigerian Middle Belt value swampland for the production of seed yam. A greater proportion of swamp yams are sold than upland yams, since they are ready for harvest when prices are at their peak.

Swamp farms offer possibilities of switching resources to the swamp farm during drought. This affords the spreading of labour peaks. For example, work on swamp yams comes before, and work on swamp rice comes after, the main period of work on the upland farm. Unfortunately, some African valley environments are agriculturally unusable because of the problem of river blindness, notably over large parts of Guinea and the southern Sudan savannas of West Africa.

Labour Requirements. One of the most important aspects of recent reassessment of African traditional crop production systems, is the realization that shortage of labour is often a greater constraint on production than shortage of land. Labour requirements for various cropping systems, e.g. rice, peak towards the latter part of the season in association with transplanting and harvesting. Cash crop production such as cocoa, coffee, and cotton has required a number of important adjustments to be made, as a result of competition for labour. The two most significant adjustments made are: (a) recruitment of short-term migrant labour, which in part draws on a pool of slack season labour available as a result of the long dry season in the semi-arid regions and (b) changes in the geographical distribution of and types of food grown.

In assessing labour productivity, measures of productivity per unit labour input, have been found to be a more appropriate assessment than yields per hactare. Often, innovations which give improved returns per hectare, fail to take root because they are labour intensive and lead to diminishing returns on labour. Finding an acceptable solution to the labour problem, is one of the areas where improvement could be made in the traditional cropping system to make it more productive.

Domestic livestock and pastoralism Small domestic livestock are an important part of the traditional farming system throughout Africa. It is not uncommon to find goats, or chickens for example, carefully penned and their dung used as manure. It was estimated in a Nigerian peasant farming system, that small domestic livestock accounted for 10% of the value of the output. Larger livestock, especially cattle, are more restricted in numbers and locations, because of problems of disease and availability of water and grazing land. Few livestock management systems are not integrated with agricultural systems in some measure or other. Nomadic pastoralism is an extreme on a continuum in this respect, but even nomads generally establish regular links with farmers to purchase grain and to graze harvested fields. In many cases, they also plant crops for themselves.

It has been shown that African pastoralists are good, practical stock breeders, with clear ideas about how to cope with natural hazards and adapt to changing circumstances. Thus, for example, the mixing of small and large livestock together is, for the pastoralist, not dissimilar to intercropping in African agriculture. It is a means to withstand ecological hazards and to speed recovery when drought reduces herd sizes. Provision of improved pasture and available water are areas in which livestock management in Africa would benfit.

Acceptance - crucial to the African evolutionary process

Acceptance of African traditional ecological knowledge is crucial to the evolutionary process. As has been demonstrated, local perspectives are always important in ecology. Human ecology is a science of adjustment, adaptation, balance and fine tuning rather than global generalizations. Knowledge produced over centuries reflects the interests of specific social groupings with respect to their environment when confronting ecological change. Knowledge and skills developed in the process of traditional farming, have strengths and limitations which are directly related to the framework within the context of which observations are made.

What has evolved came out of processes directly visible to the naked eye within the farm processes which are generally well understood and adequately handled. There is a need therefore, to make maximum use of the knowledge and skills already in the possession of the majority of Africa's cultivators - the traditional farmer. Knowledge and skills such as: the technical characteristics of African land management systems; intercropping; intensive management of soil physical properties; and integration of valley and upland farming systems; are inventions which are highly appropriate in the African context. There is no intrinsic reason why they should be treated simply as survival mechanisms from an era of subsistence production, or as evidence of involution in the face of population growth and capitalist exploitation.

Since the 1920's and 30's, it has been postulated (a) that the Sahara is expanding due to the unintended consequences of poor agricultural techniques by traditional farmers; (b) that market and population pressures were too much for the limited techniques of the African cultivator; and (c) that uncontrolled shifting cultivation and uncontrolled grazing (goats were especially singled out for criticism) modified local climates and encouraged desert creep. Various other explanations were made and several proposals were suggested to remedy the situation.

In the early 1970's the debate was once again revived in the wake of the Sahel drought. Dessication, the impact of excessive population growth, and the low level of agricultural technology on marginal land, once more sprang into prominence as an hypothesis. Causes of deterioration of the Sahelian climate were sought for and were blamed on changes in the vegetation due to overgrazing, and the response of the general atmospheric circulation to increased levels of atmospheric pollution, due in part to the result of continued bush burning.

More recently, it has been argued that Africa's increased vulnerability to drought in the twentieth century is the result of the replacement of indigenous low yield, low variability crop varieties by high yielding, high risk 'improved' crop varieties.

These assessments of African agricultural ecology are in danger of being too pessimistic since on the whole, the ecological literature on vulnerability rests on a surprisingly thin research basis. Scholars are sometimes guilty of presenting peasant knowledge as practice without theory. Instead of relying on generalities based on little research and a weak statistical base, and a very limited understanding of the vastly different social and physical environmental conditions, we should rather examine the indigenous ecological knowledge in Africa.

Agricultural education must emphasize schemes to equip Africa's peasant farmers with appropriate productive skills they do not yet have. Politicians and planners seem not to have thought that there might be any other alternative to the orthodox strategy mix, typically compounded of European, North American, and South and South-East Asian ideas and practices; apparently on the grounds that management of agricultural resources in all these regions is more 'advanced' than it is in Africa. Acceptance of such an erroneous assumption, could lead to the rejection of several centuries of solid progress towards an improved agricultural system adjusted to African ecological conditions, in favour of the importation of an inappropriate, counter-productive agricultural revolution. Recent ecological research suggests that much of African peasant ecological management happens to be right, and may be better regarded as advanced rather than backward.

African Food Crisis

For over a decade, Africa's food situation has been deteriorating and this has been a major concern worldwide. The African food crisis is only one component of several interrelated crises reflecting adverse trends in agriculture and food production, environmental and political conditions, and especially the wrong bases for socio-economic development of the continent. The farming systems used in Africa are ecologically sound. Rapid population growth and other pressures placed on it only call for the system to be improved upon in detail, but not in principle. Unfortunately, without taking such an option, 'green revolution' strategies were suggested as a remedy for increased food production for the whole continent of Africa.

Two fundamental components of the 'green revolution' are increased use of high yielding crop varieties and inputs such as tractors, chemical fertilizers, pesticides, herbicides and irrigation. High yielding crop varieties demand a regular supply of water (irrigation); availability of chemical fertilizer and pesticides; a good transport system, not only for distribution of inputs to farmers but also for timely transport of cash crops to ports and food crops to markets; an extensive local research support base; and an effective extension service system.

Most of the investments necessary for such inputs must be paid for in foreign currency since they have to be imported. Such investments become economical only if they result in generating the same, or a higher amount of foreign currency. This means that green revolution options would not be economical if applied to food production for local consumption. They must be used to support crop production for world markets; meaning intensification of cash crop production. With such options, any nation which adopts green revolution strategies becomes increasingly dependent on foreign capital and foreign technology, and is affected by fluctuating world market commodity prices, with insufficient food grown to meet its own population growth. Many African countries have opted for green revolution trials with their high-cost agricultural inputs. But, after several years of such costly trials, most wage earners in Africa cannot in 1988 provide three adequate meals a day for their families even if they spend their whole salary on food.

Fortunately, the failure of green revolution strategies to take root in Africa is a victory for the continent. For had this highly mechanized and expensive agriculture been successfully implemented at the level expected, there would have been a disastrous destruction of the African ecosystem. Violent disruption of the terrain would have been followed by vigorous soil erosion. Severe pollution of the African environment, poisoning of the main waterways, and massive poisoning of the rural population would have been some of the drastic results which would have accompanied successful green revolution agricultural production.

Africa would in addition, have had to mortgage her soul to borrow the money needed to build the required infrastructure, and train people to manage the imported inputs. She would have had to again borrow money to bring in the needed high technology to mine and process her minerals, or to bring in raw materials to produce the large quantities of chemicals needed to support and to sustain this high input agricultural system.

Either way, generations to come would have been forever saddled with the foreign debt accumulated, and those yet to be added on. There would have been a chronic spread of poverty throughout the region. for what is seen happening in Africa today is but the sign of what is yet to come. **For no nation can hope to**

survive forever with a food production system, which is based, not on the use of her own resources, but on the importation of high cost inputs from elsewhere, inputs the production of which help to support and sustain economies elsewhere, but tie the African people to a state of perpetual poverty. African governments somehow believe and are encouraged by general international opinion, that there is no other alternative but to strive harder along this path which is destined to disaster. There is another alternative, and that alternative is for Africa to use her own resources: the knowledge and skills which have been accumulated through the centuries and which are available to the masses.

A Trial R&D Project Based on Cultural Capabilities of the Traditional Food Sector

Having convinced myself after many years of searching, that Africa would have to go through a process of evolution based on her own cultural capabilities, I decided to set up a trial research and development project which would emulate a traditional crop production system. I hoped to identify some of the limitations of the system and inject appropriate modern scientific principles and technology into areas which would benefit from such introductions.

The key characteristics of a traditional crop production system are: combination of crop and small animal production with facilities for processing and preservation of the harvest; small manageable and cost-efficient units; and simple, low cost but functional equipment.

Some of the problem areas identified in the traditional system were: weeds and their control; soil fertility improvement and maintenance; and control of soil erosion and conservation of moisture during the dry season. The self-sustaining organic system of crop production was chosen as the most appropriate means to provide solutions to these problems. For crop protection, various non-toxic sprays were prepared and experimented with at various periods during the cropping season, but maintenance of adequate soil nutrient levels, was primarily relied upon to keep the growing plants healthy enough to protect themselves from insects and disease.

The experimental plot, originally filled with clay soil measured 9 by 20 metres. Traditional cropping methods of interplanting, raised beds, multi-story planting, companion plant cropping, crop rotation, etc. were tried at various stages.

On February 12, 1984, the first compost pile was built and used to begin regeneration of the soil in the experimental plot. Many different crops were a planted: vegetables, legumes, root crops, fruits and some flowers. With the help of one unskilled labourer, constant application of compost, minimum irrigation during the dry season, heavy mulching, use of hand tools, and a chipper/shredder acquired in 1987, the garden has been kept in constant production throughout the year.

Yields. Yields from this plot from January to October 1988 included: 480 kg fruits; 40 kg vegetables (mainly pepper); 52 kg cocoyam; 6.5 kg winged bean and 15 bunches of plantain: a total of 567 kg of produce excluding the plantain. With one mango tree and three carambola trees now flowering, plus two sour-sop trees ready to produce for the first time, a ton of produce is expected from this micro-plot in 1989.

Crop Processing. between 1985 and 1986, some simple laboratory gadgets and a variety of domestic food processing equipment were acquired. Basic chemical and physical parameters were determined on crop samples. With the information obtained, product formulation experiments were carried out and crop processing lines set up for: dehydration, fruit juicing and bottling, fermentation (wine-making) and jam and jelly making. Equipment was acquired to experiment with milling of tropical tubers into baking-quality flours.

With regular supplies of produce from the garden and local producers, the processing lines are kept in constant use. Some jams and jellies are now in the local market and negotiations for export are under way. Within the past seven months 2,000 bottles of jam and jellies have been produced with enough fruit-pulp in stock to make another 2,000. Seventy six bottles of wine have been bottled and 52 gallons more are in process. During this period, small scale commercial processes have been established for: raw materials processing, packaging, distribution and marketing and the technical processes involved, adapted.

African Scientific Community to Spear-head the Evolutionary Process

Mr. Chairman, if this presentation has succeeded in convincing you that Africa has no other choice but to go through an evolutionary process based on her own cultural capabilities, then I suggest, that the most relevant group to spear-head this evolutionary process is Africa's scientific community. Members of the scientific community in all their varied disciplines, will have to re-adjust their basic philosophy of working towards the support of the foreign transplant and redirect their scientific efforts towards an evolutionary process based on the cultural capabilities which exist within the traditional sector.

Most of the structures needed do exist in various forms within Africa. Their present mandate only needs to be re-oriented, and their purposes redefined so that they would better serve the requirements of the new research orientation. Collective and consciencious implementation of such a scheme would bring about an enormous multiplier effect, which would be seen as a surge towards a genuine economic growth. The dual economies created throughout Africa would be able to merge into a healthier single economy, with an African identity.

CONCLUSION

The path to this proposal, Mr. Chairman, has not been easy. It has taken fifteen years of searching and doubting; of perseverance and frustration; of isolation and loneliness and above all, of sacrifice and hard work.

The visible part, the produce and sample products which I have displayed for your viewing, has been accomplished in the last four years. But within this same period the most important invisible part and the learning process have also been achieved. This acquired knowledge, would not only enable me to set up a much larger production system, but would also help me to support and sustain any system established, more effectively. I can say with conviction that the proposal presented works, and it must therefore be given a fair trial.

Finally, I would like to share with you some inner thoughts and feelings which I have not been able to express in this presentation, but have written in another form of communication:

My Endowment

When I look around
I see majestic trees
Reaching up high to the sky.
The sun shines heartily on them
And makes their green leaves glow.
The wind blows freely through them
And their branches bow in adoration.

But what do I do with all these riches?
I have set my mind on treasures high
Which are way too far to grasp.
And struggle so hard to reach to
Things which do not nurture my soul.

The treasures around me cry out loud
If per chance I would turn my head
To gaze upon them and acknowledge them,
So they can explode, their
Hidden riches to shed
To engulf me in their bounteous beauty:
My body to nourish, my soul to nurture.
But lo, I was so busy staring out far,
And missed the treasures
That would have been mine.

J.M.K.
June 1987

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PART FIVE

FINANCING OF R&D IN BOTH PRIVATE AND PUBLIC SECTORS

Address by the Minister for Industry

Honorable D. Otieno Anyango

I am happy for the opportunity to address this important gathering of experts and top policy makers on issues concerning research and development in Africa.

Research and development, as you all know, has enormous potential for promoting economic development. Africa will not make any major development strides until it suceeds in organizing the talents of its people and directing such talents towards resource-based production of the goods and services the continent consumes.

Unfortunately, during the last three decades or so, and up to now, independent Africa continues to be dominated more by politics than by production. We give great attention to activities which put people to **power** and appear to give less priority to those activities which would put our people to **work.**

There is a major change necessary in our attitudes to politics and production, and to power and work. In Kenya, His Excellency, the President, Hon. Daniel T. arap Moi, has repeatedly said that the politics he knows is the "politics of the stomach".He puts this simply, but it is a major challenge he is throwing to our scientists, technocrats, and the elite of this country.

It is disappointing, therefore, that even after the ten years that His Excellency has been making this call to our people, there are still "intellectuals" who have not identified their roles in the development process this country needs. Some, in fact, choose to display their ignorance of the needs of our people by roaming world capital cities discrediting their mother country (and indirectly discrediting themselves) to the joy and delight of our former colonial masters. The European is happy athat Africa is still asleep and prays for the continuation of contradictions in the manner we manage our economies, provided the contradictions do not affect the African markets for his products.

It is gratifying, therefore, that ICIPE /AAS was able to organize this Consultation which will help our scientists to focus their attention on the real needs of our people and determine how we can effectively manage the very scarce scientific resources at our disposal to enhance the development of the continent.

I once heard of an expression to the effect that "a hungry man has no principles". You could also say that "a hungry man cannot sustain his self-confidence". However, the process of converting "ideas" into "products" requires a lot of self-confidence. We must, therefore, first of all direct our talents to food production and the agro-industries.

My first call to this Consultation therefore, is to give priority to the effective management of research and development in food production and the agro-industries. We may even have an advantage in Africa in that we still have a cleaner environment for the production of better and healthier foods which can be exported to the heavily polluted industrialized countries.

From the doctorate degrees the University of Nairobi awarded yestrerday, one has the impression that the scientific nucleus is sufficient and awaits comprehensive development. The knowledge is already acquired and scientists are there in good numbers.

However, we need to examine more closely the process of converting knowledge to wealth or ideas ot products:

- First, we need the Scientist (idea)
- Second, we need the Technologist (means)
- Third, we need the Entrepreneur (to identify current needs)
- Fourth, we need the Manager (to coordinate)
- Fifth, we need the Financier (to facilitate)

My second call to this Consultation, therefore is to examine how we can develop more technologists and entrepreneurs.

Our institutions of higher learning reward and recognize **knowlege** but do not give much credit for the **use of knowledge**. Lecturers and Professors respect themselves for what they know and not so much for what ideas they have converted into marketable products. At least the five people listed above, are required to convert ideas into marketable products; that is, the scientist, the technologist, the entrepreneur, the manager, and the financier (investment banker), in that order.

It seems to me that scientists can become technologists; and technologists, entrepreneurs; entrepreneurs, managers; and managers, investment bankers. The reverse process is a lot more difficult to achieve. You experts can verify if my observations hold water!

What I know from my banking background is that the investment banker will only be keen on a project if it is scientifically sound, technically feasible, economically viable and financially bankable under a competent manager.

Each of the five people I have mentioned here must be deeply committed to the development of their country and people. Unfortunately for Africa, many of our people seem to be more comfortable working for foreigners than for fellow Africans or for themselves. They seem not to mind enriching a European or Asian organization, but would have reservations enriching a fellow African. I would leave it to the social scientists among you to verify these comments and make suggestions as to how we can improve the unity of purpose amongst our people. **How do we convert primitive jealousies to orderly competition?**

Our resources are under-developed and the markets are fragmented. Unless we are resolutely supportive of each other by pooling resources and markets, we can make very little headway in economic development and the management of science for that development.

My third call to this Consultation is that the participants should determine whether or not the exising R&D institutions are sufficiently multidisciplinary and preach the importance of unity in the implementation of projects. Scientists can be terrible loners and mobilizing large numbers could be a big problem to many of them.

I would like to throw a challenge to all our professionals: the scientists, lawyers, accountants, architects, doctors, engineers, agronomists, economists, name them. Please plan for self-employment as entrepreneurs, and not as paper-writing consultants. I am looking to the day when our architects, surveyors and engineers are contractors. They would be more reliable and safer lending propositions than the less sophisticated indigenous contractors we have today. Our commerce graduates should man the distribution networks in the country instead of our present wholesalers and retailers who cannot be expected to install computerized stock systems.

I have come to the conclusion that it is indigenous business that will finance indigenous research and development. We may, however, get a few supportive foreign investors, but these cannot be many. All Africa must see and feel that they have a common problem, and that it is development. Canada is joining the USA for many economic functions, and the EEC is getting stronger. Yet, in Africa, where out of 50 countries, only nine have markets larger than 20 million peope, tribalism is still a major problem and a threat to economic cooperation and regional integration.

With these few remarks, I support the continental approach of establishing a Technology Commission for Africa to be developed to the status of the ECA.

Management of Financial Resources for Scientific Research

Zerubabel M. Nyiira

INTRODUCTION

The management of scientific research is concerned with the efficient and effective mobilization, allocation, and control of human, financial and material resources in a manner which perpetuates a productive environment for scientific and technological development activities. Invariably the major requirements in the management process are human and and financial resources. These two elements contribute considerably to the level of productivity of any scientific and technological development system and are vital for a firm S&T base and the application of S&T in spearheading national development.

It is probably true to say that the primary concern of a manager of a scientific research institution is funds. That is, whether adequate funds are available to enable the institution to attract and retain highly capable personnel and provide them with essential facilities and services; and whether the funds are available in a manner that permits effective deployment for the institution to achieve its objectives. With adequate funds, the manager should be in a position to forecast and plan activities, formulate reasonable budgets and manage with confidence the resources entrusted to him. Managers of scientific research institutions are aware of funding constraints, and convinced that adequate funding is essential for the success of their institutions.

The need for well-managed financial resources for scientific research has never been greater; especially in Africa where scientific knowledge and technology are urgently required to reverse the current trends that show the continent is increasingly dependent on imported technology for national development. Fortunately, national governments seem to recognize the key role of scientific research, and more support for them is evident for strengthening national scientific research systems. This observation is clearly demonstrated by the resolutions contained in the Lagos Plan of Action (1). While this support is mounting, and has to be maintained, its importance lies in the level and sustainability of funding for scientific research. The financing institutions, on the other hand, expect efficient and effective management of the financial resources disbursed for scientific research activities.

Despite the interlinkage between them, management of financial resources is distinctly different from administration of financial management policy or control of the financial resources. Whereas the latter two are founded on professional skills in finance and accounting, the former combines various skills and the art of general resource management. This conclusion is drawn through the experience gained during the various training forums the Special Project on Financial and Administrative Management of Research Projects in Eastern and Southern Africa (FAMESA) has staged, aimed at strengthening research management capacity of national scientific research systems.

FINANCIAL RESOURCE MANAGEMENT RESPONSIBILITIES

With greater awareness of the functions of the research manager, the practical responsibilities involved in the management of financial resources for scientific research are emerging more clearly. They range from soliciting for funds to ensuring that the funds are properly used and accounted for. In private scientific research institutions, financial management accounts for as much as 70% of research managers' engagement and embraces a variety of skills including project preparation; monitoring; evaluation of the progress of research activities through budgetary reviews and budgetary controls; and a knowledge of financial accounting.

The situation is somewhat different for public funded research that relies on assured allocations from national budgets. Even in this situation, however, the manager has the task of planning activities, budgeting them and presenting the budget to the financial resource controllers in a manner that should ensure maximal allocation to his institution. To ensure that further financial support is forthcoming, the manager has the duty of communicating the progress of his institution's activities constantly to the financiers and decision-makers and of ensuring that research results meet their expectations. Effective communication with decision-makers and influential groups becomes an essential element in the management of financial resources in a scientific research institution. Equally important, is the control and judicious disbursement of available funds.

Clearly, the effective management of research funds demands not only specific skills in financial management, but also reliability and cultivation of the confidence of financial sources.

SOURCES OF FINANCIAL RESOURCES FOR SCIENTIFIC RESEARCH

Although the main sources of financial resources and the use to which resarch funds are deployed are seemingly obvious, the importance which scientific research is increasingly assuming, calls for re-examination by research managers of non-traditional sources of funds, and more productive uses of financial resources. The traditional funding source for national research activities is the government. More often than not, allocations in national budgets for research in Africa are extremely inadequate. According to a study conducted by the International Service for National Agricultural Research (ISNAR), they are hardly beyond 1% of the GNP (2). For various reasons, particularly because of insufficient funding, regional research institutions have not performed well and the few international research institutions such as the Consultative Group for International Agricultural Research (CGIAR) centres are not only specialized in the kind of research they undertake, but are unable to satisfy completely the various needs of national programmes. For this reason, adequate funding for national research programmes is essential.

Research for the industrial sector is client-oriented, and expensive to undertake, and often produces results unlikely to be applied by a variety of other institutions. But there exists a pressing need for industrial research, particularly for small scale industries in Africa to enhance scientific creativity and technology innovations, overall productivity and economic development.

Without doubt, even more research effort is required in other important research areas of national concern such as medical and health-related and energy research. These indisputable scientific research needs can only be met by increased financial resources, and we must look beyond the traditional government sources for funding scientific research activities.

The obvious alternative sources of financial resources include the following;

The Private Sector

Considering that the major ultimate users of the results of scientific research and technological innovations are the industrial and commercial sectors, it is sensible that the private sector, including financial institutions, would be expected to contribute significantly to financing research. In Africa, there is still heavy reliance on borrowed technology and imported equipment and material. Very little locally generated technology is applied in the manufacture of essential commodities. This state of affairs seems to dampen the potential for financing scientific research by the private sector. Hence, minimal effort has been put into investigating of ways of tapping the private sector as a potential source of funding research. It is, however, without doubt that the private sector appreciates the role of S&T in economic development.

Foreign Sources: Bilateral and Multilateral Donors.

For the last two decades the African continent has experienced increasing financial support from donor organizations for a wide variety of development activities but relatively less has been obtained in support of scientific research. It is, however, important to be aware that donor agencies are another alternative source of financial resources for research. Financial resource managers ought to establish whether the funds available are grants, loans, etc. and how to acquire them. The conditions attached to this category of funding are sometimes considered disadvantageous and discouraging.

United Nations Finance

The United Nations Financing System for Science and Technology, UNDP, and the UNESCO Special Fund for Research and Development Projects in Africa and the UN Industrial Development Fund administered by UNIDO are some of the sources to which special effort might be made to seek resources for financing scientific research work.

Subventions

Some of the scientific work undertaken by regional institutions such as the Desert Locust Control Organization for Eastern Africa (DLCOEA) located in Addis Ababa, Ethiopia, and the Regional Centre for Services in Surveying Mapping and Remote Sensing in Nairobi,Kenya, are financed proportionally by subventions from member goverments and organizations. Managers of these institutions could maximize the utlization of subventions for research activities by preparing the necessary budgets and persuading the relevant policy organs to support their request for the financing of scientific research activities.

Trust Funds

Apart from direct contribution from donors, the private sector or national budgets, some countries have Trust Funds which contribute significantly to the financial provision for scientific research.

Consulting Contracts

Certain research institutes have established consultancy organs as a strategy for mobilization of research funds. This strategy has strengthened the role played by S&T and its position in the planning and execution of the development activities.

Professional Fund Raising Drives

This strategy has proved important in Kenya where the President of the country spearheaded a fundraising drive through the creation of a research fund.

The rationale behind the consideration of alternative funding sources is to ensure continuity and expansion of scientific research in the future. Allocation of secured financial resources is a management decision -making task. It is a process of deciding on what projects are to be supported and in what proportions the resources should be spent. To accomplish this task, the manager has to evaluate the merits of the proposed projects and act decisively on distribution of the resource. It goes without saying that financial managers in scientific research institutions must have clear ideas on the significance of each planned acitivity, and how best such activities may be phased out over the project period.

It is arguable what mode should be adopted in managing working capital. Industrialized countries have experimented with various approaches, including unrestricted core funding of research activities, project funding and contract research.The results have always been different from the financial management point of view. The important element is the accountability that the managers of financial resources have as a responsibilty to satisfy the financial sources. This requirement is most crucial where donor funding is involved, although the same is expected by other financial sources as well.

It seems too elementary to discuss the uses of financial resources in scientific research. Nevertheless, it is fitting to remind ourselves that it may not be true that the availability of more funds automatically leads to more output of better quality. Proper use and management of any amount of financial resources is the primary consideration. Moreover, the few main components of a research organization for which funds are expected namely, personnel, establishment and maintenance of physical facilities, scientific equipment and recurrent costs, are dynamic. The proportions of expenditure on each of them constantly change. Whereas heavy expenditure is experienced on capital development and capital equipment during the initial establishment of an institution, personnel costs take the greater portion of expenditure as the institution settles in; and certainly the running costs almost always increase with time.

It suffices to say that the managementof finances is an institution concerned with scientific research deserves elaborate definition of the activities to be undertaken for which the funds are to be used. This action facilitates fundraising and the auditing of expenditure on research activities as well as the monitoring and evaluation fo the processs of implementation of the various activities.

STRATEGIC PLANNING AND THE ROLE OF BUDGETING IN THE MANAGEMENT OF FINANCIAL RESOURCES

Basically, strategic planning is an attempt to specify the purpose and goals of research, the range of anticipated problems, the extent and limits of available resources which are to be expended and the approaches which should be used for the execution of the research activities. The results of this level of planning, are a set of institutional policies, including those concerned with resource utilization and the techniques for managing them. The logic inherent in the relationship between strategic planning and resource management is that the former process facilitates objective planning at the implementation level of activities to which the resources are to be expended, leading to more relevant research work. It also facilitates effective supervison of resources and their utilization.

Similarly, budgeting is a very helpful tool for managing financial resources. It expresses operating plans in financial terms. By doing so, it allows the manager to supervise and guide the utilization of financial resources by ensuring that the available funds are used for the purpose for which they were meant. This allows effective expenditure control; and ensures that approvals of expenditure are for planned activities based on approved levels of expenditure. The budget, further, serves to establish check points for measuring accomplishments with given financial resources.

The guidelines established by the extent and limits of financial resources available and specification of intended research activities, permit flexibility in financial management for adequate and timely disbursement of funds so as to facilitate efficient deployment of research resources on planned research programmes.

MANAGING DONOR CONFIDENCE

When donors finance a research institute or part of its activities, they need assurance that their resources will be properly managed. That is, that the funds will be put to proper use and there will be something to show for the investment. If this does not happen, they get dispirited and withdraw their support. This unfortunate situation is not uncommon in the developing world. However, some of these institutions, though faced with financial management hurdles from time to time, perform well, keeping the donors abreast of the progress of their work, the manner in which funds are being deployed, and the difficulties met. They establish constant external reviews which file independent reports on the impact of donor investment on research productivity. Thus, donor confidence is cultivated and sustained.

THE AFRICAN SITUATION

Given the position of financial resource management and functions of managers of those resources, it is appropriate to examine the African situation. First, the current level of investment in scientific research of African countries is extremely low. These countries must commit a reasonable investment in science and technology resources for improving their economic development and for raising standards of living in the rural areas. Second, the financial investment in science and technology should be well managed in order to get the full benefit out of it. This would require among other things, political will, courage on the part of policy and decision-makers, and well trained financial resource managers. Third, it is essential to ensure the development of an adequate base of research management information and to ensure the availability of that information to financial resource allocators to facilitate the decision-making process. A fourth important consideration would be to strengthen research management skills and governance processes in scientific research institutions, with special interest in efficient financial resource utilization and the relationship between financial investment in scientific research and the impact of scientific research results on integrated rural development. In this regard, many institutions have administrators responsible for supervision and control of expenditures and formulation of budgets. These are usually professional accountants and as such cannot strictly be referred to as managers of financial resources.

At this time in the history of Africa's development, there are obvious gaps in national scientific research systems pertaining to the various components of financial resource management, particularly mobilization of funds for research, administration of financial resources and accountability. The question that follows is clear: how can the situation be rectified? This seemingly difficult question was recognized a decade ago and is being addressed in several ways:

- At the national level, individual countries have established management institutes to enhance general management capabilities, including financial management. While the focus may not be specific to financial resource management in scientific research institutions, the effort has been on the improvement of such skills as budgeting and budget control, sound accounting systems, management of working capital, etc.

- At the international level, donors and development agencies have supported specially funded projects to enhance the capacity of national institutions for financial resource management. For instance, in the case of agricultural research systems, the International Service for National Agricultural Research (ISNAR) headquartered in the Netherlands, and a specific department in the United Nations Food and Agriculture Organization (FAO) were created to strengthen national research programmes, through improvement of component management including the management of financial resources.

- The new direction at the regional level, has been to explore an institution which would focus primarily on African scientific research systems. This thinking propelled the creation of FAMESA whose mandate it is to strengthen research management skills and enhance the productivity of scientific research institutions through efficient and effective human, financial and material management. FAMESA is a network currently comprising thirteen countries in Eastern and Southern Africa. It s operation is through collaborative activities and has so far been responsible for the production of research management training material and organization of both regional and national research management training workshops.

CONCLUSION

The concept of financial resource management in scientific research is shifting from mere policing of research funds. Is is perceived to cover the mobilization of financial resources, their efficient utilization and proper accountability for them. It includes such factors as resource level and expenditure predictions, risk-taking and far-reaching skills such as diplomacy. It is a field where African scientific research institutions need to fortify themselves, considering that well managed financial resources are critical to the success of any institution and the fact that skilled manpower in this area is generally lacking.

The provision of professional training available in specific institutions and the effort mounted to improve the capacity for financial resource management in scientific research institutions by national, regional and international organizations, in themselves may not be the whole answer. There ought to be available, opportunities for exposure to and for testing talents, abilities and acquired skills in challenging situations. This way there will emerge an effective capability in national systems for financial resource management.

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THE CLIENT AS FINANCIER OF R&D

Madatally Manji

I am honored to have been invited by such a learned conference to contribute my views on the theme of this Consultation, and would like to state that these views are based on my many years of experience in the food manufacturing industry. Most of these experiences relate to processing of agro-based commodities, although the principles, in terms of the relationship between scientist, entrepreneur and producer of raw materials, will often also apply to other industries.

I am not going to speak on research and development; I am going to speak on experience and development. I have been in the food manufacturing business since 1941 and would like to relate some of my experiences.

BREAD AND BISCUIT PRODUCTS

I started my business during World War II. I started in a very small way, when I bought a functioning bakery with a provision store on Ngara Road. We had two very primitive brick ovens for making bread and also had a dough mixer. The ovens were wood fired: you put a wood fire on one side and baked bread on the other side. The previous owner had made 500 loaves of bread every day.

I knew nothing about the bread baking business so I spent a lot of time in the bakery to learn about baking and to find out what the maximum capacity of the bakery was and how the capacity could be fully utilized. I carried out a market survey and learned there were several army canteens in Nairobi and all were buying large quantities of bread. Within a month I got organized. The total capacity of the plant was 5000 loaves a day. We had to increase staff from seven to seventy and train them. I personally spent a lot of time in this business, averaging 18 hours a day including weekends.

Due to war-time conditions, the importation of various products was not possible. Biscuits were one of these products. Having spent a lot of time in the bakery, I realized that after each batch of bread was put in the oven, there was at least one hour waiting for the next batch to go in. This waiting time was necessaary for the fermentation of the dough. During this period, the oven was kept warm but nothing was baked. So I started working on the idea of making some product that could be baked in about 30 minutes. I decided to try biscuits. I managed to get a good baker and with a lot of errors and experiments, we succeeded in producing a very good quality biscuit and had no difficulty in selling them to the public. This gave us new product to manufacture without additional cost. We cut the biscuits by hand and put them on trays and baked them when the oven was free. Now we are the largest manufacturer of biscuits in Kenya, producing several tons of biscuits a day.

Both the bread and biscuit business were running smoothly, but in about six months we were faced with another problem. Due to food shortages, the governement introduced a new type of flour known as "National Flour" which was 70% wheat flour and 30% maize flour. It was almost impossible to make bread with this flour. The dough was so heavy that the end result was indedible; the loaves looked like slippers! There were about ten bakeries in Nairobi; none of them could make bread of an acceptable standard with this flour. Our bread business almost came to a standstill as the public refused to buy.

I used to be on night duty three times a week from 9 p.m. to 3 a.m. During this time, in addition to the normal supervision of production I used to do my office work and also had plenty of time to think about problems to be solved. One day, before I went on duty I had dinner with chappatis and curry. The chappatis were made from National Flour. They were as good as chappatis made from normal flour. I asked myself why, if our ladies could make good chappatis from this flour, we could not make a good loaf of bread from it.

I started comparing the process of making chappatis with the process of making bread. I realized that our ladies kneaded some fat into the dough, which we did not do in our breadmaking. I then experimented with 25 pounds of ready mixed dough by kneading into it one pound of butter. When the bread came out of the oven, I could not believe my eyes. The bread was excellent with a nice golden brown top, large volume and delicious in taste.

Bread, amongst other commodities, was price-controlled and I realized that the cost of this bread exceeded the maximum permitted selling price. I experimented with a half pound of butter; again the result was excellent, but the cost was still prohibitive. I kept on experimenting every hour and by 6 a.m., I procured a loaf of bread of excellent quality which could be sold at the controlled price.

This bread created a real sensation in Nairobi. Within a week, we had our bread in every grocery shop, hotel, restaurant and institution.This created another problem. There were two large bakeries owned by Europeans, and between them, they had had the entire monopoly of the top end of the market. Their business was naturally affected as I had captured most of their customers.

Instead of trying to improve their quality, they reported me to the Chairman of the commodity distribution board, claiming that I was making better bread because I had a source of better flour. The Chairman came running to our bakery on Ngara Road and accused us of sabotaging government efforts in the distribution of essential commodities. He informed me that he wanted to inspect our godown, and if we did not allow him to do this he would bring in the police. I told him he was welcome to inspect our godown, and also told him that his suggestion of our being able to get better flour from other sources was ridiculous. Wheat was grown by European farmers. All the wheat was supplied to a European organization known as the Kenya Farmers Association and this wheat was sold to the millers who were again an association of European farmers. As that was the only mill in those days, no one could get any flour from other sources. Furthermore, flour distribution was also controlled by a European organization.

I told the Chairman that he had made a serious allegation and I insisted that he should witness the baking of my bread to satisfy himself that it was made from National Flour. After much discussion, he agreed to stay and witnessed the bread-making process; this took nearly three hours. He was amazed to see the quality of bread produced under his supervision from National Flour. He apologised for the allegation he had made and congratulated us for producing such a high quality bread. He wanted to know the secret of producing such quality. How could I tell him the idea came from Indian ladies making chappatis? Actually, the secret was not even known to the workers, as we used to melt the fat, and add colouring and flavouring ourselves, before giving it to the workers as "bread improver".

VERMICELLI AND OTHER PASTA PRODUCTS

Traditionally, Muslims eat vermicelli every day during their holy month of Ramadhan, and particularly during the celebration of Idd.

My mother told me a week before the Idd that she could not get any vermicelli and asked me if I could find some. After contacting various dealers in Kenya, Uganda, and Tanzania, I managed to get three packets from Tanga and we were able to celebrate the Idd with vermicelli. In the evening when I was on duty again, I started thinking about why the vermicelli could not be made locally. After all, it was made with only flour. Next morning I went to see a friend of mine who was a very good and experienced blacksmith and engineer, but who had no formal qualifications, and discussed a proposition with him. He told me that he could produce a machine for making vermicelli but that he needed my assistance with an electic motor controlled by the electrical controller. I managed to get this for him. Within a month, he came with a plant and we successfully produced vermicelli. Within a few hours, however, the machine got so hot that we could not even touch it. He took the machine back and constructed a chamber around it with an inlet pipe and outlet pipe for circulating tap water. This cooling system solved the problem and we started making vermicelli.

When the British Army conquered Abyssinia, we had 60,000 prisoners of war in the country and the army wanted to buy spaghetti and macaroni for them. I was the only producer of this commodity and as such they approached me. I told them I could supply two hundred pounds a day. The officer in charge laughed and said they had to feed 60,000 people.

The Army then managed to bring a very large macaroni plant from Abyssinia by road and it was installed at Nyeri station which is now known as Kiganjo. The plant was installed with the assistance of the Italian prisoners of war, but when they were ready to start production, the Italians refused to work for the British Army.

One day I had a call from the Army and I was aked if I would like to buy the macaroni palnt. I said "yes". The officer told me that the plant wa installed at Nyeri Station which was a prohibited area so I would have to go with him to see the plant. Next morning, we left for Nyeri Station and I was taken around the factory. The officer told me they wanted Shs 25,000/- for the plant and that I would have to pay extra for the drying cabinets which were made locally. I accepted the offer and paid him for the plant on the spot. The officer then told me I would be given only 72 hurs to remove the plant; I agreed to do so.

I went to Nyeri Station with twenty-five lorries on a Sunday morning. Each lorry had five to six fitters and mechanics whom I had hired temporarily. We arrived at 8 a.m. and we started dismantling the plant. The Italian prisoners of war were very helpful and knowledgeable and they helped us to dismantle and load the plant onto the lorries. By 8 p.m. we were ready to leave - i.e. within 12 hours. While we were loading, a couple of Italian prisoners came to me and told me that they would be very happy to come and work for me if I could make arrangements with the authorities. They told me that the Production Manager of the factory when it was in Abyssinia, was available and there was also a technician and an engineer working in the factory who would be willing to come. I approached the authorities with a view to employing these three Italian technicians. I was told a week later that under "The Convention" Italians were not allowed to work for non-Europeans. As the army was interested in getting my product, the authorities found a way to solve this problem. They told me that while the Italians were not allowed to work for a non-European, they could work under a European, if I hired one. I managed to get a Greek to work part-time and we were then allowed to bring the Italians to Nairobi. They installed the plant and within a month, we were supplying the Army with one ton of macaroni a day. This continued for six months after the war was over by which time the Italians were expatriated. Furthermore, as soon as the war was over, vermicelli and macaroni started arriving from South Africa and Holland and the market was flooded with products made from semolina rather than from National Flour. As a result, we had difficulty selling our products to civilians and our factory came to a complete standstill.

We decided to educate local people to eat this product and with this in view, exhibited our products at the Nairobi Show. We cooked and gave free pasta samples to the public to try. We used a cardboard plate with a small spoon to serve the samples, but to my greatest surprise, the Africans would come to the stand, watch the cooking demonstration, but refuse to eat. This went on until mid-day. I had four girls and one male assistant. I called them and told them that we were not charging anything and still we could not make them eat; selling is a highly specialized work, but as we were giving our product away, we shouldn't need expert salesmanship!

So I asked my assistant to take three girls with him and mix with the people, especially with those who had been to our stand and had refused to try this product. At about 5 p.m. they came back and told me that most of these people suffer from tapeworms and the cooked spaghetti looked like tapeworms to them, and this was the reason for their unwillingness to try our product. We immediately removed all spaghetti and next morning came back with elbow macaroni and started the demonstration again. All those who tried this product liked it and the queue became too long to meet demand. so we started charging 10 cents a plate. Even then, people patronized us. We carried out this kind of demonstration at various shows throughout the country, and gradually people started eating pasta.

When you visit our factory tomorrow you will see a fully-automatic modern plant producing eight to ten tons of pasta a day; most of this is consumed by locals.

CHARCOAL IRONS

We were living in the Ngara Raod area and one night our house was broken into by thieves; they took away all our cutlery, crockery and the charcoal iron. Due to war-time conditions, these things were not readily available. We managed to replace the utensils, crockery and cutlery, but we could not buy a charcoal iron for love nor money.

I went to my friend, the blacksmith and engineer whom you would today call "Mr. Jua Kali", and asked him if he could produce a charcoal iron for me. He was confident that he could produce one if I could get him an electric motor, grinder shafts, etc. I managed to get him the items he requested and within a week, he produced the first charcoal iron which was of excellent quality. We decided to start manufacturing charcoal irons. We started making five irons a day and then reached peak production of 25 irons per day. We could sell these without any difficulty as they were in great demand.

CONCLUSION.

I could go on giving various stories of my personal experience. As we are running short of time, I would only like to add that while

R&D is essential, it is equally important to encourage existing small industries to grow, as this will provide more employment opportunities. The Kenya Industrial Estate is doing a very good job of starting new industries, but they could do even more if they could make use of the experience of industrialists already available in the country.

PART SIX

VISION AND SPECIAL OPPORTUNITIES FOR AFRICA AND PLENARY DISCUSSIONS

PLENARY DISCUSSIONS

After the formalities of the Opening Ceremony, Prof. Olu Adegoke presented the Background Paper which forms the contents of Part Two of these Proceedings. After his presentation, the Background Paper was exhaustively discussed by the plenary session of the Consultation. The highlights of this discussion are presented below.

GENERAL OBSERVATIONS ON THE BACKGROUND PAPER

First Speaker: The first speaker raised the issue of language barriers in the development of S&T in Africa. In addition to the multiplicity of ethnic languages, Africa is constrained by the imposition of the colonial languages of English, French, Portugese and Arabic. How do we break down these barriers in order to hasten the pace of the development of S&T in Africa?

Second Speaker: This speaker raised the question of the viability of African countries, as presently constituted politically, to create the appropriate environment for the development of S&T. The smaller African countries do not appear to have a chance to withstand the heavy burden of financial investment required to sustain meaningful R&D.

Third Speaker: The issue of the automobile assembly plants, as viable technology-based industries, in which several African countries are now involved, was raised. This speaker believes it may take more than twenty years for any African country to benefit from investment in an automobile assembly plant, and even then, provided only that such countries plan deliberately to make spare parts as well as manufacture the completely knocked down parts, to increase the local content of locally assembled vehicles.

Fourth Speaker: This speaker called the attention of the Consultation to the absence of adequate correlation between basic research, R&D activities, and the imperatives of local international market forces. He believes that whether or not African countries are forced to restructure their economies by the International Monetary Fund (IMF) they owe it to their societies to established economies that are viable and wealth-generating. There are very few African institutions that are operating effectively. Those African countries that are shivering under the burden of poverty cannot afford venture capital to develop technological innovations into products and services.

Fifth Speaker: This speaker cautioned scientists to restrain the tendency to pass resolutions asking governments and other agencies to implement their needs. He wanted this Consultation to focus on practical issues which the scientists themselves and the other participants can implement. He also pointed out the reality of certain external forces, determined to ensure that the two major colonial language groups - Anglophone and Francophone are isolated and prevented from cooperating in the development of S&T in Africa. He also posed the question: How independent are African scientists?

Sixth Speaker: This speaker emphasized the international nature of science; he believes that there are no separate categories of Asian or African sciences. He gave ICIPE as a shining example of the international nature of science. The suggestion was made that we need to study those S&T institutions that have succeeded and failed in Africa; and learn the correct lessons from them. He recommended that the Consultation should place emphasis on agriculture and water development in Africa; he pointed out the need to focus on one or two achievable recommendations. Africa needs to be optimistic in the development of S&T as optimism is not costly!

Seventh Speaker: This speaker called the attention of the Consultation to the role of the trans-national corporations, and the emergence of new technologies. He wanted this Consultation to be aware that some of the raw materials produced by African countries for export purposes stand in jeopardy as a result of the emergence of new technologies. He also raised the issue of technology transfer; that it can in fact, interfere with the development of S&T in Africa. The crucial role of availability of funds was highlighted. The speaker emphasized the need to explore sources of funds to implement recommendations arising from this Consultation.

Eighth Speaker: This speaker stated that science knows no national boundaries, but then asked the pertinent questions: Are African scientists relevant to industry, in terms of training, experience and competence? Is it to the interest of the development of national industry that thousands of African students are trained abroad?

DISCUSSION UNDER THEME ONE: CREATING AN ENABLING ENVIRONMENT FOR R&D FOCUSED ON AFRICAN DEVELOPMENT ON A SUSTAINABLE BASIS.

Two papers were presented on the issue of creating an integrated approach to higher education and research in national systems with a veiw to maximizing productivity, one by Paul N. Nkwi and the other by Donald E.U. Ekong. These papers were discussed in detail during the plenary sessions; highlights of the discussion are summarized below.

First Speaker: This speaker emphasized the need to create science awareness from primary and secondary schools through the universities and other institutions of higher learning. In order to be effective in this regard, he emphasied the need for African scientists, engineers, technologists and scholars to write interesting science textbooks for schools at different levels.

Second Speaker: This speaker raised the issue of creating science awareness at the pre-school stages of a child's development in Africa. The special role of parents (the mothers in particular) was stressed. This speaker believes that there is sufficient science in traditional African society and homes to get the African child started on the acquisition of a science culture.

Third Speaker: This speaker spoke of the need for natural scientists and social scientists to work together for the creation of a science culture in Africa.

Fourth Speaker: This speaker pointed out that it will take a generation to develop a science culture in Africa. The child in Africa should have, as part of his environment, electricity, and other toys and gadgets driven by electricity. He did admit, however, that inexpensive equipment, simple implements, plants and animals in the African child's environment are sufficient for the African child to get started on the acquisition of a science culture.

Fifth Speaker: A stable political system, according to this speaker, is a prerequisite for creating a favourable environment for the development of science and technology in Africa. African governments should have the political will to initiate and execute programmes to create a favourable atmosphere for S&T. In this speakers' view, the funding of research - basic or developmental - should not be tied to the vagaries of annual appropriation budgets; rather, research funding should be through independent foundations administered preferably by scientists. This speaker suggested that the AAS should take on the added responsibility of serving as an independent body to advise African governments on S&T.

Sixth Speaker: This speaker pointed out the complementary relationship between African traditions and modern science. For example, traditional agricultural product storage systems and modern scientific storage of agricultural produce are not in conflict. Creating a favourable atmosphere in this speaker's view, does not mean everything must be African. Africans should not be afraid to borrow from the outside world. Japan and the United States, borrowed technology from others. Every country has a history of borrowing technology. Borrowing technology saves time.

Seventh Speaker: This speaker, while acknowledging the need to start early in the African child's life to inculcate a science culture, stressed the need for African countries to produce well qualified science teachers to impart scientific culture to the young.

Eighth Speaker: An effective infrastructure to produce spare parts, machine tools, the presence of iron and steel industries, and capability in engineering industries, are absolute requirements in the view of this speaker, to create a favourable atmosphere for the nourishing of S&T in Africa.

Ninth Speaker: This speaker was emphatic that it is not the role of governments in Africa to develop patents, and transform them to products and services. It is a myth to expect governments to develop break-throughs in S&T. The scientist should accept that it is his role to help bridge the gap of communication between the policy-maker in government and the industrialist. The scientist and scientific associations must lobby government functionaries to ensure that the scientist is incorporated into the policy-making system of government in Africa. Again, the scientist must be willing to serve as the link between the laboratory results and the extension worker who delivers a package of technology to the field.

Tenth speaker: This speaker directed his question to Dr. Paul Nkwi who gave the paper on the relationship between universities and research institutes in Cameroons; he wanted to know whether the model of administering universities and research institutes within one bureaucracy is working. The speakar highlighted the dangerous phenomenon in Africa in which, in the face of any economic recession, scientific activity and funding are the first to undergo collapse.

Eleventh Speaker: This speaker wanted to know the special situation of the management of research institutes in those small African countries that have no universities of their own.

Twelfth Speaker: The question of dissemination of S&T information in Africa was raised by this speaker. Why is it that a technological breakthrough in one African country is not reported and made use of in another African country? He gave the example of a composite flour made up of traditional grains in Nigeria which is being used to make bread - why is this breakthrough not made available to other African countries?

Thirteenth Speaker: This speaker thought that there was need for university specialists and scientists to educate the African politician in economics, science and technology. He also empahasized the need for African scientists and technologists to be aware of ethical considerations in their work.

Fourteenth Speaker: This speaker raised the question of how industry and other end-users of science can have an impact on the training of scientists, engineers and technologists. He also stressed the need for African countries and their universities to train the critical mass of manpower for S&T.

Fifteenth Speaker: This speaker wanted scientists in Africa, whether located in big or small countries, to consider as their constituency, their own projects, and then lobby the politician, policy-maker and industrialist to join the effort. He agreed with others that it is the scientists role in Africa to sensitize the politician on the issue of S&T.

Sixteenth Speaker: On the issue of the quality and relevance of university graduates for industry, this speaker said that in many parts of the world, a fresh university graduate is no more to industry than a trainable product. He also advised that the employment of highly qualified foreign scientists and engineers is one effective way of ensuring transfer of knowledge and technology.

DISCUSSION UNDER THEME TWO: EVOLVING MECHANISMS FOR CREATING AN INTERFACE BETWEEN SCIENCE AND INDUSTRY.

Three papers were presented under this theme. The first by Prof. Mjojo, looked at the topic from the view of the scientist; the second from the view of the industrialist was presented by S. Ita. and the last paper by J.M. Kordylas urged recognition of African traditional/cultural capabilities. As the plenary discussion of this theme was not extensive, it is only highlighted .

Prof. Mjojo's proposal for the establishment of the African technological Group elicited spirited discussion; the main issue was how to translate the grandiose but commendable proposal into reality. Some of the speakers were of the view that the African Technological Group would have to draw members from the universities, research institutes and indeed, financiers and politicians. There is need to educate and sensitize the various groups for the need to form the African Technological Group. The question of time-scale was raised; any initiative of this type must plan to sustain its effect over a long time frame.

A pertinent issue was raised as to why a practising scientist need transform himself into an industrialist or entrepreneur; what should be his motivation? Will such transformation not affect the credibilty of the African scientist? The response to this was that not every scientist need become an entrepreneur. Only a small fraction with the appropriate training, and motivation need to venture into technological entrepreneurship.

The issue of the appropriate laws, and regulations needed in the various African countries, to enhance the effective interface between science and industry was emphasized.

DISCUSSION OF THEME THREE: FINANCING R&D IN BOTH PRIVATE AND PUBLIC SECTORS.

Three papers were presented on this theme: one on the view of a banker, by Hon Mr. Dalmas Otieno; another on the client as financier by Mr. Madatally Manji, and the third on management of financial resources for scientific research by Dr. Nyiira. The highlights of the plenary discussion under this theme are summarized below.

The plenary discussions were unanimous in the recognition of the general lack of financial support for R&D by African governments, their agencies and financial institutions. Participants also agreed that Africa should not depend solely on aid agencies for support of R&D. The positive suggestion arising from the discusision was the need for African governments to legislate and enforce the contribution of private sources toward the formation of an independent fund. Such contributions should be tax-deductible. The various governments in Africa would also bear the burden of allocating 2% of GDP or 5% of annual budgets to basic research and R&D. Participants agreed that, in general, the scientist has to play the role of the broker; to get the governments in Africa, financial houses, private companies, and individuals, to support R&D.

THEME FOUR: VISION ON SPECIAL OPPORTUNITIES FOR ARICA.

Under Theme Four, the Chairman for this session. General Olusegun Obasanjo, presented the following overall recommendations and objectives.

Theme Four: Vision of Special Opportunities for Africa

General Olusegun Obasanjo

Management and utilization of science for development in Africa, as elsewhere, is the joint responsibility of scientists, political leaders and entrepreneurs. In Africa, these sectors must understand one another and work together to achieve the following objectives by the year 2000:

- **self-sufficiency in basic food production**
- **self-reliance in transportation and basic equipment for land and inland water-ways and agriculture.**
- **production of 50% of drugs and medicaments required**

In order to achieve these objectives, we urge:

- **political leaders to make S&T high priority in their planning and to utilize scientists as advisers to, if not members of, their cabinet for this purpose;**

- **scientists, knowing the constraints and preoccupation of political leaders, to promote and present cost-effective structures and organizations to politicans, and relevant and credible programmes and projects to both politicians and entrepreneurs, nationally and regionally;**

- **entrepreneurs to re-invest or give grants and donations of not less than 10% of their profits to R&D and make scientists their close allies in indigenising their production and products (such investment or grants to R&D to be made tax deductible);**

- **the African Academy of Sciences (AAS) to assume responsibility for collation and dissemination of applied research work and products by national and regional reseach centres to prevent duplication of efforts and to assist commercialization;**

- **the AAS to convene another conference that will involve more political leaders and entrepreneurs, on the theme of management and utilization of science for development in Africa and to review the implementation of the recommendations of this Consultation. This conference should consider the proposal for and African Technology Group (ATG) after investigation of details by the AAS.**

- **the AAS to carry out a study of brain-drain of scientists in Africa and propose measures to stop and reverse the trend, and to work out a code of ethics for African scientists.**

- **the international community and donors to support the AAS with donations and grants to carry out the three responsibilities assigned to it by this Consultation**

- **wide distribution and dissemination of this Proceedings to African scientists, political leaders, entrepreneurs, research stations, international communities and donors.**

Closing Remarks

Thomas R. Odhiambo

This conference has generated issues and questions which pose major challenges to the scientific community, industrialists and entrepreneurs. These three groups, if they work together, can, undoubtedly, improve the human condition, particularly in Africa.

This Consultation has come up with several fresh recommendations with respect to the management of science for development. What is urgently needed, is the identification of the means of achieving the goals and objectives contained in these recommendations.

I wish to thank the delegates for their commitment, devotion and contributions to the success of this Consultation; it has been a stimulating exercise. The outcome of this conference will enable us to do more effective strategic thinking in the years ahead.

May I, on your behalf, thank Prof. O. S. Adegoke for an excellent background paper. This paper made the work of the conference easier; without this paper, it would have perhaps taken this conference double the time to achieve what it has today.

I wish to thank Prof. Lydia Makhubu, Chairman of this Consultation; she performed her difficult task with grace, without rancour, and without evidence of tiredness; she provided a peaceful and calm atmosphere throughout the Consultation which made it possible to be so creatively productive.

Finally, I wish to thank the Canadian International Development Agency (CIDA) for providing generous financial support for this Consultation, without attaching any strings; this support will go down on historical record as making a major contribution to the renaissance of science in Africa.

List of Abbreviations

AAS	African Academy of Sciences
AAU	Associations of African Universities
ADB	African Development Bank
APPER	African Priority Programme for Economic Recovery
ATG	African Technology Group
CASTAFRICA	Conference of Ministers Responsible for the Application of Science and Technology
CEAO	Communite economique de l'Afrique de l'Ouest
CEEAC l'Afrique	Communaute economique des Etats de Centrale
CEPGL	Communaute economique des Pays de Grands Lacs
CESRST	Council for Higher Education and Scientifc and Technical Research
CGIAR	Consultative Group for International Agricultural Research
CIDA	Canadian International Development Agency
CIRAD Agricultural	Centre for International Cooperation in Research for Development
DGRST	General Delegation for Scientific and Technical Research
DLCOEA	Desert Locust Control Organization for Eastern Africa
DRST	Department of Scientific and Technical Research
ECA	Economic Commission for Africa
ECOWAS	Economic Community of West Africa
FAMESA	Financial and Administrative Management of Research Projects in Eastern and Southern Africa
FIIRO	Federal Institute for Industrial Research, Oshodi
GERDAT	(now CIRAD)
ICIPE	International Centre for Insect Physiology and Ecology
IDRC	
IITA	International Institute for Tropical Agriculture
IMF	International Monetary Fund
ISNAR	International Service for National Agricultural Research

MESRES	Ministry of Higher Education and Scientific Research
MRU	Mano River Union
NASO	Network of African Scientific Organizations
ODA	Overseas Development Agency
ONAREST	National Office for Scientific and Technical Research
R&D	Research and Development
S&T	Science and Technology
TCA	Technology Commission for Africa
TWAS	Third World Academy of Sciences
UDEAC	Union douaniere des Etats d'Afrique Centrale
UNCSTD	United Nations Conference on Science and Technology Development
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
USAID	United States Aid for International Development

APPENDICES

Appendix 1.

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Nairobi, Kenya 21-24 November, 1988

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Appendix 2.
Population growth, 1965-85 and projected to 2000.

Country group	Population (millions)	Average Annual growth (percent) 1965-73	1973-80	1980-85	1985-90	1990-2000
Developing countries	3.451	2.5	2.1	2.0	2.0	1.8
Low-income countries	2.305	2.6	2.0	1.9	1.8	1.7
Asia	2.071	2.5	1.9	1.7	1.7	1.5
India	765	2.3	2.3	2.2	2.0	1.7
China	1.041	2.7	1.5	1.2	1.3	1.2
Africa	234	2.8	2.9	3.0	3.2	3.1
Middle-income countries	1.146	2.5	2.4	2.3	2.3	2.0
Oil exporters	502	2.5	2.6	2.6	2.6	2.3
Oil importers	643	2.4	2.2	2.1	2.0	1.8
Major exporters of manufactures	420	2.4	2.1	1.9	1.8	1.6
High-income oil exporters	20	4.6	5.4	4.3	3.9	3.3
Industrial market economies	737	0.9	0.7	0.6	0.5	0.4
World, excluding non-market industrial economies	4,209	2.2	1.9	1.8	1.7	1.6
Non-market industrial economies	393	0.8	0.8	0.8	0.7	0.6

Appendix 3.
Desertification in Africa (in thousands of hectares).

Type of Land	Northern Africa	Sudano Sahelian Africa*	Southern Africa**
Irrigated Land			
Total	4,050	2,126	720
Affected by desertification	987	284	49
Percentage of total	24	13	7
Rangeland			
Total	166,300	814,412	156,500
Affected by desertification	156,000	783,458	49,300
Percent of total	94	96	32
Rainfed Cropland			
Total	17,005	27,103	2,940
Affected by desertification	13,701	23057	2,225
Percent of total	81	85	76

Source: Y.F. Ahmad and M. Kassas. *Desertification: Financial Support for the Biosphere*, Hodder and Stoughton, London. Table 1, pp 63-66.

*includes: Cape Verde, Chad, Djibouti, Ethiopia, Gambia, Kenya, Mali, Mauritania, Niger, Nigeria, Senegal, Somalia, Sudan, Uganda, Cameroon, Burkina Faso
**excludes South Africa

Appendix 4.
Defense, Education and Health Expenditure as % GNP

	Population % (1000) US$	GNP Capital	Defense %	Education %	Health %
Industrialized Countries	1,116,969	9,415	516	5.2	4.8
Developing Countries	3,574,133	720	5.6	3.8	1.5
Africa*	455,608	616	4.1	3.9	1.2
Middle East**	141,875	1,556	17.1	5.9	2.5
South Asia	971,915	255	3.4	3.0	0.8
Far East***	1,490,582	462	1.4	3.6	1.3
Latin America	385,168	1867	1.4	3.6	1.3

* Excluding South Africa
** Excluding Israel
***Excluding Japan

Appendix 5.
Global distribution of R&D scientists and engineers estimated perecentages for 1970, 1975 and 1980.

	1970	1975	1980
Africa*	0.3	0.4	0.4
Latin America	1.5	1.8	2.4
Arab States	0.6	0.7	0.9
Asia	17.4	18.6	18.5
Europe	22.0	22.6	22.3
USSR	36.8	37.8	36.6
North America	21.8	17.3	18.0
Oceania	0.9	0.8	0.9

*Not including Arab States

Source: UNESCO, Statistics on Science and Technology, October 1986.

Appendix 6.
Food production in thousands of metric tons.

Average Annual Growth Rate:	1978	1979	1980	1981	1982	1983	1984	1985	1986	1978-1982.	1982-1986.
Algeria	5014	5317	6528	6168	5108	5088	5643	7746	7205	0.5	9.0
Angola	3531	3538	3613	3595	3623	3650	3595	3590	3580	0.6	-0.3
Benin	2290	2360	2145	2115	2133	2067	2467	2766	2581	-1.8	4.9
Botswana	209	206	224	248	222	215	200	218	210	1.5	-1.4
BurkinaFaso	1765	1811	1673	1913	1882	1837	1787	2328	2503	1.6	7.4
Burundi	3296	3018	3102	3435	3406	3397	3419	3553	3776	0.8	2.6
Cameroon	5168	5015	5063	5125	6963	5085	5246	5438	5169	-1.0	1.0
Cape.Verde	54	46	63	53	45	44	46	61	63	-4.5	9.0
Central African Republic	1568	1583	1579	1578	1630	1552	1607	1643	1425	1.0	-3.3
Chad	1611	1626	1609	1477	1516	1595	1455	1878	1887	-1.5	5.6
Comoros	171	173	175	177	180	184	187	192	191	1.3	1.5
Congo	935	981	1022	1055	1079	1031	1040	1073	1030	3.6	-1.1
Cote D'Ivoire	6607	6837	7425	7256	7785	7424	8043	8836	8407	4.2	1.9
Djiboute	8	10	23	15	14	15	18	19	16	15.0	3.7
Egypt	20271	21180	21472	21744	23239	23904	23318	24833	22300	3.5	-1.0
Equatorial Guinea	106	107	109	110	110	112	114	115	112	0.9	0.5
Ethiopia	9466	10977	10174	10018	11559	10236	8501	9878	10721	5.1	-1.9

continued.

Appendix 6, continued.

Gabon	574	607	656	650	688	709	702	685	686	4.6	-0.1
Gambia	226	221	173	190	240	227	212	270	193	1.5	-5.4
Ghana	5489	5573	5508	5386	5517	5060	8406	6508	6954	0.1	6.0
Guinea	2555	2441	2371	2542	2370	2519	2551	2626	2571	0.1	0.0
Guinea Bissau	226	235	239	278	309	283	313	342	346	8.1	2.9
Kenya	6965	6790	6652	6761	8011	7382	6563	5874	8279	3.6	0.8
Lesotho	381	317	283	265	219	222	227	265	232	-12.9	1.5
Liberia	828	843	838	873	883	934	949	946	950	1.6	1.9
Libya	1416	1351	1517	1584	1617	1769	1604	1637	1327	3.4	-4.8
Madascar	5709	5793	6067	5973	6148	6665	6661	6859	6961	1.9	3.2
Malawi	3273	3224	3063	3178	3371	3205	3346	3263	2921	0.7	-3.5
Mali	2160	1795	1841	2090	2254	1993	1853	2275	2556	1.1	3.2
Mauritania	364	362	374	451	414	380	397	423	501	3.3	4.9
Mauritius	794	816	590	704	828	743	722	802	760	1.1	-2.1
Morocco	10420	10098	10364	7672	11090	9700	9997	11854	13436	1.6	4.9
Mozambique	4817	4906	5032	5125	5100	5893	4866	4987	4858	1.4	-1.2
Niger	2584	2779	2823	2781	2811	2841	2099	2767	2934	2.1	1.1
Nigeria	46173	47433	49236	50122	52061	46754	52896	58762	58876	3.0	3.1
Rwanda	4077	4553	4521	932	5192	5555	4230	4529	4606	6.2	-2.9
Sao Tome Princi.	26	27	26	28	30	33	32	32	29	3.6	-0.5
Senegal	2041	2069	1646	1708	2024	1943	1613	2329	1532	-0.2	-6.7
Seychelles	13	14	14	15	13	14	13	14	11	0.0	-4.3
Sierra Leone	1221	1109	1143	1148	1264	1297	1140	1220	1203	0.9	-1.2
Somalia	1259	1242	1265	1367	1451	1417	1521	1692	1759	3.6	4.9

continued.

Appendix 6, continued.

Sudan	8287	7398	8449	10109	8510	8582	8587	10409	9264	0.7	2.1
Swaziland	563	541	635	675	665	663	761	690	705	4.3	1.5
Tanzania	12631	13462	14520	14627	13647	14023	14728	15024	14989	2.0	2.4
Togo	1347	1387	1450	1459	1395	1335	1483	1451	1415	0.9	0.4
Tunisia	3565	3647	4222	4084	3661	4232	4193	5341	3001	0.7	-4.8
Uganda	16146	11824	11889	13228	14832	15755	14053	14456	19045	-2.1	6.4
Zaire	16772	17118	17918	18496	19547	20052	20597	21146	20941	3.9	1.7
Zambia	2240	1778	1839	1875	1667	1909	1861	2152	2196	-7.1	7.2
Zimbabwe	3137	2532	2984	4394	3407	2427	2855	4747	3864	2.1	3.2
Total	230349	229070	236127	240752	249928	242954	247717	272523	271077	2.1	2.1

Appendix 7.
Population and GNP per capita, 1980, and growth rates, 1965-85

(%)	A	B	C	Average annual growth of GNP per capita 1965-73	1973-80	1981	1982	1983	1984*	1985**
Country Group										
Developing countries	2,064	3,124	660	4.1	3.2	1.0	-0.7	0.0	3.3	2.4
Low income countries	550	2,102	260	3.0	2.7	3.0	3.2	6.1	7.4	6.1
Asia	497	1,900	260	3.3	3.0	3.5	3.7	6.9	8.3	6.6
China	287	978	290	5.0	3.8	3.5	6.1	8.8	12.8	9.6
India	162	687	240	1.6	1.8	3.5	0.5	5.1	2.2	1.9
Africa	53	202	260	1.2	0.1	-1.3	-2.4	-2.7	-2.8	-0.4
Middle-income importers	963	580	1,660	4.6	3.1	-0.8	-2.0	-1.6	1.8	1.0
East Asia &Pacific	212	162	1,310	5.7	5.7	3.9	1.8	4.7	4.7	1.0
Middle East and N.Africa	25	31	820	3.5	4.2	-1.9	4.4	0.3	-0.9	1.6
Sub-Saharan Africa***	26	33	780	2.0	0.5	3.8	-5.0	-5.5	-4.5	-0.6
Southern Europe	213	91	2,340	5.4	2.9	0.2	0.0	-0.9	0.9	1.1
Latin America and Caribbean	411	234	1,760	4.5	2.9	-4.2	-4.9	-4.5	1.2	2.1

continued

Appendix 7, continued.

Middle-income oil exporters	551	441	1,250	4.6	3.4	1.5	-2.8	-4.4	0.7	0.0
High-income oil exporters	226	17	13,290	4.1	5.9	-.7	-7.6	-15.7	-3.0	-8.5
Industrial market economies	7,540	716	10,530	3.7	2.1	1.1	-1.3	1.6	3.9	2.4

A = 1980 GNP (billions US$)
B = 1980 population (millions)
C = 1980 GNP per capita (US$)

*estimated.
**Projected on the basis of GDP
***Excludes South Africa

Appendix 8.
Consumption, savings and investment indicators, selected years, 1965-84

Country group and indicator 1984*		1965	1973	1980	1981	1982	1983
Developing countries							
Consumption	79.8	76.7	75.6	77.2	78.1	78.0	76.9
Investment	21.1	24.1	26.7	26.0	24.6	22.9	22.3
Savings	20.2	23.3	24.4	22.8	21.9	22.0	23.1
Low-income Asia							
Consumption	79.8	75.4	75.8	76.8	75.8	75.5	75.7
Investment	21.3	24.8	27.2	25.4	25.7	26.1	26.5
Savings	20.2	24.6	24.2	23.2	24.2	24.5	24.3
Low-income Africa							
Consumption	88.6	85.7	91.0	91.6	93.1	92.8	95.7
Investment	14.2	17.0	19.2	18.5	16.9	15.3	11.8
Savings	11.4	14.3	9.0	8.4	6.9	7.2	4.3
Middle income oil importers							
Consumption	79.1	77.0	77.2	78.5	79.4	79.7	78.3
Investment	22.0	24.9	26.9	25.9	23.8	21.7	20.5
Savings	20.9	23.0	22.8	21.5	20.6	20.3	21.7
Middle-income oil exporters							
Consumption	79.9	76.8	71.0	74.0	76.4	76	75.3
Investment	19.8	22.3	26.7	27.6	25.4	22.8	21.6
Savings	20.1	23.2	29.0	26.0	23.6	24.0	24.7
Industrial market economics							
Consumption	76.7	75.0	78.4	78.4	80.1	80.3	81.1
Investment	22.9	24.7	22.5	21.9	20.1	19.6	19.6
Savings	23.3	25.0	21.6	21.6	19.9	19.7	18.9

*Estimated

Appendix 9.
Africa's share of the world reserves of some important minerals and agricultural products.

Diamonds	96
Chromium	85
Platinum	85
Cobalt	55
Manganese	40
Bauxite	40
Copper	13
Phosphate	50
Gold	50+
Gold	50
Thorium and Uranium	30
Traded oil	20
Cocoa	70
World hydroelectric potential	20-27
Oil palm produce	50
Coffee	33

Appendix 10.
World total manufacture value added (%).

Developing nations	11
Developed capitalist countries	65
Soviet Union and Eastern Europe	24
Latin America	6
Asia	4
Africa	1

Appendix 11.

Free market prices of selected primary commodities (dollars per metric ton).The price indicated for each year is an average of 12 months of the the monthly observations on one or several free markets where the commodity has been quoted.

Commodities	1978	1979	1980	1981	1982	1983	1984	1985	1986	1978-82	1982-86
Wheat	131	163	176	178	162	158	153	138	115	5.5	-8.2
Maize	132	155	210	181	138	162	167	135	113	1.1	-4.9
Rice	368	334	434	483	294	277	252	217	210	-5.5	-8.1
Sugar	172	213	632	372	185	187	115	90	133	1.8	-7.9
Coffee	3421	3737	3322	2544	2767	2820	31112	2943	3754	-5.2	7.9
Cocoa	3402	3292	2603	2077	1741	2119	2395	2254	2068	-15.4	4.4
Tea	2181	2157	2228	2018	1931	2324	2458	1983	1930	-3.0	0.0
Bananas	287	326	374	401	375	429	369	380	401	6.9	1.7
Groundnuts	621	565	499	636	385	392	438	361	323	-11.3	-4.3
Groundnut oil	1079	889	859	1043	586	711	1017	905	569	-14.2	-0.7
Coconut oil	683	905	674	570	464	729	1154	590	297	-9.2	-10.6
Palm kernels	364	500	345	317	265	366	529	291	142	-7.6	-14.4
Palm kernel oil	764	1049	726	588	458	709	1037	551	288	-12.0	-11.0
Palm oil	600	654	784	570	445	502	729	500	257	-7.2	-12.8
Olive oil	1421	1686	1823	1629	1657	1374	1303	1185	1389	3.9	-4.3
Cotton	1607	1706	2076	1879	1603	1868	1771	1362	1165	-0.1	-7.7

continued

Appendix 11, continued.

Sisal	521	737	787	688	622	638	651	619	614	4.5	-0.3
Rubber	993	1283	1423	1086	845	1054	938	755	798	-4.0	-1.4
Beef	2140	2886	2775	2473	2389	2442	2262	2153	2095	2.8	-3.2
Manganese ore	141	135	164	172	164	137	137	138	138	3.8	-4.2
Iron ore	19	23	27	23	24	24	22	22	22	6.0	-2.2
Aluminium	1324	1585	1775	1262	991	1437	1252	1042	1150	-7.0	3.8
Copper	1364	1984	2173	1743	1480	1593	1378	1417	1374	2.1	-1.8
Tin	12874	15442	16785	14150	12824	12992	12236	11951	5740	-0.1	-18.2
Phosphate rock	34	34	43	53	40	32	33	33	35	4.1	-3.3
Crude petroleum	94	127	211	240	245	214	210	205	107	27.1	-18.7

Appendix 12.
Debt and debt service of developing Africa (values given in billions of US$).

	1984	1985	1986	1987*
Total debt	152.1	174.4	207.7	218.1
Sub-Sahara	80.6	95.5	117.4	118.1
North Africa	71.5	78.9	90.3	100.0
Debt service	21.7	24.3	26.4	26.5
Sub-Sahara	9.9	12.0	13.7	13.8
North Africa	11.8	12.3	12.7	12.7
Ratios				
Debt/GDP	0.57	0.67	0.74	0.70
Debt/exports	1.94	2.14	2.98	2.95
Debt service ratio	27.6	29.3	42.7	35.8
Sub-Sahara	26.1	29.3	42.9	47.2
North Africa	29.1	30.4	38.5	28.9

*Preliminary

Source: OECD, *Financing and External Debt of Developing Countries*, 1986 Survey, Paris, 1987, and *External Debt Statistics*, Paris, 1987; IMF, *World Economic Outlook*, October 1987 and *International Financial Statistics*, January 1988, *African Economic Digest*, several issues, *Economist Intelligence Unit*, several issues and ECA Secretariat.

Appendix 13.
Selected social indicators

	Primary School Enrollment		Secondary School Enrollment		Adult Literacy Rate	
	1965	1984	1965	1984	1960	1985
Algeria	68	94	7	47	10	50
Angola	39	134	5	12		41
Benin	34	64	3	19	5	26
Botswana	65	97	3	25		71
BurkinaFaso	12	29	1	4	2	13
Burundi	26	49	1	4	14	34
Cameroon	94	107	5	23	19	56
Cape.Verde						47
Central African Republic	56	77	2	16	7	40
Chad	34	38	1	6	6	25
Comoros						
Congo	114		10		16	63
Cote D'Ivoire	60	77	6	20	5	43
Djiboute		76				
Egypt	75	84	26	58	26	45
Equatorial Guinea		78				37
Ethiopia	11	32	2	12		55
Gabon		46				62
Gambia						25
Ghana	69	67	13	36	27	53
Guinea	31	32	5	13	7	28
Guinea Bissau		33				31
Kenya	54	97	4	19	20	59
Lesotho	94	111	4	21		74
Liberia	41	76	5	23	9	35
Libya	78		14		22	67
Madascar	65	121	8	36		68
Malawi	44	62	2	4		41
Mali	24		4		2	17
Mauritania	13	37	1	12	5	
Mauritius	101	106	26	51		83
Morocco	57	80	11	31	14	33

continued.

Appendix 13, continued.

Mozambique	37	83	3	6	8	38
Niger	11	28	1	7	7	14
Nigeria	32	92	5	29	15	42
Rwanda	53	62	2	2	15	47
Sao Tome Princi.						
Senegal	40	55	7	13	6	28
Seychelles						
Sierra Leone	29	45	5	14	7	29
Somalia	10	25	2	17	2	12
Sudan	29	49	4	19	13	
Swaziland						68
Tanzania	32	87	2	3	10	
Togo	55	97	5	21	10	41
Tunisi	91	116	16	32	16	54
Uganda	67	57	4	8	25	57
Zaire	70	98	5	57	31	61
Zambia	53	100	7	17	29	76
Zimbabwe	110	131	6	39	39	74

Appendix 14
Science and technology policy-making organs in African countries - October 1986.

	A	B	C	D	E	F	G	H	I
Algeria	O		O		O			O	
Angola									
Benin	A	A	O	A	O	O		O	X
Botswana			A	A				A	
BurkinaFaso	X	X	X		O	X		X	
Burundi	A			A	X			X	X
Cameroon	A	O	O	A	O	O		O	
Cape.Verde									
Central Afri Republic	A	X	O		X				
Chad	A		O	A	X	A			
Comoros									
Congo	A	O	A	X	X		X		
Cote D'Ivoire	O	X	O	X	O	X		X	X
Djiboute									
Egypt	O			O	O	O	X	O	O
Equatorial Guinea									
Ethiopia			O	X	O	X		X	X
Gabon	X	X	X	X	X			X	X
Gambia									
Ghana		O	O	X	X	X		X	X
Guinea	O	X	O	X	X	X		X	X
Guinea Bissau									
Kenya									
Lesotho									
Liberia		O		X	X	X		X	
Libya		A	X		X	X		X	
Madascar	X		O	X	X				X
Malawi	A		X	X	O			A	
Mali	A	O	X	X	O	X		X	
Mauritania									
Mauritius									
Morocco	A		A		O		O		
Mozambique									
Niger	A	O	O	X	O			X	

continued.

Appendix 14, continued.

Nigeria	A	O	O	O	O	O		O	
Rwanda	A	X			X				
Sao Tome Princip.									
Senegal	A	O	O	X	X	X		X	X
Seychelles									
Sierra Leone			A		A				
Somalia			A						
Sudan	A	O	O	A	O	O		O	X
Swaziland									
Tanzania	A	O	O	X	X	X		X	X
Togo	X		X	A	X	X		X	X
Tunisia	O	O		X	X	X			
Uganda					A			A	A
Zaire	A	O	O	X	O	X	O		
Zambia	A	O	O	A	O	O	O	X	
Zimbabwe	A								

A = Ministry of Science of ministerial science policy committee
B = Science planning body, general
C = Multisector body for coordinating scientific research

Coordinaing bodies for scientific research:

D = Natural sciences research
E = Agricultural research
F = Medical research
G = Nuclear research
H = Industrial research
I = Environmental research

X indicates institution which existed before 1979
O indicates institution which existed in 1983
A indicates institution existing after 1979

Source: Compiled from ATUL, WAD and RADNOR (1983) Science and Technology in Africa. Priorities and Implications for International Cooperation, North Western University, Evanston, Illinois, US.

UNESCO: Cooperative Study on the National Science and Technology Policy-making Bodies in the Countries of West Africa. Science Policy Studies and Documents. No 58, 1986.

UNESCO: World Directory o f National Science and Technology Policy-making Studies and Documents No 58, Paris 1986.

Appendix 15.
Trends in the formation of science and technology policy-making bodies, 1973-1986

	1973	1979 Increase	1979 Total	After 1979	Total 1986
Ministry of Science or Ministerial Science Policy Council	5	+4	9	**+18**	27
Science planning body in general	12	+6	18	+2	20
Multisector body for co-ordinating scientific research	18	+6	24	+4	28
Natural science research	2	**+14**	16	+9	25
Agricultural research	13	**+15**	30	+2	32
Medical research	6	**+14**	20	+1	21
Nuclear research	3	+1	4		4
Industrial research	7	**+15**	22	+3	25
Environmental research	1	**+13**	14	1	15
Total	69		157		
Increase		88		40	
Grand total			157	40	197

Bold type:
Indicates bodies rapid increase

Source: compiled from Appendix 14, 1986.

Appendix 16. Total stock of scientists and engineers per million inhabitants in selected African countries and percentage of gross national product (GNP) devoted to R&D.

Country	Period	Scientists and Engineers per million inhabitants		%GNP	
		BP	EP	BP	EP
Central Africa Republic	1975-84	37	78	0.1	0.3
Congo	1977-84	197	509	0.4	-
Cote d'Ivoire	1970-75	60	74	0.4	
Egypt	1973-82	299	466	0.8	0.2
Ghana	1970-76	199	396		
Madascar	1970-80	24	13	0.9	0.2
Niger	1972-76	7	20		0.1
Nigeria	1970-77	25	30	0.1	0.3
Sudan	1971-78	89	250		0.3
Zambia	1970-76	18	49	0.2	

*BP = Beginning of period
** EP = End of period

Source: Compiled from: Statistics on Scientific Research and Experimental Development in Africa, SC-878 CASTAFRICA II/REP.2. UNESCO, Paris, 1987.

Appendix 17.
Global distribution of R&D expenditure (%) by major areas for 1970, 1975 and 1980.

Region	1970	1975	1980
Africa*	0.2	0.3	0.3
Asia	7.3	10.8	14.8
North America	44.5	33.7	32.1
Arab States	0.2	0.3	0.5
Latin America	0.8	1.5	1.8
Europe	25.3	32.0	34.0
USSR	20.9	20.4	15.6
Oceania	0.8	1.0	0.9

*excluding Arab States

Source: UNESCO: Statistics on Science and Technology (extracts from UNESCO Statistical Year Book, 1986)

Appendix 18.
Local Soil Classification and their agricultural use by the Sissala people.

Local Sissala Name	SOIL		INDICATOR PLANTS		Agricultural use
	Description	Location	Sissala Name	Botanical Name	
Bakdabule	Gravelly reddish brown colour colour	Upper slopes	Banpoloingo	Heteropogon Contortus	groundnuts*, white guinea corn and millet
Tenullo	Dark grey	Middle slopes	Vu-nyor	Schizachryrium sp.	millet*, groundnuts, guinea corn
Pupullo	Dark grey	Land around compound houses	Kendaa	Aristidakerstingii	Brown guinea corn*, maize

continued.

Appendix 18, continued.

Nyipopumma	Loamy greyish	Lower slopes	Papuie	Cymbopogan Giganteus	yam*, rice maize
Nyipobinno	Loamy black soil with poor soil-moisture relationship	Valley bottom	Fuoliniui Papuie	Hyparrhemia Rufa Cymbopogan Giganteus	rice*, yam
Techuo	Dark grey	Broad valley	Mouro	Prisma grass	maize*, millet

*First choice

Adapted from Benney (1974). Proceedings of Ghana Scopes Conference on Environment and Development in West Africa. Ghana Academy of Arts and Sciences with Cooperation of UNESCO and the Ghana Environmental Protection Council

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African Governments and their societies unanimously support the global objectives of rapid industrialization and technology development geared towards increasing national productive output and developing dynamic and self-reliant economies. There are however, ineffective mechanisms to realize these objectives:

"We have erected stifling barriers and constraints that have all but snuffed out any emerging growth points in science and technology; we have strenuously attempted to build up an African culture from which the vital component of science is divorced; and we have kept our small struggling science enterprise in a separate compartment from all,. other factors necessary for economic development. "

"Our resources are under-developed and our markets are fragmented. Unless we are resolutely supportive of each other.... we can make little headway in economic development... How do we convert primitive jealousies to orderly competition?"

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