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SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

Draft ECA regional paper for the United Nations Conference on Science and Technology for Development

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I. INTRODUCTION

A. Origins of the Conference

1. When the General Assembly of the United Nations designated the period 1961 to 1970 United Nations Development Decade, it was already clear that science and technology were not fulfilling the expectation of providing the less developed countries with the means whereby they could narrow the development gap between the advanced countries and themselves, and attain over-all socio-economic improvement. Neither aid channelled through direct arrangements between Governments, nor market-oriented private investment, had substantially improved the condition of the private individual in those countries. The specialized agencies of the United Nations, reinforced by the technical assistance programmes and the United Nations Development Programme, could cite creditable achievements and promising examples. They had established their regional and field office system and, within the means available to them, were responding to requests from Governments and encouraging regional co-operation and interagency collaboration.

2. Those agencies, however, while performing the functions assigned to them in their charters, did not encompass the entire range of possible applications of science and technology to development. In 1961 the Economic and Social Council, acting on a proposal of the United Nations Scientific Advisory Committee, decided to convene a United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, as an "international technical conference of Governments". Other scientific conferences under United Nations auspices had preceded that endeavour, notably one on new sources of energy in 1961, two which were convened to discuss the peaceful uses of atomic energy in 1955 and 1958, and, as early as 1948, the United Nations Scientific Conference on the Conservation and Utilization of Resources. There was also a survey of current trends in scientific research which was undertaken under the auspices of the United Nations and UNESCO in the years 1958 to 1960.

3. Conceived initially as a means of exploring the applications of recent advances in science and technology, the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, which convened in Geneva in 1963, found itself confronted with the much wider and more fundamental problem of ensuring that science and technology made their proper contribution to development. In essence the Conference strengthened the belief that the socio-economic development of the developing countries could be accelerated through the effective application of science and technology. There also emerged the conviction that the Conference should lead to positive action on a scale commensurate with the objectives of the Development Decade.

4. To achieve such positive action, it was felt in some quarters that a new specialized agency would need to be established. The United Nations, however, decided that the task was one to be shared among the existing bodies of its family, on condition that their efforts in science and technology were intensified and properly co-ordinated. Accordingly, in 1964, the Economic and Social Council established the Advisory Committee on the Application of Science and Technology to Development, to give the application of science and technology new and greater impetus in the programmes and activities of all appropriate United Nations bodies,

and to promote the effective co-ordination of their efforts in that field. The Advisory Committee was also required to keep under review progress in the application of science and technology to development, and to propose practical measures for such application for the benefit of the developing countries.

5. Apart from its annual reports to the Economic and Social Council and reports on specific subjects such as protein deficiency, natural resources, and science education, the Advisory Committee produced the World Plan of Action for the Application of Science and Technology to Development, a major work and an integral part of the strategy for the Second United Nations Development Decade. The World Plan is principally a generalized statement of priorities and principles for introducing industries and technical services into less developed countries. But it has so far been lying on the shelf, no more than a blueprint without the formula needed to begin action, because it was not backed by the necessary political will both nationally and internationally.

6. As the Decade progressed, it was found that the Advisory Committee, although attracting competent and experienced members, lacked the necessary coupling with the policy-making process. Therefore, in 1971 the Economic and Social Council took a further step towards reinforcing the central machinery of the United Nations for science and technology by establishing an intergovernmental Committee on Science and Technology for Development. This took account of the advantages which a body consisting of representatives of Governments might have in seeing that their recommendations were implemented at the national level. The Council however retained the Advisory Committee, recognizing that it could give essential technical advice on programme priorities and feasibility. The Advisory Committee has the additional responsibility of furnishing expertise to the intergovernmental body.

7. At the end of the First United Nations Development Decade, the General Assembly noted the need for increased international co-operation in bringing the benefits of science and technology to all peoples of the world, and adopted resolution 2658 (XXV) in which the Secretary-General was requested to prepare a study which would evaluate the main implications of modern science and technology, particularly for development, and appraise the results achieved by the United Nations system in promoting science and technology and their application to development since the 1963 Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas. He was also requested to suggest ways and means of implementing various recommendations made, practical ways and means of strengthening international co-operation in the new applications of science and technology in the economic and social fields, and additional forms of international action within the framework of the United Nations system, to ensure that scientific and technical achievements were more effectively applied, particularly in the developing countries.

8. In his report, the Secretary-General expressed the view that the 1963 Conference had not been followed by the action needed and that, while it had created awareness of the importance of science and technology in the process of development, it had given insufficient indication of the measures needed to translate that awareness into action by Member States. The report recommended that the Committee on Science and Technology for Development should give serious thought to the question of generating the necessary political will and action, consider the merits of another international conference on science and technology to focus

on policies and practical courses of action at the national and international levels, and not only deal with new dimensions and new opportunities with relevance to the problems of development but also illustrate the new modes of international relations.

9. Subsequently, the General Assembly and the Economic and Social Council took various measures to promote the convening of a United Nations conference on science and technology. In 1974, the Economic and Social Council emphasized the necessity for such a conference, and recognized that the new needs in the field of science and technology made it imperative for the United Nations to expand international co-operation in that field on the basis of principles designed to adjust the scientific and technological relationships among States in a manner compatible with the special requirements and interests of developing countries. 1/ In 1975 the Council convened an intergovernmental working group of the Committee on Science and Technology for Development to examine the specific objectives, topics and agenda of a possible United Nations conference on science and technology, on the basis of the recommendations of the Advisory Committee on the Application of Science and Technology to Development, the UNCTAD Intergovernmental Group on Transfer of Technology, the regional commissions and other relevant United Nations bodies. In September 1975, the General Assembly adopted a resolution on development and international economic co-operation in which it recommended that a United Nations Conference on Science and Technology for Development should be held with the main objectives of strengthening the technological capacity of developing countries to enable them to apply science and technology to their own development; adopting effective means for the utilization of scientific and technological potentials in the solution of development problems of regional and global significance, especially for the benefit of developing countries; and providing instruments of co-operation to developing countries in the utilization of science and technology for solving socio-economic problems that cannot be solved by individual action, in accordance with national priorities, taking into account the recommendations made by the Intergovernmental Working Group of the Committee on Science and Technology for Development. 2/

10. In 1976, at its third session, the Committee on Science and Technology for Development, after considering the report of its Intergovernmental Working Group, stressed that the Conference should be oriented towards practical action and should be attended by national policy and decision makers, accompanied by their scientific advisers. The preparatory period was visualized as a process involving all countries and regions with the greatest possible participation of relevant governmental and non-governmental organizations as well as members of the scientific community so as to promote widespread appreciation of the role of science and technology among developing countries. A panel of experts convened by the Secretary-General pointed out that the need was not for a science fair for scientists, but for a launching platform for joint efforts for development which would integrate the policy-makers, decision-takers, development agencies and technology users with the scientists and technologists. The Committee approved a draft resolution on the Conference which was subsequently adopted by the Economic

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1/ Economic and Social Council resolution 1897 (XVII).

2/ General Assembly resolution 3362 (S-VII), chap. III, para. 7.

and Social Council in August 1976 /resolution 2028 (LXI)/. The General Assembly at its thirty-first session, acting upon a recommendation of the Economic and Social Council, decided to convene the United Nations Conference on Science and Technology for Development during 1979 in time for the Assembly to take action at its thirty-fourth session in the light of the results of the Conference. 3/ The main objectives recommended for the Conference were as follows:

(a) To adopt concrete decisions on ways and means of applying science and technology in establishing a new international economic order, as a strategy aimed at economic and social development within a time frame;

(b) To strengthen the technological capacity of developing countries so as to enable them to apply science and technology to their own development;

(c) To adopt effective means for the utilization of scientific and technological potentials in the solution of problems of development of national, regional and global significance, especially for the benefit of developing countries;

(d) To provide instruments of co-operation to developing countries in the utilization of science and technology for solving socio-economic problems that cannot be solved by individual action, in accordance with national priorities. 4/

11. The General Assembly also proposed an agenda for the Conference and various measures to be taken during the preparatory period.

B. The African scene

12. The African region accounts for between a quarter and a fifth of the world's land surface. Its climate is mediterranean in the extreme north and north-west, temperate in the extreme south and on the plateaux, and tropical in between, covering some of the hottest and most humid areas of the world.

13. Of the total land area of 30,310,000 square kilometres, arable land, including land under permanent crops, makes up 7 per cent, permanent meadows and pastures 26 per cent, forests and woodlands 21 per cent, and other land 46 per cent. Thus only about 50 per cent of the land areas of Africa has been classified as arable, permanent meadows and pastures, and forest and woodland.

14. The population of the continent increased from about 270 million in 1960 to about 410 million in 1975, reflecting an average annual rate of growth approaching 3 per cent, the highest in the world. The region's population, which is expected to increase to 470 million in 1980 and 550 million in 1985, is still characterized by relatively low density and wide dispersal of concentrations. Thus, of the 49 independent African countries, 30 have estimated populations of 5 million or less, 9 populations of between 5 million and 10 million, 8 populations of between 10 million and 30 million and only 2 more than 30 million. The population density ranges from 1 to about 470 persons per square kilometre if total land surface is considered, and between 25 and about 1,200 persons per square kilometre of arable land.

3/ General Assembly resolution 31/184, para. 2.

4/ Economic and Social Council resolution 2028 (LXI), para. 2.

15. Africa possesses vast mineral resources which make her one of the richest regions in the world. The continent accounts for 96 per cent of the world's diamond deposits, 90 per cent of the world's chromium, about 50 per cent of its cobalt, 10 per cent of its iron ore, 55 per cent of its manganese, 40 per cent of its bauxite, 20 per cent of its copper, 50 per cent of its phosphate rock, 30 per cent of its thorium and uranium and about 50 per cent of its gold. In terms of output, Africa produces about 26 per cent of the world's cobalt ore, 81 per cent of its gold, 74 per cent of its diamonds, 26 per cent of its phosphate rock, 19 per cent of its copper ore and about 7 per cent of its iron ore. Hence it can be claimed that for many years to come, the development of many African countries will continue to depend on the resources of their soil, though such development cannot be achieved without the application of science and technology on a large scale.

16. Africa is also rich in energy resources although, as in the case of mineral resources, they have yet to be developed. To date only about 10 African countries are crude oil producers, but the continuing search for hydrocarbon deposits on the continent may lead to the discovery of crude oil in more countries. Africa is also rich in such energy resources as coal, solar energy, geothermal energy, hydroelectric power and the resources for nuclear energy. It is estimated that Africa has about 1.3 per cent of total world reserves of coal, and 27 - 40 per cent of the world's total hydroelectric power potential.

17. The African region is recognized as the least developed of the regions of the world. Of the 29 internationally recognized least developed countries, 18 are in Africa; of the 45 countries identified as the most seriously affected by the economic crisis of the early 1970s, 28 are in Africa. Both the list of least developed countries and that of the most seriously affected economically contain all the Sudano-Sahelian countries affected by the scourge of drought in the early 1970s. Similarly, of the 20 internationally recognized developing land-locked countries, 14 are in Africa. This list does not include the geographically disadvantaged island economies, of which Africa has a sizeable share. It is thus clear that economic co-operation in its wider sense is an imperative for African countries.

18. While the distribution of natural and human resources may be uneven, there is no doubt that the continent is richly endowed with both. Yet their exploitation, as reflected in the output of goods and services, leaves no doubt about the low level and slow rate of socio-economic growth and development. Notwithstanding deliberate efforts over the past three decades to achieve rapid transformation of the African economies and to improve living standards, the income and technology gaps between the developed countries and African countries have not narrowed but widened. The existing economic situation in which Africa finds itself, and its international role as a primary supplier of raw materials and a consumer of manufactured goods and imported technology, make socio-economic transformation rather difficult in view of its basic weak position and lack of capabilities. African countries therefore see in the Conference on Science and Technology for Development a major means for bringing about a new international economic order and changing from a weak and dependent position to an economically and technologically self-reliant one.

1. In search of indigenous capabilities

19. At the root of Africa's economic and technological backwardness lies not so much limited financial resources but rather limited capabilities, technical and managerial know-how, ownership of patents and control over inventions, the capability to develop suitable technologies and to comprehend, negotiate, transfer, adapt and apply foreign technologies. To live up to the challenge of the efforts to establish a new international economic order and take full advantage of its opportunities, Africa must first acquire and develop the basic capabilities needed for effective participation in the new order.

20. Hence, as far as African countries are concerned, the purpose of a conference on science and technology for development should be to enable the continent to:

(a) Evolve national development policies with full recognition of science and technology as the sinews of development strategy;

(b) Evolve needs-oriented education and training systems in which science and technology have pride of place at all levels, not only in terms of educational content and structure but also in resource allocation and use;

(c) Develop national, multinational and regional institutional infrastructure for the effective localization of a capability for technology development, transfer and adaptation in African countries, for maximum impact in agricultural, industrial and socio-economic development.

21. Technology cannot become nationalized in Africa on the basis of negotiated patents and technical co-operation experts. These are only short-lived palliatives. What is needed is to ensure the permanent acquisition of skills and knowledge in technology development, adaptation and application by the people of Africa, and the setting up of institutions to carry out technological research and train present and future generations on a continuing basis.

22. Technological education and training should be designed to bring about the technological transformation of production processes and supporting infrastructure. Simultaneously, industrial production should provide for the mass production locally of science and technology teaching equipment and aids so as to ensure an appropriate science and technology orientation through all the levels of the educational system.

2. The transfer of technology

23. The key issues involved here are, first, that technological knowledge is not freely available to developing countries except on terms which are often extremely burdensome; second, the element of dependence; and third, the relatively weak technological capabities of African countries. Some action at the international level in respect of technology transfer and development has been taken within UNCTAD, where a code of conduct is being elaborated for the Negotiating Conference on the Transfer of Technology in 1978. WIPO is also preparing for a revision of the Paris Convention for the Protection of Intellectual Property. Such a revision will be of particular importance since it will improve the existing patent system in the transfer of technology.

24. A significant step was taken in Africa when the meeting of African plenipotentiaries in November 1977 in Kaduna, Nigeria, decided to establish an African Regional Centre for Technology. The Centre will have as primary objectives the strengthening of the technological capabilities of African countries so as to decrease their technological dependence, the promotion of the use of technology suitable to African conditions and the formulation of technology policies and planning as an integral part of national socio-economic development.

C. Scope and objectives of the report

25. The problem of socio-economic development in Africa has many dimensions and calls for a critical analysis of many issues; it requires action at the national, regional and international levels. It would therefore be beneficial for a start for the countries of the African region to share past and current experience in their attempts to develop priority areas for technological development, and to see how they can individually and collectively develop the ability to assimilate, adapt and improvise technologies. This is definitely a goal of the conference for Africa.

26. This paper discusses the role of science and technology in development and the present state of scientific and technological activities in the continent. This is necessary to enable African countries at the conference to exchange information and ideas with other third world countries with a view to benefiting from each other's successes and failures; to study future plans and efforts designed to enhance their capacity to use technology effectively; and to discuss the problems of the impact of transfer of technology on the development of local scientific and technological capability, the cost of transfer, the appropriateness of the technology transferred, policies needed to obviate adverse effects, and so on. The paper examines the technology links created through trade and other economic linkages within, for example, ECOWAS, OMVS and UDEAC. Finally it proposes actions at national and regional levels and to improve science and technology capacity in African countries, and examines and suggests significant inputs from the United Nations system to help improve the current economic situation and trends.

II. THE ROLE OF SCIENCE AND TECHNOLOGY IN DEVELOPMENT

A. The dynamics of socio-economic development

27. To facilitate discussion of the role of science and technology in development, it seems appropriate to begin by stating briefly what the principal terms involved in such a discussion mean. Development will be used here to refer to the twin processes of growth and change, which are aimed at improving man's working and living conditions. It seems useful to give development its widest meaning, and in this paper, therefore, its meaning will not be restricted only to considerations of man's material well-being, but will embrace the totality of man's welfare.

28. Development has reached different stages in different countries. It is common usage now to refer to countries in which development has advanced beyond a certain stage as developed countries, and to all of the others as developing countries. However, this does not mean that in developed countries development has run its full course and come to a standstill. Nor does it mean that in

developing countries development is necessarily progressing at great speed. On the contrary, it is now widely accepted that in several respects developed countries are in fact developing faster than developing countries.

29. The word science is used to refer to man's "organized attempt, through the objective study of empirical phenomena, to discover how things work as causal systems". 5/ Because the primary aim of science is to infer empirically the relationships between things and events in this world, and not so much to find ways of putting the relationships so obtained to practical use, it may be - and often is - said that science seeks to comprehend (to "know why") and not to invent (to "know how").

30. The study and practice of developing practical applications of the findings of science for the production or improvement of goods or services is here referred to as technology. Technology practitioners use technology to meet concrete human needs and wants. They do so by conceiving, designing and developing new forms of equipment, machines or installations which greatly amplify man's effort, increase the efficiency of his exertions and refine the products of his labours. The business of technology, therefore, appears to be to "invent", and not so much to "comprehend".

31. Such sharply contrasting definitions of science and technology are of course possible only conceptually. In actual fact science and technology are so closely interwoven that it is not possible to draw a sharp line between them. Today few scientists profess the complete lack of interest in the practical applications of their findings implied in the definition of science that has been given. Likewise, few technologists today are not well-versed in at least the scientific theories which have direct bearing upon their branches of technology.

32. It is perhaps also useful to indicate the meaning of the term "research and development" ("R and D"). Research denotes the search for new knowledge. Development, on the other hand, consists of the systematic use of the results of research and existing empirical knowledge directed towards the introduction of new materials, products, devices, processes and methods - or the improvement of existing ones - including the development of prototypes and pilot plants. Development comprises the studies which need to be made to ascertain the technical, social and economic feasibility, usefulness, acceptability and profitability of innovations. 6/

33. Development, as has already been indicated, consists of two transformative processes: growth and change. Growth consists of an expansion of existing goods and services and is thus a quantitative transformation. Rises in per capita income, in the number of schools or hospitals per specified number of residents, in the quantity of food available to each consumer - all of these and others like them are instances of the growth component of development. Growth, therefore, entails doing more of what was being done before. In contrast, change entails the adoption of new ways of doing and looking at things, and is thus a qualitative transformation. Improvement in feeding habits towards more balanced diets, realignment of school

5/ "Science and technology in African development" (UNESCO document SC/CASTAFRICA/3), chap. I, para. 26.

6/ Ibid., para. 28.

curricula to meet local exigencies, introduction of novel ways of combating disease - all of these and others like them are instances of change. Change, therefore, can involve the adoption of new means of realizing old aims. But it may also entail the substitution of new aims for old.

34. Growth and change are coupled one to the other, and occur simultaneously. Even when growth is apparently all that is taking place, almost always some change is bound to be occurring as a result. Likewise, when change is seemingly all that is happening, some growth - albeit sometimes negative - is likely to be taking place as well. Two corollaries then follow. First, obstacles to growth not only retard growth itself, but often also impede change as well. Second, barriers in the way of change not only forestall change itself, but often also thwart growth. Events in the developing world bear testimony to this.

35. It will suffice to give the following example. Social and cultural traditions codify human values and attitudes and, in Africa especially, constitute a formidable barrier against change. At the same time, it is widely recognized now that economic growth, which is "a primary, if not the primary objective of most governments in Africa", 7/ will require extensive and intensive changes in human values and attitudes. In the words of the programme of action adopted by the 1976 ILO World Employment Conference it will require, among other things, "measures aimed at changing the pattern of growth and access to the use of productive resources by the lowest income groups". But, as the programme of action goes on to say, "often these measures will require a transformation of social structures, including an initial redistribution of assets, especially land". 8/ The restructuring of society entailed in these measures, however, is likely to run up against tradition, which abhors change and tends to preserve the status quo. In acting as a barrier to change required for economic growth, tradition thereby also acts as a barrier to economic growth.

36. The significance of science and technology for development lies in the fact that their application can influence both growth and change decisively. As was demonstrated by the field surveys of needs and priorities in science and technology in individual African countries which were carried out during the preparation of the African Regional Plan for the Application of Science and Technology to Development (hereafter referred to as the African Regional Plan), this influence of science and technology in development is widely recognized "at senior government and other levels", although, as one might expect, the general public is ignorant of it. 9/

37. The application of science and technology influences growth through increases in efficiency and improved productivity. Use of machines and installations born of science and technology greatly amplifies man's effort, increases the efficiency of his exertions, refines the results of his labour, removes drudgery from work, and generally raises the level of comfort in his working and living conditions.

7/ Ibid., para. 112.

8/ Meeting basic needs: Strategies for Eradicating Mass Poverty and Unemployment (Geneva, International Labour Office, 1977), p. 25.

9/ African Regional Plan for the Application of Science and Technology to Development (United Nations publication, Sales No. E.73.II.K.3), para. 13.

38. The application of science and technology also brings about change. This occurs in two ways. First, it occurs indirectly through the effects of science and technology on growth. But growth and change, as has been indicated, are interconnected. The quantitative growth produced through the application of science and technology in turn produces qualitative changes in life. For example, the economic growth which the application of science and technology brings about reduced rural poverty and urban squalor. This in turn produces changes in attitudes and habits (which in Africa are often concessions to raging adversity), thereby raising the quality of life. But science and technology may also effect change in a second and direct way: through education. By many estimates this contribution of science and technology towards development is likely to produce the speediest and greatest impact upon development in Africa. It seems appropriate, therefore, to deal with it in detail.

39. At one level, development in Africa depends on the actions of the constituent countries themselves, and, in particular, on their peoples and governments. Achievement of the conditions required for rapid over-all development is possible only if this is accepted and if governments pursue stable policies directed towards this end. At a second level, it must be recognized that in most developing countries, including those of Africa, lack of scientific knowledge and technological know-how are seldom the critical limiting factors. Instead, the obstacles to development in these countries are often of an economic and social nature. They relate to such factors as education and general level of skills, communication between different social groups, responsiveness to new ideas, the effectiveness of the administrative apparatus, the entrepreneurial spirit in industry, and sound political leadership.

40. At both of the above levels, removal of the barriers to development requires the building up of a scientific culture. This involves fostering a wider and deeper understanding by the public - especially at the adult level - of science and its applications, through adequate provision within the educational system. In all of the developing countries in Africa, members of the public must be disabused of the many erroneous notions they hold in regard to the environment and their interaction with it. They must be won over to the view that each response of the environment must have sufficient cause - that, in short, nature cannot be cajoled but must be dealt with scientifically. When this happens, members of the public will be receptive to the measures which development requires.

41. All strategies of development must sooner or later engage the common man in a dialogue about the ways in which his working and living conditions would be improved if he did what the strategies ask of him. But unless he has at least a nodding acquaintance with science and its applications, how can anyone expect the vocabulary, let alone the propositions, of any strategy for development, to be intelligible to him? Certainly one's attempts at expounding the virtues of proteins are less likely to succeed with an audience which does not always think of the human body in scientific terms than with one which does.

42. It follows that developing countries in Africa need to make scientific education available to as broad a base of their populations as possible. For development will be brought about not by the isolated efforts of a handful of scientists and technologists, but by the concerted efforts of the masses. Against this background, adult literacy campaigns assume special importance.

In the first place, the agents of growth and change, and so of development, are adults. Development may be greatly accelerated by fostering in this segment of the populace a responsiveness to measures aimed at development. Secondly, literacy among adults reinforces literacy among the young. This is particularly important in Africa. In Africa, only 20 per cent of the pupils in primary schools (who themselves represent only about 40 per cent of all school-age children) go on to secondary school, and an even samller percentage (15 per cent) of those in secondary school ever reach university. 10/ Thus about 90 per cent of Africa's young people have only primary education or less. Primary education, however, is usually not sufficient to overcome the inertia of an illiterate environment. After some years those who have gone no further than primary school usually relapse into illiteracy, and illiteracy among young people returns to the 90 per cent figure. Unless adult education is undertaken simultaneously, therefore, it is possible to attain the goal of universal primary education and yet continue to have rampant illiteracy.

B. Science and technology policy

43. In this paper, science and technology policy is used to refer to the framework provided by the guidelines aimed at circumscribing the development of the scientific and technological capacity of a country and steering it towards chosen objectives. In order for such policies to be effective and useful, they should not only spell out explicitly what the short-term and long-term aims of science and technology in the country ought to be, but should also expressly indicate the courses of action designed to achieve those aims.

44. Earlier, science policy somewhat blithely assumed that if sufficient resources were devoted to building up and staffing scientific institutions, these would have an automatic modernizing effect upon industry and agriculture and upon society generally. It is now recognized, however, that this is simply not so. While the deliberate and studied application of science and technology to development is still hampered by inadequate knowledge of just how the process works, it is already apparent that the provision of scientific institutions does not by itself ensure an automatic contribution to development. This has led to a reassessment of earlier premises of science policy making.

45. In Africa, the problems associated with the formulation and implementation of science and technology policies have attracted increasingly serious attention by African Governments in the years since national independence. At a conference convened by UNESCO in Lagos in 1964, it was noted that African countries were handicapped by the absence of an adequate national science policy, and that they lacked national machinery for co-ordinating and preparing such a policy. Three years later, many States had either set up or had reinforced their national agencies for science planning, decision-making and co-ordination. Much had by then also been done towards preparing and implementing national science policies which were adapted to development needs. Since then there have been further important developments, and today most countries in Africa are working towards central machinery for policy-making and planning in science and technology. 11/

10/ Education in a rural environment (Paris, UNESCO, 1974), p. 16.

11/ UNESCO document SC/CASTAFRICA/3, chap. I, paras. 16-18.

46. As a result of the steady assaults which have been made on the problems relating to science policy in recent years, a new pattern has begun to emerge. One good description of this is contained in the first chapter ("General development of scientific and technological capacity") of the African Regional Plan.

47. According to the African Regional Plan, science and technology policy in Africa should have the general aim of promoting and reinforcing the development of technological independence. The Plan offers the following as objectives selected to guide action to this end:

(a) Development of national organs to deal with scientific and technological affairs and to determine national policies in these spheres;

(b) Creation of scientific awareness among the public so that it appreciates the potential offered by the use of science and technology for development;

(c) Institution of scientific and technological planning as an integral part of development planning;

(d) Evolution of new and more effective forms of international co-operation in the use of science and technology;

(e) Reinforcement of the national network of institutions for science and technology;

(f) Reorientation and mobilization of the scientific and technological communities in each country; and

(g) Establishment of information and documentation centres. 12/

48. But while considerable progress seems to have been made with regard to the making of science and technology policy, there still persist serious problems as a result of which only a few countries in Africa have evolved from their policies and implemented concrete programmes of action aimed at strengthening their technological capabilities. These problems include the following:

(a) The goals of science and technology policy do not always show clarity of vision, and are often not action-oriented;

(b) These goals often receive little more than lip-service, either because of a lack of political will to pursue them or because of the absence of the means required to pursue them, or both.

49. These problems are further complicated by the fragile nature of the national organs whose function is to formulate science and technology policy and to draw up and implement programmes of action designed to fulfil such a policy. Many times this fragility stems at least partly from a duplication of effort. Many African countries find it difficult to resist the impulse to erect a new institution around each new idea. As a result they have in time come to boast several

12/ African Regional Plan, op. cit., paras. 22 and 34.

science and technology bodies with overlapping functions. When the situation gets out of control, a favourite ploy is to hatch yet another institution to subsume them all. This often proves to be a paper tiger, and seldom manages to rein in the warring factions. This instability makes it difficult to pursue any policy with the doggedness often required - let alone prepare such a policy.

50. Then there are, of course, difficulties relating to the training and deployment of manpower. In Africa, quite apart from the fact that sometimes crucial posts can go to people whose training and talents are ill-suited to the posts, while those qualified for them languish in meaningless jobs, there is also high job mobility caused by people's movements from one job to another within the country or outside. This creates a state of flux which leads to a lack of continuity. Many years after their inauguration, a great number of science and technology institutions in Africa are still plagued with "teething problems". Long after the countries should have begun collecting returns from them, these institutions are still not able to deliver.

C. Integration of science and technology programmes into socio-economic development

51. Science and technology policy governs the "change" component of development in so many areas of socio-economic policy that there is a great need for the two policies to be closely interlinked. This means in practice that the policy-making bodies for national science and technology and the planning agencies for over-all national development must co-operate closely with each other. Operationally, science and technology programmes must dovetail into, and mesh with, national programmes for over-all development so that the two sets of programmes are mutually reinforcing and constitute an integral whole. This scheme ensures the convergence of developmental targets and the means provided by science and technology for achieving those targets, so that the latter are at all times geared to, and supportive of, the former.

52. At the moment, in many developing African countries, the integration of science and technology planning in national development planning is loose and ineffectual. Because of the great importance of such integration, it is appropriate to discuss briefly some of the common problems encountered.

53. One of the barriers to effective integration of science and technology planning in over-all national development planning is the professional difference between those who make science and technology plans and thos who prepare the national development plans. National development planning agencies are generally run by economists. Science and technology planning agencies, on the other hand, are of course in the hands of scientists and technologists. Practical problems soon arise when representatives of these two camps meet to work out integrated national plans.

54. The economists tend to concentrate on problems of <u>economic growth</u> in the short-to-medium term. On the other hand, the scientists and technologists tend to focus on long-term issues of <u>techno-scientific</u> change. The resulting impasse is further complicated by the problem of communication. But in Africa and elsewhere the dice are often loaded in favour of the economists and against the scientists and technologists (who are required to be on hand to answer technical questions, but are often excluded from the decision-making process). Right or wrong, therefore, the economists usually carry the day.

55. The remedy to problems arising from professional differences between national development planners and science planners would appear to lie in education. In order to have credibility with the development planners, science planners need to have both technical and economic skills. Moreover, scientists and technologists as a community must show greater concern for the development needs of their countries. Likewise, since science and technology are the motor of development, development planners must cultivate acquaintance with them. In other words, bridging the professional gap between development planners and science planners ultimately requires reducing the educational gulf between them. In many countries in Africa, students elect very early during their education to cultivate ignorance either in "science" on the pretext of studying the "arts", or in the arts on the pretext of studying science. There is a need to eliminate this specialization in the early stages in favour of integrated education. There would then remain the plaguing question of the "correct" balance between science and the arts in such an integrated curriculum. But countries which are seriously gearing themselves up for development cannot lack arguments in favour of according greater emphasis to science.

56. Other difficulties, broached earlier, are the absence in many countries of explicit strategies for developing national scientific and technological capabilities adapted to over-all scoio-economic development, and the fragility of the institutions whose function is to work out such strategies. In addition to the need to establish machinery for incorporating science and technology programmes in programmes for over-all national development, there is therefore also a need to strengthen the policy-making bodies for science and technology.

D. Technological information and documentation

57. Technological information constitutes an element of fundamental importance in the process of development and transfer of technology. It is vital in the generation of indigenous technologies, and in the evaluation, selection, transfer and adaptation of foreign technologies.

58. Technological information is useful to:

(a) Governments for:

(i) The technological decision-making required in formulating and implementing national development plans;

(ii) The generation of indigenous technologies, and the evaluation, selection, transfer and adaptation of foreign technologies.

(b) R and D institutions for:

(i) Planning research and development programmes and activities;

(ii) Awareness of current technological developments;

(iii) Reference material for technical libraries;

(c) Universities for:

(i) Research programmes and activities;

(ii) Preparing educational material;

(d) Industry for:

(i) The identification and location of technologies which could be introduced;

(ii) The comparative evaluation of, and selection among, alternative technologies;

(iii) The industrial application of selected technologies.

59. Because of the great volume of information on science and technology, and the necessity of instituting efficient means of collecting and disseminating it, the need to establish centres for the storage and provision of such information is now commonly recognized. In the case of "industrial property", which consists primarily of patents for inventions, trade marks, and industrial designs, for example, about 1 million patent documents are published each year, describing approximately 350,000 new different solutions to technological problems. 13/ There is clearly a need to devise efficient means of access to this wealth of information. Against this background, the plans by the World Intellectual Property Organization (WIPO) to establish two patent documentation and information centres, 14/ one for French-speaking Africa to be based in Yaoundé and another for English-speaking Africa to be based in Nairobi, would therefore seem to be pertinent indeed.

60. At the global level there are many information services which are either in existence already or in an advanced stage of planning. They include the Universal System for Information in Science and Technology (UNISIST) of the International Council of Scientific Unions (ICSU) and UNESCO; the FAO International Information System for Agricultural Sciences and Technology (AGRIS); the Industrial Information System (INDIS) and the Industrial and Technological Information Bank (INTIB) of the United Nations Industrial Development Organization (UNIDO); the Integrated Set of Information Services (ISIS) of the International Labour Organisation (ILO); and the International Nuclear Information System (INIS) of the International Atomic Energy Agency (IAEA). 15/ Less elaborate information services with similar missions need to be established in Africa at the national, subregional and regional

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13/ "Transfer, adaptation and development of technology: legal aspects of the application of science and technology for development in Africa", study prepared by WIPO for the African Regional Meeting in preparation for the United Nations Conference on Science and Technology for Development, para. 32(i).

14/ Ibid., para. 18.

15/ See Directory of United Nations Information Systems and Services (Geneva, Inter-Organization Board for Information Systems, 1978), p. 33.

levels. 16/ The African Development Information Network (AFDIN), currently being established by the Economic Commission for Africa, is an important step in the right direction.

III. THE PRESENT STATE OF SCIENTIFIC AND TECHNOLOGICAL ACTIVITIES IN AFRICA

A. Science and technology knowledge, manpower training and existing skills

61. Many countries in Africa are at a crossroads, economically as well as educationally. After almost two decades of independence, a model of economic development based primarily on the expansion of the urban (modern) sector has increasingly been shown to be inadequate. In spite of the growth of real GDP at rates between 4 and 6 per cent in many countries, and in some cases as high as 7 or 8 per cent throughout the 1960s, the expected fruits of this growth have not materialized. Large parts of the rural areas are only marginally better off than before. It is true that wage-earning employment in urban areas has grown considerably, but in recent years the growth has slowed down and in any case it never absorbed more than a small proportion of those annually joining the labour force. Besides, the expansion of the modern sector frequently strengthened linkages with the world economy in a way which perpetuated the economic dependence of Africa on the richer countries of Europe and the Americas.

62. It is commonly recognized that Africa has great potential for development. The problem is how to transform this potential into reality. One way of achieving this is to apply science and technology as the highly developed nations have done. But a close look soon reveals that there are a number of subtle impediments. Modern science and technology is largely of foreign origin, and the process of assimilation poses special problems. African personnel not only have to master science and technology nearly as fast as it is developed elsewhere: they also have to overcome the psychological problem of gaining enough self-confidence to use the acquired knowledge creatively in their environment so that they too can contribute to the creation of science and technology. Unfortunately, the educational systems in most African countries have not sufficiently addressed themselves to these problems.

63. The most outstanding defect in the present educational systems is that they have not been evolved to cater for the needs of African society but have been transplanted from alien sources almost wholesale and without adaptation. Hence the curricula are not sufficiently oriented towards education to solve national problems. In 1961, the Addis Ababa Conference of Ministers of Education drew up a list of educational priorities and a set of short-term and long-term targets for educational development in Africa to 1980. In brief there were four long-term targets for 1980:

(a) Primary education shall be universal, compulsory and free;

16/ See also "The contribution that co-ordinated information and documentation services can make in the application of science and technology to development", a paper written for the African Regional Meeting by the Regional Committee for the Development of Information Services in Eastern Africa (P.O. Box 47288, Nairobi, Kenya).

(b) Education at the secondary level shall be provided to 30 per cent of the children who complete primary school;

(c) Higher education shall be provided, mostly in Africa itself, to 20 per cent of those who complete secondary education;

(d) The improvement of the quality of African schools and universities shall be a constant aim. 17/

64. In 1961 primary education in Africa covered barely 40 per cent of the relevant age group, secondary education only 3 per cent, and tertiary education a mere fifth of 1 per cent. In the decade and a half since the Addis Ababa conference, the quantitative changes that have taken place may truly be described as an educational explosion. Between 1960 and 1972, school attendance in Africa almost doubled at the primary level and more than tripled at the secondary and tertiary levels. Total school enrolment in Africa increased from 21.4 million in 1960 to 44 million in 1972, a rate of increase higher than that of all the main developing regions of the world, with the exception of the Arab States (see tables 1 and 2). Table 3 indicates the size and structure of formal education by African subregion in 1973.

65. Despite the rapid increase in enrolment, the increase in the primary enrolment ratio since 1960 is smaller than that envisaged in the Addis Ababa plan. On the other hand, at the secondary and tertiary levels, the expansion of enrolment ratios has exceeded the Addis Ababa plan. Thus there has been a significant switch in priorities away from primary education and towards secondary and higher education. This would not have been a cause for concern if the courses - particularly at the tertiary level - had been oriented more towards national development and self-reliance. Within secondary education, the Addis Ababa plan called for a clear shift in favour of the proportion of students enrolled in technical, vocational and teacher training courses. In fact, the proportion of enrolment in technical and vocational courses appears to have dropped, while the proportion in general education has risen and the proportion in teacher training has remained more or less the same. Similarly, attempts to increase substantially the proportion of science and technology students in higher education have often failed.

66. The very success of quantitative expansion has sharply revealed the inadequacies of the educational targets. Successive conferences of African Ministers of Education held in Abidjan in 1964, in Nairobi in 1968 and in Lagos in 1976 have increasingly stressed the need not just for quantitative and qualitative improvement but for redirection and restructuring at all levels. In the words of the final report of the 1976 Lagos Conference: "The time is no more when Governments feel that educational development can be achieved through the numerical expansion of enrolment in institutions of a conventional nature which would reproduce and perpetuate the aims, content and programmes inherited from the previous generation and from the colonial past. What is now at stake and under way is fundamental rethinking of educational systems so that they can mould the African man of

17/ "Survey of economic and social conditions in Africa 1976 - 1977 (Part I)" /E/CN.14/690 (Part I)/, p. 68.

tomorrow, rooted in the culture of his continent but prepared for participation in the building of a modern and prosperous Africa, contributing towards the establishment of the new world order with the rest of the international community." 18/

Technical training

67. In virtually all African countries, shortages of skilled manpower place serious constraints on development. There are shortages of persons who combine engineering or agricultural expertise with managerial skills, industrial designers, production engineers, engineering draughtsmen, broad-based technology practitioners, environmental designers, quality control personnel, management accountants - to name only a few. Among the skilled personnel now available, there is often an unfavourable ratio of middle-level technicians to professionals, and a general lack of correlation between skill requirements and the training provided. A number of countries have noted these shortages and imbalances, but have been unable to rectify them.

68. Most countries appear not to have adequate facilities for training technicians. This has resulted in shortages of technical personnel, who are therefore in great demand in most African countries.

69. As far as so-called "high-level" professional personnel are concerned, training programmes in engineering have adhered to the tradition of producing civil, mechanical and electrical engineers. Most universities and other institutions for technical training have taken no practical measures to diversify their course options so as to reflect the needs of the economy more accurately. A few universities, however, have introduced innovations which are likely to make training in such institutions more relevant. Such universities as those of Ife and Ibadan in Nigeria, and the University of Science and Technology in Ghana, offer courses in food science and technology, chemical technology, and so on; other institutions, like the University of Dar es Salaam, have incorporated sandwich programmes into their course structures. Such sandwich programmes provide a desirable link between the educational institutions and the "world of work" in industry.

70. Research units and research workers in Africa are often located in the universities, and this imposes on these institutions extremely important functions in the national development process. But, unfortunately for Africa, growth in the supply of R and D manpower from higher education is far from adequate. According to a recent UNESCO survey there are, on average, 480 students in higher education for every 1 million inhabitants in the ECA member States, excluding Egypt. This represents a fifth of the ratio for Asia (excluding Japan and China), a tenth of that for Latin America and only a twentieth of that in Europe (excluding the USSR). 19/

18/ Ibid., pp. 71 - 72.

19/ "Statistics on research and experimental development in African countries (UNESCO document SC/CASTAFRICA/ref. 1), paras. 40 and 46.

71. Over half the students studying at national institutions of higher education are enrolled in the humanities, religion, education, fine arts, law and social science faculties. Engineering and agriculture are the smallest groups of study in most African countries (on average 5.3 and 4.8 per cent respectively). This fact, of course, has dire consequences for the building up of an adequate potential for industrialization, for the mechanization of agriculture, and for economic growth and national development as a whole. (Egypt is an exception to this rule.) In Asia, for example, 10 per cent of all post-secondary students study engineering; in Latin America the proportion is 14 per cent, and in Europe 18 per cent. Similarly, the low percentage of students in agricultural sciences (barring exceptions such as Mauritius) is highly undesirable for countries largely dependent on national utilization of cash crops, as well as on the exploitation of forests.

72. Some countries think that the above situation is righted to a fair extent by large numbers of their nationals studying engineering, agriculture and medicine abroad. This is unfortunately not the case because the number of students abroad is, in absolute numbers, relatively small and because the distribution by field of study of those who study at home and those who study abroad does not significantly differ. It is a fact that for many African countries study abroad is an essential supplement to local education, and that in certain instances (Benin, Central African Empire, Gabon, Mauritius and the Upper Volta) the number of students abroad is several times higher than those in national institutions. But if Egypt is excluded, the ratio of the total number of students from African countries studying abroad (in 50 selected countries in the UNESCO study) to those enrolled locally was approximately 1 to 3.5 including Egypt, where higher education is relatively well developed and the proportion of students abroad is considerably lower, brings that ratio down for the whole of Africa to about 1 to 9.

73. A further aggravating factor for scientific development is that the number of graduates from national institutions of higher learning is very low compared with the population. In 12 countries the number of students graduating annually for every 100,000 inhabitants is 5 to 10, and only in 5 countries does the figure exceed 20.

74. The above statistics leave no doubt that the present situation of tertiary education in African States, with the possible exception of Egypt, does not offer encouraging prospects for the development of R and D on the continent, even when the ratio of students enrolled abroad is taken into account.

B. Science and technology planning

75. Science and technology policy formulation and planning has been making progress in many African countries during recent years. Throughout the continent science and technology policy is now generally seen to have two main aspects: the long-term development of national scientific and technological potential, and the most effective use of this potential to meet development needs. It is accepted that a national science and technology policy should be a reflection of long-term national goals and objectives, and of the over-all economic and social development plan designed to achieve those aims.

76. In practice, nevertheless, few countries in Africa as yet have a science and technology policy clearly formulated in these broad terms. Instead they have an agglomerate of many partial and implicit science and technology policies which, co-ordinated to a greater or lesser extent at the centre, have only very slight impact on the national process of policy formulation.

77. It can be said that over the past decade the intellectual dimensions of African science and technology policy have evolved from a primary concern with the allocation of resources for the support of basic research to a recognition of science and technology as key components in economic development. In any event, a few countries have already included special chapters or sections dealing with science and technology in their over-all national development plans (Ethiopia, Senegal, Tunisia, United Republic of Cameroon and Zambia). The Madagascar plan includes research policy in relation to agriculture, and several others show an appreciation of the value of scientific research by making substantial financial allocations.

Institutional systems for science and technology

78. The types of institution which, at the decision-making level, affect the fulfilment of the objectives of any science and technology policy are, generally speaking, institutions such as the councils of universities, scientific and technological institutes, academies of sciences, national research councils, scientific and technological associations, higher educational programming departments (at the ministry and planning levels) and, in some countries, ministries of technology. The institutions that fulfil or implement the objectives of science and technology policy at the operational level are generally university departments, research institutes and occasionally industry.

79. Institutions at the sectoral level which have responsibility are generally the sectoral planning departments and offices of the ministries of health, housing, industry, transport, works, and so on, and financial and State holdings. At the operational level, policy is generally implemented within the production units themselves (companies, technological institutes, or departments created in the aforementioned policy-making institutions).

80. For most of the countries in the region two central aspects of the institutional problem can be seen. Firstly, government institutions and bodies explicitly commissioned to undertake the formulation and implementation of science and technology policy concentrate primarily on science policy and only incidentally on technology policy. Secondly, even in the absence of an explicit institutional framework for technology policy in these countries, there has been and is an implicit form based on institutions directly linked to production and economic and social planning. The institutional problem is being tackled in some countries, and the inadequacy of the existing framework has been recognized.

81. The designations of the institutions for science and technology policy differ in various countries, but the institutions are quite similar. They are directly responsible to either the President, the Prime Minister, the Council of Ministers or the Ministry of Planning or Education. They are officially entrusted with the formulation of science and technology policy or with assisting in its formulation.

82. A clear-cut institutional distinction between technology policy and science policy has proved much more effective in the advanced countries of Europe. This distinction does not mean that technology policy institutions should be created on an ad hoc basis; on the contrary, this area of policy should be incorporated into an existing institutional framework, or one to be developed, of economic and social planning and implementation. The institutions responsible for formulating and implementing technology policy must, in turn, encourage the establishment of links between the requirements of technology development on the one hand and social and economic objectives and the scientific and technical resources available in independent academic and scientific institutions on the other.

83. In conclusion, it can be stated that the machinery for indentifying, selecting and planning scientific and technological activities is undergoing progressive change, and that there is a tendency to entrust the control and supervision of technological policies to centralized agencies and to endow these agencies with scientific infrastructure capable of providing short-term, medium-term and long-term solutions to the problems of the development and implementation of technology policy.

84. Although the progressive development of the systems and methodology for identifying, selecting and planning scientific and technological activities is geared to the link between these and the structural development of the national economy, no combination of realistic objectives has yet been arrived at in most of the countries, whether formal or even merely stated, allowing science and technology to be developed as a function of coherent objectives at the policy making, manufacturing company, or research institute level. And no evidence has been found of any specific criteria for establishing priorities and allocating resources, whether at the State, sectoral, or even subsectoral or company level.

85. Table 4 shows policy-making policies for science and technology in African countries. Most African countries now have science and technology policy-making bodies, and some others have announced their plans to follow suit. Though considerable scientific infrastructure has been built up with some substantial research and extension activities, often some of these have been based on inherited institutions which are not necessarily best suited to the needs of a country aiming at rapid development. Some countries still find it necessary to rely heavily on foreign-based institutions, staffed largely by expatriate personnel. While these have made useful contributions, they are not readily harnessed to local development needs. Many countries will therefore still need to restructure their research and supporting organizations to form a more coherent force for development. Co-operation with non-African institutions can be useful, but only within the context of strong national institutions.

C. Industrial base

86. With the exception of a few countries, the structure of output in Africa is predominantly under-developed. The large share of agriculture in West and Eastern Africa compared with North and southern Africa is an indication of the low level of industrial development in the Western and Eastern subregions.

87. In 1972 Africa's share of total world manufacturing output was only 0.6 per cent, while its share of the output of the developing world was less than 10 per cent. Further, manufacturing output broke down as follows: consumer non-durables - about 70 per cent; intermediate goods - 15 to 16 per cent, and capital goods, including consumer durables - 14 to 15 per cent. 20/ Thus it can be seen that, with the exception of a few countries in which basic metal industries have been established, some where metallurgy, chemicals and rubber are relatively advanced and some North African countries where chemicals and certain basic metal and metal product industries have been developed, light manufacturing is predominant in Africa at the present time. This is a very unsatisfactory situation when it is realized that intermediate and capital goods industries constitute the heart of industrialization, and hence economic growth, since they essentially shape productive capacities such as skill and technology development, and supply the means of production not only to themselves but to other sectors of the economy.

88. Many countries in the region are now giving increasing weight to the development of specific branches of heavy industry, including cement, non-metal products, fertilizers and other chemical products, in addition to a number of metal products, including table and kitchen utensils, simple tools and implements, or to the assembly of some transport equipment, refrigeration units and other electrical appliances largely using imported parts.

89. However none of the African countries has reached the stage of industrial development where the expansion of industries for heavy consumer goods and the development of intermediate goods industries have not resulted in increased growth in imports for the expansion of established heavy industries.

90. Probably the greater number of imports used in manufacturing are intermediate goods which have not as yet reached the stage of final production by industries in the continent. Africa is, of course, a producer of a variety of the raw materials which go into the making of a long list of intermediate goods which, in turn, are used in manufacturing in the continent. A great number of African countries import from outside the region an increasing volume of intermediate manufactures, the basic inputs of which may have originated in Africa. Africa as a whole is a net importer of leather for shoes, wood pulp for paper, metal products for non-ferrous metals, tanning materials for leather, dyeing products for textiles, and so on. At the same time, it is a net exporter of hides and skins, sawn wood, basic non-ferrous metals (including copper, tin, zinc, lead and aluminium), pigments, indigo, coal-tar dyes and other tanning and dyeing materials, all of which go into corresponding imported intermediate goods. It seems that these input goods could be produced locally from domestic materials, partly for use by the growing industries and also for export at higher values than are obtained from their export in primary forms. It is also evident that intraregional trade in such goods is very limited in extent, which partially explains the lack of co-ordinated development of manufacturing among African countries.

D. Scientific and technological research and development

91. The present state of R and D in Africa will be discussed under four headings: R and D manpower; R and D financing; R and D institutions, facilities and equipment; and R and D projects.

20/ "The African economy-background to the examination of the issues of technology transfer, adaptation and development in Africa" (E/CN.14/ACTT/2/Add.1), para. 30.

1. R and D manpower

92. The most recent study on R and D manpower in Africa can be found in UNESCO publication SC/CASTAFRICA/ref. 1. The situation may be summed up as follows:

93. In terms of the numbers of scientists, engineers and technicians per million population, a majority of African countries possess only about a half to a third of the corresponding numbers in Asia and only a thirtieth of those in Europe. The number of scientists, engineers and technicians engaged in R and D in most of the countries does not exceed 10 per cent of the total; this proportion is roughly comparable to that in the countries of Asia and Europe.

94. No African country has so far achieved the target laid down for the Second United Nations Development Decade in the World Plan of Action: 200 research workers per 1 million inhabitants by 1980. The corresponding targets proposed for Asia and Latin America were respectively 380 and 400 research workers per 1 million inhabitants. As of 1967, most European countries had 1,000 R and D scientists per 1 million population, and this figure has risen considerably since. African countries closest to the target are Mauritius (137), Egypt (84), Gabon (81), Ivory Coast (78), Senegal (77), Kenya (65), Tunisia (62), Congo (60) and Ghana (60). Moreover, these figures include persons of foreign nationality, who in certain countries can represent up to 70 per cent of the number of scientists and engineers.

95. Part-time scientific personnel appear to constitute a considerable proportion of total numbers of scientists and engineers in R and D (48 per cent on average for all the countries surveyed). Generally the natural sciences are represented by the largest group of R and D scientists and engineers (37 per cent in total). Agriculture accounts for 33 per cent of the total, while engineering - a major group required for the tasks of development and adaptation of technology - is one of the smallest R and D groups (9 per cent), and is mentioned in only 20 of the replies from the 36 countries.

96. The higher education sector is the most important employer of R and D scientists and engineers: 55 per cent of the total number. The productive sector employs 36 per cent, and the general service sector only 9 per cent.

97. The ratios of technicians per R and D scientist and engineer are different in the various sectors of R and D performance. In higher education, the ratio is 0.6, in the productive sector 1.6 and in the general service sector 1.5; the average for all sectors is one technician per scientist or engineer. This is a rather low ratio, and highlights the shortage of technicians able to lend effective support to higher R and D personnel. 21/

2. R and D financing

98. In general data on R and D financing in Africa are inadequate. UNESCO records that 10 out of 20 African countries reporting on their level of expenditure for science and technology, in connexion with R and D, stated that they had reached or surpassed 0.5 per cent of their GNP for that purpose. 22/ It is not clear,

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21/ SC/CASTAFRICA/ref.1, chap. II, sect. B.

22/ Ibid, para. 67.

however, whether these countries have reached the 0.5 per cent of GNP target for R and D laid down by the General Assembly in the International Development Strategy for the Second Development Decade. It seems probable that many African countries are still below the 1 per cent of GNP target proposed by UNACAST (0.5 per cent of GNP for R and D proper, plus 0.5 per cent of GNP for the cost of related scientific and technological public services).

99. In most of the countries in the region, government funds constitute the main source of R and D financing, though only a few countries, such as Senegal, appear to identify R and D expenditure as a separate item in the national budget. In some countries, however, the productive and/or service sectors play a major role in R and D financing. To judge by data for a small number of countries, the higher education sector appears to contribute to total national R and D expenditure in widely varying degrees ranging from almost nil to a fairly sizeable percentage. Regional R and D expenditure per R and D scientist (engineer) appears to be in the range of $US 9,000 to $US 20,000; this is considerably below the world average of $US 30,000. Almost all available funds are spent on current expenditure; it is clear that African nations have difficulty in meeting the capital costs of R and D.

3. R and D institutions, facilities and equipment

100. A UNESCO survey of the scientific and technical potential of the countries of Africa provides a list of scientific and technical research institutions in 40 African countries. At the time of the survey there were 722 institutions with a total of 6,048 full-time and 5,045 part-time researchers, or 11,903 researchers in all. There is no doubt that the number of institutions as well as the number of research workers has increased to some extent since the survey. The range of R and D issues which are being dealt with by African institutions is shown in table 5, while table 6 shows the distribution of the research workers who at that time worked in the 722 institutions surveyed. From these tables it can be seen that National Councils for Science and Research have been established in many countries, and that institutions for research, particularly in the field of agriculture, are fairly numerous. 23/ In contrast, R and D activities and institutions in industry are extremely rare, and those that exist seem to be engaged in quality control activities rather than industrial research as such. The great majority of enterprises still rely on the R and D facilities of the parent firms outside Africa.

101. In some cases, where substantial industrial research and development facilities exist, there is still a tendency to shop abroad for manpower and expertise, thus depriving local personnel of the chance to gain experience through "learning by doing", particularly in the field of consultancy. Moreover, the few industrial research and development facilities that do exist often adopt the university laboratory approach to research, leading to publication in international journals rather than commercialization of the research results. There are thus few contacts with industry and the users of technology.

23/ UNESCO document SC/CASTAFRICA/3, chap. I, paras. 59 - 64.

4. R and D projects

102. Africa has for a long time depended on the scientific and technological knowledge made available by the developed countries, mostly because of lack of resources and technical capability. But Africa is now in the process of making up for the scientific and technological lag. When one considers what was accomplished in Pharaonic Egypt, one can easily understand that this lag is a historical accident and that the African, like other human being, is capable of carrying out scientific and technological research at the highest level in order to find adequate solutions to the problems posed by his environment and his development.

103. Considerable interest is now evinced in many African countries in the use of solar energy for pumping water for domestic supply and small-scale irrigation, for cooking, drying, water distillation and so on. The earliest solar pump in Africa was installed in the Institut de Physique Météorologique in Dakar in 1968. Similar pumps are now in operation in Algeria, Chad, Egypt, Kenya, Madagascar, Mali, Mauritania, the Sudan, the United Republic of Cameroon and the Upper Volta, and some are being installed in Cape Verde, Rwanda and the United Republic of Tanzania. The Niger Solar Energy Office (ONERSOL), established about 10 years ago, the Institute of Solar Energy and Related Environmental Research (ISERER) in the Sudan and the Solar Energy Laboratory in Bamako, Mali, have already produced a promising line of samples of equipment using solar energy, such as solar water heaters and solar stills. The Rwanda Centre for Energy Studies and Applications (CEAER) also has an applied research programme on such appliances, including solar refrigerators and bio-diggsters.

104. In the bio-gas production field, research is being conducted by the Inter-African Committee for Hydraulic Studies in the Upper Volta. For more than 20 years a private firm, Fort Therman, has been manufacturing bio-digesters in Kenya. The bio-digesters produce not only methane fuel gas but also excellent fertilizers. The high quality of the Shidge as fertilizer has been demonstrated scientifically by the Coffee Research Foundation of Kenya.

105. Efforts are also being made to use wind energy in Africa, particularly for pumping water for domestic supply and small-scale irrigation. Field and pilot experiments are continuing in many African countries. In Senegal the Physics Unit at the Thiès Ecole Polytechnique is working on the use of wind energy with generators with a nominal capacity of between 13 and 15 horsepower. The object of the work is to identify and solve problems in connexion with the adaptation of the various types of machine already developed. Experimentation on the aerodynamics of wind mills and the production of new types of windmills is being conducted in Ouagadougou, Upper Volta. Work is also being done on a number of problems to improve the operational efficiency of windmills by solving such problems as those related to jamming due to high winds, the best adjustment of the blades, better operation in low wind and increasing resistance to high and violent winds. Locally manufactured windmills have been installed in a number of countries in the region, including Ethiopia, Mali, Senegal, the United Republic of Tanzania and the Upper Volta. Cape Verde has an industry for the commercial production of windmills.

106. In the Ivory Coast and Nigeria, several research projects are under way in the area of agricultural production. Substantial work has been done in agronomic research to improve grain varieties and to study systems of cultivation which will increase farmers' productivity. Researchers in the region are trying to improve local varieties by experimenting with hybrids adaptable to local economic and climatic conditions. Fertilizers and technical equipment are also being tested in this search for greater productivity.

107. Research and development projects on housing, water, power, agro-industries and manufacturing industries are going on in Botswana, Ghana, Kenya, Nigeria, Uganda, the United Republic of Tanzania and Zambia. 24/ In Nigeria the Federal Institute of Industrial Research has promoted the development through local technical innovation of a processing plant for gari (a cassava product). The work involved fundamental research, quality improvement and large-scale production. The Tanzanian Small Industries Development Organisation has embarked on a number of projects for the development and popularization of appropriate technology for small-scale and rural industries. Some of the projects include food processing, building materials and clay products, textiles and clothing and a rural mechanized workshop. The Technology Consultancy Centre in the Kumasi University of Science and Technology in Ghana participates in R and D work by providing technical know-how and assisting in the testing of new products in pilot plants. The Centre also provides technical production, access to credit and improvement of equipment. Similar work is being done by the Appropriate Technology Centre in Botswana and by the Technology Development Advisory Unit (TDAU) of the University of Zambia.

E. Science and technology records, documentation and dissemination

108. The importance of national information systems and their links with regional and world information resources cannot be over-emphasized. Unfortunately, the development of information systems on science and technology in Africa is very fragmentary. One of the tasks of the research worker starting on a project is to obtain as much information as possible about previous work done on the same or related subjects. He can thus reduce the risk of duplicating work already successfully accomplished, and also learn much about methods, instrumentation and results relevant to his own activities.

109. Many thousands of scientific and technical journals and books are published every year, and useful information may be spread over a world-wide range of literature. Information searches may therefore be time-consuming, and special means are necessary to assist the researcher in this exercise. This is the function of the documentation service.

110. The main tasks of the service are: to procure copies of publications specifically requested by research workers; to draw the research workers' attention to literature likely to be useful to them, even though not specifically requested; and to provide translations of material published in languages unfamiliar to the research workers.

24/ See Hans Singer, Technologies for Basic Needs (Geneva, International Labour Office, 1977).

111. Methods used to provide the above services will be adapted to suit particular circumstances. Thus as regards document procurement, much will depend on whether the documentation service is located inside a substantial scientific or technical library or is located close to such a library. In these circumstances, volumes can be lent or photocopies made. If, however, the documentation service is not near such a library, microfilms of the publications may be more appropriate. Literature awareness services may take the form of providing current lists of selected journals, indexes of world literature, abstract bulletins covering particular subject fields, or special bibliographies. A documentation service is a dynamic service, and is not merely a repository of documents.

112. For the efficient operation of such services it is important, first, that the scientific and technical literature held in all the specialized libraries in the country should be catalogued in a unified system, co-ordinated by the documentation centre; and, secondly, that the documentation centre should maintain close links with corresponding centres in both advanced and developing countries, so as to facilitate access to information from all parts of the world.

113. Documentation services can be used to provide publications - including patent specifications and other specialized literature - from any country; they are of obvious importance in the transfer of technology, which is bound to play a large part in the developing countries of Africa.

114. But if one looks at the information services in Africa today, two facts emerge. First there is an almost complete lack of trained documentalists. Some libraries, particularly university libraries, try to perform jobs that should be performed by documentation centres. The activities undertaken by such libraries are generally restricted to reprography. Yet most government departments and parastatal organizations in Africa collect information which must be properly disseminated if it is to be of any use. Secondly, there are very few institutions which can rightly be called documentation centres. One is the former East African Community EAAFRO-EAVRO library at Muguga in Kenya. This is hampered by staff shortages and the great volume of literature in science and technology. Its activities are limted to sending photocopies of important articles published in international trade journals to interested scientists in natural science or technology. 25/

115. Information services in libraries, documentation centres and archives have been slow to emerge in the continent, even though it has long been acknowledged that a rational programme of information service education is vital to innovation and progress. Most of the information work is carried out mainly in libraries of one type or another. There are academic libraries - university libraries, private libraries and public libraries - carrying out information work. As far as training of information manpower is concerned, there is the East African School of Librarianship which was set up at Makerere University in Kampala, Uganda in 1969 and there are Departments of Library Studies in the University of Ibadan in Nigeria and the University of Ghana. However, these institutions do not provide sufficient guidance for their students to enable them to handle science and technology information. It can be said that the lack of trained staff in sufficient numbers is one of the main obstacles to the development of scientific and technological documentation and information services in the continent.

25/ "The contribution that co-ordinated information and documentation services can make...", op. cit., pp. 2 - 3.

116. There is some co-operation among libraries in the continent, and also among documentation centres. Many universities in Eastern Africa co-operate with the co-ordinating Centre for Regional Information Training in its programmes. However, there is not much other co-operation in the field of libraries and documentation centres at the regional level, even though different libraries in individual countries co-operate fairly well. Such co-operation generally takes the form of three activities: inter-library I lending, photocopying and offering duplicates and other publications. International co-operation is mostly bilateral and depends on the type of libraries and the information centres concerned.

F. Emigration of scientific and technical manpower

1. International mobility

117. As was pointed out earlier, Africa suffers from a severe shortage of highly trained scientists and engineers. Consequently the international flows of African research scientists and technologists are not only much smaller than those occurring in other regions, but also their geographical distribution is even more unbalanced than elsewhere.

118. This is due to the language barrier which splits the African continent into two main zones of spoken and printed communication with the international scientific community, and to the strong ties that often link African scientific institutions to similar institutions in the highly developed countries.

119. The above facts, together with the difficulties and high cost of exchanging correspondence and travelling from one African country to another, have certainly influenced and even distorted the pattern of the international movements of African scientists and engineers towards the scientifically advanced countries of Europe and North America on the one hand, and to the African countries using the same language on the other.

2. The brain drain

120. It cannot be said that increased travel opportunities are always beneficial, especially in the case of undergraduate and post-graduate students in science and technology. As seen today, the brain drain is the result of two forces. One is the so-called "pull effect", whereby countries that are short of scientists or engineers attract foreigners; the other is the "push effect", which compels unemployed, underemployed, underpaid or politically harassed scientists and technologists to emigrate.

121. It is neither desirable nor practicable to halt international movements of scientists and technologists entirely; nevertheless countries at the losing end of the brain drain are bound to examine at what stage this depletion of their scientific and technological manpower will cause serious damage to the national economy, remembering that the losses are effectively doubled by the gain of the receiving country, which is usually a more advanced country whose economic objectives conflict with those of the unwilling "donor".

122. The prevailing educational, economic and social conditions in the developing countries combine to intensify the problems of the brain drain. On the one hand,

the number of trained scientists, technologists and technicians, as a proportion of the total population, is generally low compared with the figure for the advanced countries, so that any losses will be felt more acutely. On the other hand, as a consequence of the relatively low level of economic and industrial development, the number and distribution of suitable posts may be insufficient to absorb even this relatively small number of trained personnel. Those not absorbed into science-related occupations naturally seek employment elsewhere, and it is likely to be the most highly qualified among them who will find posts abroad, in more advanced countries.

123. However, it must not be assumed that trained personnel migrating from developing countries all go directly to the most advanced countries. In fact, since the countries of the region are at different stages of development, and the subject distribution of specialists differs from country to country, there is a certain brain drain among the African developing countries themselves.

124. In addition to the adverse effects of the brain drain on the development of science and technology in a country, there are also serious educational and cultural repercussions resulting from the loss of teachers at various levels, and detrimental effects on public health from the loss of medical personnel. Another important aspect of this phenomenon is the political one. By shifting valuable scientifically trained human resources from the less to the more developed countries, the disparity between them will be increased, the technological and economic gap will tend to widen, and the prospects of the less favoured countries for attaining economic and social independence will be reduced.

125. Under various existing technical co-operation and assistance arrangements, there is a substantial number of highly trained scientists and technologists from advanced countries serving temporarily in developing countries. Their presence should be regarded as an interim "brain loan", though indeed one designed to contribute to the strengthening of scientific and technological capacity.

126. To reduce the brain drain an increased proportion of advanced training will need to be provided in the developing countries themselves. More centres of advanced study should be established which will aim for international standards in advanced training and research in selected fields. The attainment of international standards might be facilitated and accelerated by encouraging graduate students from advanced countries to participate in training and research at these advanced centres in developing countries.

G. <u>Current methods for choosing and transferring technologies</u>

127. Almost all countries feel the need to acquire technology for development, which in view of the present low technological capabilities of African countries invariably means importing it from external sources. Most countries are therefore dependent on foreign sources of technology, but few fully appreciate the implications of this technological dependence, which most of the policies pursued in the various countries tend to perpetuate rather than diminish.

128. For example, investment decisions and project selection are often determined by the financing conditions of the external investor/partner, who also invariably selects the technology. The result is that the technology supplier dictates the terms and conditions of the transfer, as well as determining the future patterns

of sources of intermediate inputs and also various elements of the technology. Invariably the source of machinery is tied to the foreign partner. In some cases, both the machinery and technology turn out to be obsolete. In trying to correct this, some countries go to the other extreme and choose ultra-modern technology with its accompanying problems of scale, skill intensity, capacity utilization and lack of markets.

129. A few countries have realized the importance and necessity of greater involvement by national institutions in the process of the acquisition and development of technology. Such countries have established regulatory frameworks to monitor and control the acquisition of technology. Nevertheless, it remains true of most African countries that there is a gap between pronouncements of policy in this field and the translation of such policy into action for strengthening national technological capability.

H. Entrepreneurial and management skills

130. In discussing entrepreneurial and management skills, it is first necessary to define what is meant by a good entrepreneur. In the words of Schumpeter, "the defining characteristic [of the entrepreneur] is simply the doing of new things or the doing of things that are already being done in a new way". And Schumpeter goes on to remark that the new thing "ned not be spectacular" and that the capacity for creative innovation is to be found "even in the humblest levels of the business world". 26/ This concept of creative innovation seems to be inapplicable to most African countries, where so much of business practice involves imitative technology and marketing techniques. Nevertheless, what is important is not pure originality but rather non-routine activity. The capacity for non-routine activity is not, of course, confined to the business world; it is encountered in politics, in community affairs and in the school system.

131. The fact that entrepreneurial business skills involve an element of creative imagination or original improvisation, deriving from a restless search for new opportunities, means that neither the set of skills involved nor the people who have acquired them can be precisely categorized or neatly defined. To set up a tea stand or a repair shop employing one or two helpers calls for quite different entrepreneurial talents from those needed to run a timber yard employing 15 to 20 men with an inventory valued at 10 times the monthly turnover. There are, so to speak, low-level, middle-level and high-level entrepreneurial skills. High-level entrepreneurship needs not only entrepreneurial but also managerial and other skills.

132. In view of the fact that the growth of manufacturing in Africa has generated little additional employment in recent years, the idea has arisen that employment opportunities should be promoted by encouraging the growth of small-scale rather than large-scale enterprises in the informal as well as the formal sector. Some of the recent country studies under the ILO World Employment Programme have in fact given a new emphasis to the employment potential of the informal sector. Unfortunately, African entrepreneurs are limited not only in quantity but also

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26/ P. Manis and A. Somerset, African Businessmen - A Study of Entrepreneurship and Development in Kenya (London, Routledge and Kegan Paul, 1971), p.2, foot-note 1.

in quality, and this is one of the crucial bottle-necks barring the way to vigorous growth of the informal sector in the continent. The limited numbers of African entrepreneurs are partly due to the academic orientation of the educational system, which promotes aspirations for white-collar employment. While the poor quality is due partly to lack of management training facilities.

133. In a recent study of African businessmen, based on in-depth interviews with a random selection of about 1,000 businessmen throughout Kenya, Marris and Somerset found that about three quarters of them had never gone further than primary school and that, of the rest, only half had attained school certificate standard. Since the career structure in Kenya like other African countries) is closely related to educational attainment, these were men who lacked the formal qualifications which would have entitled them to well-paid government jobs, and consequently would have had to fill subordinate posts working to others. They chose a business career because of a sense of frustration that, for one reason or another, they had been prevented from climbing the conventional ladder of examination successes leading to white-collar employment. 27/ Indeed, in some cases, it was the denial of secondary education that seemed to have been the spur to original enterprise. By contrast, the moment a boy has secured a secondary school leaving certificate, he turns his eyes to seeking wage employment for himself, instead of creating it for himself and others.

134. Certainly some form of education is a necessary condition for the emergence of entrepreneurship, although the existence of successful uneducated women traders in the markets of Accra and Lagos makes one wonder if that is true in all cases. It is possible to teach book-keeping, accounting and even specific management techniques, but these are routine skills which do not add up to entrepreneurship. They are more useful for the clerks or managers whom the entrepreneur may engage than to the entrepreneur himself. The Management Training Centre in Nairobi, set up in 1966 with the help of ILO, has experimented with short role-playing courses in starting and managing a small retail business, which comes closer to imparting entrepreneurial skills than any of the highly formalized courses that are found in many of the training centres on the continent. 28/ But even the Nairobi Centre devotes only a small portion of its staff resources to such courses, tailored to the needs of petty African shopkeepers. For the most part, its courses are designed to meet the needs of staff the Government and big business.

135. There are at present many experiments going on in Africa combining productive work experience with schooling at both primary and secondary levels. The United Republic of Tanzania has already made considerable progress in developing the concept of the community school in which children divide their time between work and study, and Zambia, among other countries, is exploring the same concept as the basis for a reform of its educational system. The aim of these reforms is to instil the value and attitudes of "self-reliance", or in other words, to encourage children to seek self-employment after leaving school. Evidence about the determinants of the formation of values and attitudes in children is as yet too rudimentary to allow us to predict the distinct effects on entrepreneurial

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27/ Ibid., pp. 64-66.

28/ Ibid., pp. 221-222.

attitudes such reforms will have. What is almost certainly true is tthat the values of self-reliance are more effectively instilled by the entire culture of a society, which children pick up without even being aware of it, than by any curriculum practices in school. 29/

136. If a country wants to provide entrepreneurship, it is not enough to reform the school system. Even agricultural reform, credit reform, training facilities and the like are not enough. What appears to be most important is precisely what is most difficult to achieve: a major overhaul of attitudes, incentives and economic structures to provide a setting in which entrepreneurship may flourish. In other words, it requires a reorientation of the values of the society and a form of economic organization which confers high status and reward on the person of initiative. The reward need not be financial; it can take the form of recognition and acclaim. What is important is not whether entrepreneurs are rewarded in money or in kind, but that society should recognize the positive value of entrepreneurship. 30/

Training for management

137. In most African countries, the growth of the formal sector has meant rapidly rising demand for management skills. Nowhere is this more obvious than in the public sector, for three main reasons. Firstly, government is the largest single employer in most countries, and its decisions affect a large proportion of national resources. Secondly, the rapid growth of public employment over the past decade, the shift towards State enterprises, and the need for rapid indigenization of senior positions, have meant that middle and senior posts have been available to relatively young and inexperienced persons. A lack of on-the-job experience among many public sector managers has created a need for more training courses designed to teach management skills. A final point of critical importance relates to the low levels of productivity in the civil services of many countries. Governments are increasingly aware that the almost total security of public employment and the system of more or less automatic promotion after entry tends to induce people to seek work in the public sector but does not provide similar incentives for better work after having joined the service. The quality of management at the top is often cited as the critical variable capable of improving general standards of public service, in terms not merely of monitoring performance more effectively but also of setting more exemplary standards of work and commitment at middle and senior levels.

138. For all three reasons, there has been rapid growth in the number of management training courses provided in Africa over the past decade. Most of the larger countries now have public service management training institutes

29/ E/CN.14/690 (Part I), pp. 104-105.

30/ Ibid., p. 105.

providing a range of courses designed specifically for public sector needs; and some of the smaller countries offer similar training on a co-operative basis. Moreover, many African universities now offer undergraduate and post-graduate courses in management and administration, and a range of certificate and diploma courses are also available in technical and commercial colleges. Because of the rapid expansion of recent years, there are few systematic evaluations of the effectiveness of these efforts in formalized management training, although their recent rate of growth suggests that most governments view them favourably. Nevertheless, it remains true that managers learn as much by working with experienced colleagues in a well-organized work environment as they do from a formal training course. It is as easy to learn bad work habits as good ones, and for that reason the existing work environment may be critical to an improvement in the quality of management in the public service. Consequently, on-the-job training will remain an essential complement to formal training for management development.

IV. OBSTACLES AND BOTTLE-NECKS

139. In Africa, development is hampered by a host of obstacles and bottle-necks, the identification and elimination of which are an essential prerequisite for progress. The following paragraphs indicate obstacles in eight areas. The areas have been selected because of their special importance in Africa.

A. Institution building

140. The establishment of institutions is of vital importance for the effective utilization of science and technology for development. 31/ In this area, problems exist in the following areas:

(a) Leadership: Inadequacies arise when the leadership of existing science and technology institutions lacks proper training and relevant experience, or changes frequently;

(b) Programmes: Implementation suffers from poor planning, weak co-ordination, and indifferent supervision;

(c) Resources: Financial, physical, human, technological and informational inputs to institutions for science and technology are very often inadequate;

(d) Structure: The structures of institutions and the processes established for their operation and maintenance are not sufficiently streamlined, and often give rise to practical difficulties;

(e) Linkages: The linkages, or exchanges, between science and technology institutions and their environments are weak. Weaknesses exist in:

- (i) The enabling relations with entities that control the allocation of resources needed by the institutions;
- (ii) The functional relations with organizations which perform complementary functions and services as well as those which supply the inputs and use the outputs of the institutions;
- (iii) The normative relations with organizations which incorporate norms and values relevant to the programmes of the institutions;
- (iv) The diffused relations with the public and elements in the society which cannot be clearly identified by membership in formal organizations;

(f) Number: Finally, the number of existing institutions for science and technology is not sufficient. 32/

31/ See Amy G. Mann, ed., Institution Building: A Reader (Bloomington, Indiana, Programme of Advanced Studies in Institution Building and Technical Assistance Methodology, 1975), for full treatment.

32/ Ibid., pp. 17-18.

B. Education and training

141. Advancement in the area of education and training for the application of science and technology to development is impeded by the following obstacles:

(a) Resources: Available human, financial and physical resources are grossly inadequate when matched against the programmes needed for expansion, restructuring and extensive democratization of the educational system;

(b) Planning: Plans for education and manpower training show the following defects:

(i) Lack of policy explicitly spelling out the order of priorities in national educational and manpower requirements;

(ii) Only perfunctory attention given to the factors and magnitudes which need to be considered during planning, as well as absence of precision;

(iii) Weak co-ordination, indifferent supervision and general lack of evaluation and monitoring of programmes of activities;

(iv) Incomplete inventories of available manpower, and inefficient deployment as well as under-utilization of personnel;

(v) Lack of integration with national plans for over-all development;

(c) Curricula: Existing curricula are frequently inappropriate to Africa's special circumstances and requirements;

(d) Environment: The majority (over 80 per cent) of the people live in rural areas, which makes universal provision of education especially difficult;

(e) Attitudes: Some resistance and discriminatory attitudes regarding, for example, the education of women, constitute barriers to advancement;

(f) Brain drain: There is considerable migration of highly skilled and direly needed manpower to developed countries.

C. Transfer, adaptation and development of technology in Africa

142. The obstacles which require action at the national, regional and international levels include:

(a) Lack of clearly formulated policies for science and technology;

(b) Lack of adequate scientific and technological infrastructure;

(c) Lack of criteria to govern the choice, transfer and adaptation of technology;

(d) Lack of information and expertise to evaluate the technology to be transferred and the best means for its acquisition;

(e) Lack of entrepreneurial and managerial skills;

(f) Reluctance of those transferring technology to provide information on technological advances and new technology and to complement that information with adequate technical services and assistance;

(g) Lack of an adequate legal framework within which the parties to a technology transfer transaction can determine their respective rights and obligations;

(h) Lack of information and skills to deal with the many legal aspects of industrial property and licensing and technology transfer agreements;

(i) Scarce financial resources to exchange for technology;

(j) Dependency of the productive sector on imported technology;

(k) Lack of machinery for evaluation of technology alternatives;

(l) Lack of machinery for the identification of technological needs in the light of the objectives of economic and social development;

(m) Lack of adequate information systems in science and technology;

(n) Lack of extension services;

(o) Lack of internal capacity for the choice, adaptation and absorption of technology;

(p) Unpackaging of technology;

(q) Technologies tied to foreign aid;

(r) Inappropriate programmes for education and training of personnel in science and technology.

D. Food and agriculture

143. Problems exist in the following categories:

(a) Weather: There is almost total dependence on natural weather, with the result that delayed, early, excess or inadequate rainfall create problems;

(b) Methods: Prevailing agricultural practices are not only inefficient, but also quickly degrade the soil;

(c) Crop yields: Crop yields per unit area of cultivated land are exceedingly low, leading to serious nutritional deficiencies;

(d) Productivity: The productivity of labour is diminished further by low yield rates of traditional crops;

(e) Crop losses: Considerable losses (over 30 per cent) 33/ are caused before, during and after harvest by insects, animals, plant diseases and poor storage methods;

33/ J. McDowell, "The village technology component in primary health care systems" (a paper prepared for the UNICEF Eastern Africa Regional Office), p. 3.

(f) Technology: In developing countries, agricultural technology has to be labour-intensive, while in developed countries it has become extremely labour-saving, implying that modern technology cannot be taken over as directly in agriculture as in industry. Adjusting agricultural technology to factor proportions in developing countries raises financial and personnel demands far in excess of available resources;

(g) Inertia: Millions of peasants must be induced to use new farming techniques and to raise the level of their technology, which requires a major educational effort ;

(h) Land tenure: Sharecropping and other forms of land tenure are conducive neither to technological changes nor to increases in the quality and quantity of agricultural labour. Land reform aimed at equitable redistribution of land is necessary in some countries, even though this is likely to be resisted by the land-owning classes;

(i) Habits: Feeding habits are so deeply entrenched that difficulties are encountered in efforts to introduce new varieties of crops and other types of food even when the new varieties are more nutritious and have higher yield rates than traditional varieties of food;

(j) Resources: Properly trained manpower (especially agricultural extension workers), financial provisions, and institutions for inducing change in this area are generally inadequate.

E. Housing and urban development

144. The provision of decent and cheap housing as well as the development of urban centres are impeded by a number of obstacles and bottle-necks which include:

(a) Rapid growth of the urban population: this is a threat to orderly growth, as it leads to overcrowding and lack of the most elementary amenities;

(b) Problems of land tenure;

(c) High cost of construction;

(d) Lack of an adequate local building materials industry;

(e) Lack of a comprehensive policy for co-ordinated efforts in the development of the building materials and components industries;

(f) Lack of an efficient and vigorous indigenous construction industry;

(g) Technical and organizational defects in the building and construction industry which impede the economical use of more productive methods;

(h) Lack of standardization and modular co-ordination of structural and non-structural components;

(i) Problem of housing designs, which are conceived with imported materials in mind;

(j) Lack of building regulations and specifications establishing the use of new materials and techniques;

(k) Lack of building materials research;

(l) Shortage of technical and managerial expertise;

(m) Problems of settlement planning and development;

(n) Problems of urban transport: traffic congestion, inadequate and inefficient public transport systems, lack of parking facilities, narrow roads, lack of transport planning;

(o) Problems of the urban environment: waste disposal, pollution (air, land and water), overcrowding;

(p) Problem of repair and maintenance.

F. Health and sanitation

145. In Africa, malnutrition, as well as communicable and parasitic diseases, continue to exact a heavy human toll, especially among infants and children. Problems exist in the following categories:

(a) Access: Large sections (70 to 80 per cent) of the populations have limited (and at times, no) access to public health centres; 34/

(b) Community participation: To achieve wide coverage of the population, health programmes, which should emphasize prevention over cure, must mobilize community participation on a self-reliance basis;

(c) Nutrition: Malnutrition arises from deficiencies caused by insufficiency of food, and also by bad feeding habits;

(d) Traditional medicine: Though still widely used and apparently efficacious, traditional medicine has high risks and has yet to be put on a satisfactory scientific basis. Efforts in this direction are in hand in some African countries, and should be encouraged and expanded;

(e) Attitudes: Superstitions regarding the nature and origin of disease and death still prevail, especially in rural areas. Health programmes (such as primary health care therefore are not understood. Often they are not accepted and sometimes are even resisted;

(f) Diseases: Six parasitic diseases especially plague the lives of people in Africa - malaria, trypanosomiasis, schistosomiasis, filariasis, onchocerciasis and leprosy;

(g) Personnel: The number of medical doctors and sanitary engineers is very inadequate. They must be supplemented with "extension" or front-line

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34/ Primary health care (Afro technical report No. 3) (Brazzaville, WHO Regional Office for Africa, 1977), p. 2.

workers. The approach in some African countries of developing cadres of trained paramedical personnel to operate under the guidance of the few professionally qualified personnel needs encouragement;

(h) Resources: Financial provision and hospital facilities are grossly inadequate.

G. Transport and communications

146. The role of efficient transport and telecommunications services in the social and economic development of a nation cannot be over-emphasized. Unfortunately, in Africa, the development and operation of these services are seriously hampered by a number of obstacles. Some of these are:

(a) Deficiencies in the transport and telecommunications infrastructure;

(b) Handicap of land-locked countries due to poor access to ports in neighbouring countries;

(c) Lack of over-all transport planning and development at both national and regional levels;

(d) Lack of proper maintenance of transport networks and equipment;

(e) Lack of adequate terminal facilities;

(f) Lack of adequate and standard transport equipment;

(g) Lack of standardization of transport network design and carrying capacity;

(h) Irregularity in the operation of transport services;

(i) Lack of expertise and management skills in transport and telecommunications;

(j) Poor national and regional telecommunications networks;

(k) Shortage of telecommunications spare parts;

(l) Inadequate physical facilities, skilled manpower and equipment manufacturing facilities;

(m) Limited resources and inadequate funding;

(n) Inefficient port operations, leading to port congestion;

(o) Inadequacy of national, subregional and regional shipping companies;

(p) Lack of growth and efficient management of national shipping lines;

(q) Reliance on foreign shipyards for ship design and construction and repairs;

(r) Lack of a region-wide transport network linking roads, railways, inland waterways and air services;

(s) Inadequacy of multinational airlines;

(t) Securing ownership of user rights in the manufacture of transport equipment both for construction and for carriage;

(u) Basic technological problems such as differences in the technical specifications of railways, development of modern road construction and maintenance services at suitable cost, improvement of the navigability of inland waterways, and development of technologies for the most efficient handling of cargo at modal interfaces;

(v) Lack of harmonization of domestic, intra-African and other international traffic;

(w) Lack of efficient airport services and facilities;

(x) Low density of Afri an railways (some countries have no national railway or section of international railway);

(y) Poor maintenance of telecommunications networks and equipment;

(z) Inadequate multinational co-operation in the development of river basins and lakes;

(aa) Lack of indigenous research and development activities in the area of transport and telecommunications;

(bb) Problem of construction methods;

(cc) Lack of storage and parking facilities for merchandise and perishable produce, which must await collection by agents or trans-shipment to other destinations.

H. Natural resources

147. The problems in this area are as follows:

(a) Natural resources are not well identified and exploited;

(b) Problems of calibration and maintenance of an increasing range of delicate, complex and expensive equipment for exploration of natural resources;

(c) Limited capability for design, manufacture, repair and maintenance of requisite structures and equipment;

(d) Activities in mineral resources research and exploitation are oriented more to export production to satisfy the needs of consumers in other countries than to the needs of national economies;

(e) The problem of energy development is very complicated, encompassing important technical, industrial and general economic aspects including the necessity for a full survey and evaluation of all available fuel, hydropower and other energy resources which require geological and hydrometeorological studies;

(f) The greater part of the known mineral wealth is exported out of the continent, and too little is actually used for local consumption or for intra-African trade;

(g) Technical problems in the development of non-conventional sources of energy;

(h) Lack of technical and managerial capability in the transmission and distribution of energy to consumers;

(i) High initial investment for power stations;

(j) Insufficient subregional and regional co-operation in the development of hydroelectric and other types of energy.

V. METHODS FOR IMPROVING SCIENCE AND TECHNOLOGY CAPACITY AT ALL LEVELS

A. Development of criteria for the choice, transfer and adaptation of technology

1. The state of technological dependency 35/

148. The capacity of a society to create, assimilate, improve and adapt scientific and technological knowledge, and to use it effectively in development, is based on three interdependent elements. Firstly, there is the knowledge to which a society has access; this knowledge, defined in its broadest sense, encompasses . "to know-what, to know-how, to know-why". The second element is the availability of people with the capacity to understand and use the knowledge productively in development activities. And the third element is the structure and efficiency of the institutions concerned with the development and application of scientific and technological knowledge. This third element consists of:

(a) Centres that generate or assimilate knowledge (R and D institutions, science and engineering departments, etc.), and those that disseminate knowledge (consultancy firms, information services, extension services, etc.);

(b) Users of such knowledge (production enterprises, consultancy organizations, etc.) and their functional links with the centres mentioned in (a);

(c) The institutional and legal framework or system, predominantly in the government sector, whose functions include the establishment of priorities, the allocation of resources and the regulation of, or direct participation in, the interactions between the factors mentioned under (a) and (b).

149. The absence of these complex structures in most of the countries in Africa has led to marked technological dependence, with serious economic repercussions. The symptoms of this dependence are, among other things:

(a) The amount of imported knowledge in relation to the production needs of the African region;

(b) The need to import this knowledge, not as a result of selection based on relative efficiency but as a matter of sheer necessity;

(c) The one-way nature of the flow of knowledge resulting from the lack of specialization on the part of the developing countries in development and management of such knowledge.

35/ This section draws extensively on Andean Pact Technology Policies (Ottawa, International Development Research Centre, 1976), chap. I, pp. 7-11.

150. The effects of the unsatisfactory relationship with other countries as regards technology are loss of control over decision-making in programming, production, and marketing; the frequent import of inappropriate technology; and the weak negotiating power of member countries in the purchase of technology.

151. The causes of the present situation have been discussed in earlier chapters, and must be understood within the general context of the constraints to development. Some of the causes are related to policies or the lack of policies for science and technology in African countries, and these contribute heavily to the scarcity and inefficiency of the use of knowledge in production activities. Two of the most important are the orientation of technological development efforts and the way the African countries at present import technology.

(a) Orientation of technological development efforts

152. The scientific and technological activities carried out in the African countries have been concentrated on the natural sciences and basic research, which, although important, do not cover the whole spectrum of the components of technological development required to satisfy socio-economic needs. More than 70 per cent of all research personnel in the universities or centres that carry out research are in the natural and medical sciences; and less than 10 per cent are engaged in industrial research.

153. As a result of this, and of the relatively low aggregate demand for local technology originating in production activities, two types of brain drain are occurring in the region: an "external brain drain" whereby some of the best scholars that the region can produce are migrating to the advanced countries, and an "internal brain drain" due to the employment of professionals in activities little related to the technological development effort. The present state of affairs cannot be improved simply by increasing funds for scientific and technological activities, even though they are at present insufficient. It is necessary to attach more importance to where such funds are spent; to developing the capacity of the people, enterprises and institutions that utilize scientific and technological knowledge to solve national development problems; and to the specific consideration of scientific and technological inputs by those who plan economic and social development policy.

(b) Import of technology

154. The lack of internal technological capacity has resulted in the import of a considerable amount of foreign technology. A key feature in most of the countries is the "packaging" of knowledge, which has the effect that the technical inventive capabilities of the countries are displaced, or do not develop. In addition, the capacity to innovate by creating a synthesis of different technologies so that they become appropriate for local production processes is also displaced. Consequently, foreign technology is applied without being absorbed by the internal technological infrastructure.

155. The use of imported knowledge has several effects. In the first place, it often ignores the internal factors of production and resources available locally. The increases (if any) in production achieved with inappropriate technology tend to conflict with certain basic development objectives, such as the level of employment. Likewise, the export of products manufactured with imported technology (essential to integrating the national economies with the rest of the world) is severely restricted by the terms under which technology is made available. Moreover, the need to import essential knowledge from abroad, when added to the present patents system, leads to economic and even political power being concentrated in foreign centres, whose objectives and interests do not necessarily coincide with those of the recipient countries.

156. In addition, there are many direct economic costs resulting from the high degree of dependence on foreign technology: for example, explicit payments for technology (royalties for licences and patents) and indirect payments for capital goods (whose purchase is often a condition of the sale of the technology).

157. All the above factors have created heavy technological dependence that holds back the development process in most African countries. As a result, Africa must bear a high opportunity cost in a factor that is critical to growth: the mastering of science and technology and their application in production activities. Internally, this indicates that urgent needs are going unfulfilled. Externally, Africa maintains this dependence, and exchanges products that have a small added value for those complex products that involve paying for sophisticated production factors that enjoy monopolistic profits.

2. Problems in the choice and transfer of technology

158. For most African countries, the most difficult of the problems connected with the transfer of technology is the initial one, namely the selection of what technology is needed. A technology which is suitable in one environment is not necessarily the best for another. A country develops technology mainly to suit its own internal market conditions and needs, and not necessarily for exporting it to other countries.

159. Organizations that have developed significant new technologies are very reluctant to license them except on very profitable terms. Even if these terms are met, the advanced technologies may not be the most appropriate for a particular developing country. The developing countries, and African countries in particular, are at a great disadvantage in selecting what technology to acquire through licensing. First of all, the technologies of the developed countries are not specifically geared to the conditions prevailing in the developing countries, or if they are, it is only coincidental. Also, the developing countries do not have the necessary infrastructure for studying and evaluating the various technologies available; and most of the time they do not even have the information on what technologies are available for a particular job. An organization trying to sell its technology to a developing country will only rarely give such complete and unbiased advice that a proper selection of technology can be made on that basis alone. Very often the result of obtaining advice from such an organization is that its technology and the services of its experts are bought.

160. Many developing countries lack the necessary expertise even to select their advisers properly, and it is not simple to choose an independent and impartial consultant to advise on the selection of technologies. The handicaps are many. The consultant himself may be unfamiliar with the background, the infrastructure and the social conditions in the developing country. Also, his advice is conditioned by the experience he has had and the expertise he has gained in the industries with which he is familiar.

161. Even when the necessary infrastructure exists in a developing country for evaluating technologies, many other handicaps have to be overcome if the best choice is to be made. The Government itself may not have laid down proper criteria for selecting technologies. In many countries, policies for achieving higher living standards have not been laid down clearly or spelt out in sufficient detail to ensure the selection of appropriate technologies from other countries. Furthermore, the concept of appropriate technology is not always understood, and even if it is, its implementation is often inadequate. As a result, inappropriate technologies are often selected.

162. Another major problem in the choice and transfer of technology is that some technologies are tied to foreign aid. A developing country has little leeway in the selection of technology for a particular purpose when the technology is tied. The choice, then, is restricted to the technologies available in the developed country offering the aid. In this way the concept of appropriate technology, the terms on which such technology is transferred, and the leverage that will be exercised by the developing and the developed countries on the whole transaction, are all influenced by the aid that is offered.

163. Separation of technology from aid would be desirable. The developing countries would then be more likely to choose appropriate technology, since they would be in a better position to assess all the technologies available irrespective of their sources.

3. Factors to be considered in choosing and importing technologies

164. Notwithstanding national and regional efforts to create technology, technological resources for the socio-economic development of African countries will for a long time to come depend on technological imports. Even in the more distant future, it may still be advisable to exploit the technologies available on the international market. This is because the need to develop new technology at an ever-accelerating pace has led to a rapidly growing international exchange of technical knowledge, which would help to avoid duplication of efforts and to reduce the tremendous costs which now fall on the recipient industry or country in technology transfer transactions.

165. But in order to gain maximum benefit in acquiring technologies developed and already used successfully elsewhere, the African countries will need to follow certain guidelines in the exchange and transfer of technical knowledge. A few principles to be followed are:

(a) The technology to be provided should be appropriate to conditions in the acquiring country. In some cases, this may mean that the latest and most advanced version should be provided; in others, simpler or more labour-intensive versions would be more suitable;

(b) The proprietor should be obliged to provide, and capable of providing, the needed training of key personnel in the developing country. Some of this training may be given at the headquarters of the proprietor, where the trainee can better appreciate the scope of what is involved. But the greater part of such training should take place in the acquiring country, where the proprietor's instructors can see, at first hand, the best way in which the licensed technology can be adapted to local conditions;

(c) The imported technology should utilize, as much as possible, local resources, including raw materials, labour skills and supervisory personnel;

(d) The activity should make a contribution to the economy of the acquiring country that is greater than mere import substitution. Thus the possibility of producing exports that will earn a substantial amount of foreign exchange should be a goal. In this connexion the existing interests of the proprietor in some of the potential export markets should be taken into consideration;

(e) The import of the technology should have some positive side effects such as encouraging the growth of certain local supporting or supplying industries. On the other hand, such technology should not tend to destroy any cultural, historical or ecological situation existing in the acquiring country that should be preserved. 36/

166. Finally, it should be mentioned that licensing agreements with organizations and enterprises in African countries should contain provisions that can accomplish the transfer of technology efficiently and without creating areas of uncertainty that can become bases for future disagreements. Even if the recipient entity is a joint venture, partly owned by the proprietor, it is wise to define clearly the conditions of the technology transfer in a formal agreement. Such an agreement should define the technology to be acquired or transferred, describe the territory and the degree of exclusivity, provide thoroughly for the technology transfer and training, tailor production to the capabilities and needs of the acquiring country, install strict quality control procedures, provide for a local research and development programme, and establish effective reporting requirements between the parties concerned. 37/

4. Procedure for adaptation of imported technologies 38/

167. The mode of technology transfer can be classified into two major categories:

(a) Different technological elements appear as a package and thus are negotiated as one complete unit, which also comprises foreign provision of other services, equipment, financing, etc., to enter the productive process as a larger package. Here the user has no direct access to the different parts of the imported technology and consequently cannot assimilate, adapt or improve

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36/ "National approaches to the acquisition of technology" (ID/187), pp. 85-86.

37/ Ibid., pp. 86-87.

38/ This section draws extensively on Technology Policy and Economic Development (Ottawa, International Development Research Centre, 1976), chap. VI.

them in keeping with his own needs. As a result, the opportunity to make use of imported technology as an instrument for one's own future technological activity is not provided. This is, in general, the present mode of transfer of technology as applies to most African countries: the technology is neither absorbed nor assimilated, but is merely superimposed on the acquiring country's productive process;

(b) Technology is acquired element by element: first, the technological package is separated from the rest of the project components (equipment, financing, capital contributions, etc.), and, secondly, the technological package itself is broken up into its different elements: basic process licences, basic designs, detailed engineering, specific engineering services, technical assistance for start-up and plant operations, etc.

168. Such a breakdown of technology into its component parts allows for the most comprehensive transfer of knowledge, not only because of the nature of the information transmitted, but also because of the greater need to adapt the manufacturing processes and products to the conditions prevailing in the recipient country. Accordingly the supplier is compelled to undertake adjustments that will entail research and development and thus gradually promote the evolution of technology in the recipient country.

169. Unfortunately, in order to accelerate the development of local manufacturing activities, most African countries have resorted to importing the various technological inputs as packages, with the consequent negative repercussions on technological development and on the economic progress of Africa as a whole. The acquisition of packaged technology has four main consequences.

(a) Suppliers have monopolistic power since the purchasers cannot obtain part of these inputs from other sources. Thus the purchaser's relative bargaining power weakens and higher prices are paid. Furthermore, the import of packages makes it difficult to evaluate and negotiate the best adaptations to local conditions;

(b) The package acquired often includes technological components and other inputs that could be found or produced locally. This reduces the potential demand for several domestic activities - not because these would lack efficiency or availability, but because of the ties within the imported package;

(c) The import of a package impedes proper understanding of its parts. It further obstructs the adaptation or improvement of foreign technology, and thus restrains the development of domestic technology;

(d) Finally, the essence of a package includes the additional capacity to combine the different cognitive elements. This faculty constitutes a special innovative capacity needed to translate different types of knowledge into economically feasible or socially useful processes. It follows that under the package deal, an importer lacks the incentive or even the need to develop his own capacity for combining and applying this knowledge in productive activities.

170. It is clear, then that one of the first steps in the adaptation of technology is the unpackaging of technology. This may take place in several ways:

(a) Breakdown into core and peripheral technologies. The separation of the technology package from the rest of the project's components and the breakdown of the package into its main technological elements identifies two main types of

technology or technological service: the core and peripheral technologies of a product or process (see table 7). Core technologies correspond to that body of knowledge that is inherent in, and specific to, a project, product or process. This type of technology is seen in basic process designs, general equipment or product specifications, operation or performance data, prototypes, pilot plant data, and certain types of engineering designs pertaining to products or processes. Peripheral technologies correspond to a body of elements of knowledge non-specific to the manufacturing of a product or to a process but needed for application of the core technologies in producing goods, service activities, or even in the generation of further knowledge. They relate to engineering services that are not specific to a process or product and may be common to various projects such as calculations in different areas of engineering: soil, foundations, structures, civil, electrical, mechanical, and others. They also relate to detailed designs of production equipment based on data contained in the basic process engineering, which in turn belongs to core technology;

(b) Breakdown of a project into different phases, which include:

(i) Conception and preparation of a project (such as feasibility studies, evaluation and selection of inputs and suppliers, bargaining, etc.);

(ii) Construction and start-up of a plant or project (such as knowledge about basic engineering or processes to be used, about design and detailed engineering, architectural and construction engineering, equipment selection and installation);

(iii) Production (such as basic process technology management; physical, chemical and mechanical features; internal material transport systems, quality control, etc.);

(c) Breakdown according to different units or processes or operations, which may or may not be included in each of the aforementioned phases. For example, an activity like the chemical or metal-working industry might include unit operations for storage, heating, annealing, blending, cooling etc.;

(d) Breakdown of intermediate components or components of a product. In terms of local production this concept is generally described as the "degree of vertical integration" of a product. For instance, in the assembly of a car there are: chassis, engine, and within this, valves, generator, distributor, etc.

171. For any project, product or component, a company or country may choose the degree of breakdown it considers feasible according to the different phases in its execution as well as according to the corresponding processes or operations. The combination of these two factors and their evaluation eventually determine which of these phases it is economically feasible to perform inside the plant, which may be carried out or purchased nationally, and which must be acquired abroad.

172. The successful unpackaging of technology: first, the act of unpackaging or disaggregating projects needs to be undertaken by qualified personnel, and the information generated can be utilized by various types of users. The depth and degree of the process of disaggregation will depend on the complexity involved in each level as compared to the capabilities of the users.

173. The act of synthesis or of combining the segregated elements so as to undertake a productive activity will often require more qualified capabilities than those necessary for the segregation process. This capability of synthesis can be elevated in a proper innovative activity and constitutes a necessary element for the technological development of a society.

174. The immediate consequences of the unpackaging of technology are: improvement of the bargaining power of the user at the time of importing the technology (leading to savings in foreign exchange); the generation of engineering services such as consulting engineering (selection and breakdown of technologies, feasibility studies, etc.), service engineering and back-up of design details, selection and supply of equipment, construction, supervising technical assistance in operation, etc.; a gradual regional orientation with respect to handling of contracts for certain technologies, which will have the important effect of greater participation of local equipment and supplies; the training of the user in the efficient handling of the technological factor in the productive process, which means he can begin to assimilate the technological elements; as a consequence of this last factor, the user may progressively come to know, in depth, the process and the purchased product, and will thus be able to understand the essence of the technology which he uses and which he himself has separated from the rest of the technological package.

175. To progress from the independent application of imported technology to the next phase, which is the generation of technology by adaptation, modification or creation, requires the development of the professional groups that will eventually be in charge of handling the technological factor in their institutions or manufacturing companies. These groups can be drawn from applied research laboratories, planning and development departments, engineering and productivity departments, etc. It will also be necessary to call on specialized technological development services as offered by research institutions that would have to progress simultaneously in various fields, once the breakdown, assimilation, or adaptation of the imported technologies has started.

5. Development of national policies for effecting technological change 39/

176. A national technology policy should include a set of guidelines for action and criteria for decisions. These should ensure and regulate the constructive incorporation of technology into national planning and development.

177. The specific objectives of a national technology policy are to strengthen the capacity to select and apply the technological solutions most suitable for national development, bearing in mind prevailing economic and social conditions in the country; and to overcome gradually internal and external technological constraints that affect freedom of decision-making in national development.

178. It will be possible to obtain these objectives only to the extent that each African country adopts policies at the national level incorporating the following:

39/ This section draws extensively on Andean Pact Technology Policies, op. cit., chap. II.

(a) Planning of technological activities, particularly those directly related to economic activities;

(b) Establishment of measures to stimulate the creation of technology in the country;

(c) Evaluation and selection of imported technology;

(d) Incentives for generation of indigenous technology;

(e) Technological information and documentation services;

(f) In the field of R and D, the establishment of management procedures for selecting projects, monitoring the research process and evaluating results.

(a) Priority areas

(i) Areas of social interest

179. No national technological development effort can encompass the entire range of modern knowledge. The average standard of living of the vast majority of Africans, which is currently low compared with other regions of the world, necessitates selecting and focusing on problems related to nutrition, health and housing. Similar considerations lead to importance being attached to the effects of technology on employment. Social considerations and employment problems underline the importance of technological development in relation to the promotion and improvement of agricultural activities.

(ii) Traditional exports

180. Another priority task would be the improvement of the competitive standing of traditional exports.

(b) Strategy

181. A technology policy that seeks to attain the above objectives should act simultaneously on two specific and interdependent fronts, which broadly stated are the development and commercialization of technology, and the assimilation and proper management of technology by potential users. These two areas require the backing of certain auxiliary activities, which complete the different elements of technology policy. Among these the role of information and documentation services must be stressed.

(c) Institutions 40/

182. To attain all the above policy goals, there is a need to create comprehensive national centres for technology. The precise form of the national centre will be determined by each country depending on its development goals and priorities. The primary role of the centre would be to promote the technological development of the country through such activities as:

40/ See "Interagency Mission on the Establishment of an African Regional Centre for the Transfer, Adaptation and Development of Technology" (E/CN.14/ACTT/1 - E/CN.14/ECO/122), paras. 76-78.

(a) Assisting in the identification of technical needs for a variety of economic activities;

(b) Assisting in the acquisition and analysis of need-based information on alternative sources of technology from all available sources, domestic and foreign, and its dissemination among users;

(c) Assisting in the evaluation and selection of technologies for the different jobs to be done, with the emphasis on decision making, this being the critical stage in the whole process;

(d) Assisting in the unpackaging of imported technology, including assessment of its suitability, the direct and indirect costs and the conditions attached;

(e) Assisting in the negotiation of the best possible terms for imported technology, including arrangements for registration, evaluation and approval of agreements for its transfer;

(f) Promoting and assisting in the absorption and adaptation of oforeign technology and the generation of indigenous technology, linked specifically to design, engineering, research and development;

(g) Promoting the diffusion of technologies already assimilated, whether indigenous or foreign, among users.

183. The centre would also play a part in the training of the different kinds of personnel required, not only for its own operations but also progressively for all those who are involved in the development and transfer of technology.

B. Activities at the national level

184. Since the purpose of improving the national scientific and technological capacity is to accelerate national development, it seems essential to link the discussion to what are widely accepted as being the major factors upon which a country's capacity for over-all development depends. These factors include the following:

(a) Human resources, notably the quantity and quality of the nation's labour force;

(b) Material resources, both in the form of non-renewable natural resources, such as available cultivable land and minerals, and in the form of man-made resources, such as communications and transport systems, power plants, buildings and inventories of raw materials and intermediate goods;

(c) The institutional organization, social attitudes and customs of society. 41/ Precisely how, therefore, should a developing country proceed in order to improve its science and technology in recognition of these factors?

41/ A.I. MacBean and V.N. Balasubramanyam, Meeting the Third World Challenge (London, Macmillan, 1976), p. 45.

1. Need for planning

185. Economic growth in general, and growth in scientific and technological capacity in particular, are subject to the influence of a wide variety of forces, acting often in random and not rarely in opposing directions. When maximum growth rates are desired, therefore, neither of these processes can be left to itself to evolve spontaneously. Instead a purposeful arrangement of the forces controlling these processes must be contrived which so manipulates the forces that the effects they produce are coherent and directed towards desired goals. This realization constitutes the case for planning. And so the first and foremost task towards the improvement of a country's scientific and technological capacity must be the planning of the process by which that improvement is to be achieved.

186. The aim of planning is to engender advancement by co-ordinated State policies. Such policies should:

(a) Be based realistically on valid perceptions regarding the mechanism of advancement which they seek to set in motion;

(b) Keep firmly in view the set of goals towards which advancement is to be directed;

(c) Recognize the set of "initial conditions" from which advancement is envisaged to proceed.

Consideration will now be given to each of these requirements as they relate to the improvement of national scientific and technological capacity.

187. With regard to the first of these requirements - the need to base policies on valid perceptions regarding the mechanism of advancement - it is unfortunately true that an understanding of the mechanism by which the scientific and technological capacity of a developing country can be improved is bedevilled by the difficulty of distinguishing cause from effect. A country is not a laboratory in which test conditions can be controlled and altered at will so as to determine valid casual relationships. Whatever ideas one may offer for the improvement of science and technology in developing countries cannot be entirely free from this disclaimer, and all embody in varying degrees an element of uncertainty - or even error.

188. There are nevertheless some perceptions regarding the growth of science and technology in developing countries which, in the absence of anything better, provide a basis for national policies. These perceptions, some of which are also applicable to development generally, include the following:

(a) A self-sustaining and effective development process must be powered by forces which are essentially indigenous. As a force for development, the national scientific and technological capacity, therefore, must be indigenized;

(b) Development strategy must be intimately interwoven with the fabric of society and must show concern for the consequences of development upon society. This realization should be embodied in any scientific and technology capacity aimed at development;

(c) "Factor proportions" - that is, the relative abundances of the factors of production (capital, labour and natural resources) - are what distinguish one economy from another. Accelerated advancement requires utilization of the least scarce factor, which, in developing countries, is labour, or natural resources, or both. This imposes a natural bias on the scientific and technological capacities of developing nations. 42/

189. There still remain the problems of evolving from the above and other relevant perceptions to concrete and implementable programmes of action, and of executing them to achieve improvements in the national scientific and technological capacity itself. These problems constitute a second tier of obstacles, perhaps more formidable than the first tier mentioned above in connexion with the present state of our understanding of the rules governing the growth of science and technology in a developing nation. One difficulty, Gunnar Myrdal has observed, is an unwarranted optimism which seems to come naturally to planners in developing countries, a testimony to this being the fact that planning there tends to err in the optimistic direction. This leads to disillusionment, which assumes previous illusions. 43/ This is true of development planning generally, but it is especially true of the planning of scientific and technological growth particularly. This and the other problems, however, may be particularized to specific sectors of scientific and technological growth. It seems appropriate therefore to return to this subject later while discussing those sectors.

190. Concerning the second requirement in the planning of scientific and technological growth - namely, the need to keep firmly in view the set of goals towards which that growth is to be directed - it is generally recognized that in principle a country is at liberty to choose whatever goals of scientific and technological growth it pleases. In practice, however, that choice is never entirely unfettered, but is instead limited by a number of factors, both internal and external in origin, Examples include:

(a) The co-existence of extremes of poverty and affluence in any society is a cause for concern for that society. Social inequality is perceived not only as a breach of social justice but also as an inhibitor of development. One goal of scientific and technological growth, therefore, ought to be social, but especially, economic equality;

(b) Although it does not seem to be widely accepted that the quest for equality, apparently accepted within nations, can be extrapolated to the international community, global international interdependence is now widely recognized. Scientific and technological growth must therefore have as one of its aims healthy international co-operation in the spirit of the Declaration and Programme of Action on the Establishment of a New International Economic Order;

(c) Because over-all development must be powered by indigenous forces if it is to reach a stage of self-sustenance, science and technology, as two forces which power development, must be indigenous and their indigenization must be one of the goals of scientific and technological growth;

42/ C.C. Onyemelukwe, Economic underdevelopment: An Inside View (London, Longman, 1974), p. 15.

43/ Gunnar Myrdal, The Challenge of World Poverty (New York, Pantheon Books, 1970), pp. 43-44.

(d) Available resources, both human and material, are the fuel of development and science and technology the engine of development. There is clearly a need to aim scientific and technological growth at effective utilization of available resources.

191. We may now turn to the third and last requirement in planning scientific and technological growth - the need to recognize the set of initial conditions from which scientific and technological growth is to proceed. A major prerequisite for rational planning of development generally, and of scientific and technological growth particularly, is very much improved statistics on the relevant magnitudes. The lack of such information in many developing countries of Africa constitutes an obstacle to effective planning. A second and related problem is that even when accurate information exists, effective use of it is not always made. To a great extent this is due to the absence of systematic efforts to collect, pool and disseminate available information. But it is also due to insufficient appreciation of the value of information generally.

192. Because planning in Africa is often based on inaccurate data, and not rarely on intuitive hunches, regarding initial conditions, serious problems soon surface during plan implementation. These problems may have the unfortunate consequence of persuading the country to abandon what may otherwise have been a sound growth strategy. Indeed, one of the causes of the frequent mid-course changes in plans is the realization that the assumptions made regarding available resources and prevailing conditions were wrong. And so the systematic and continuous collection of data on the magnitudes of relevant local factors is an extremely important national activity.

2. Development of human resources

193. Doubtless the most important single question in scientific and technological growth is how to develop and harness human resources towards scientific and technological maturity. The importance of this question is of course a reflection of the fact that man is both the object and the agent of development - that is, development is aimed at improving his well-being, but that improvement can only come about through his own exertions. This importance amounts to extreme urgency in Africa, where at least 80 per cent of the population does no more than eke out an existence in abject conditions of material deprivation.

194. Paul Hoffman once estimated that "if we took a random sample of 100 new-born children from the world's low-income nations, ... 40 would be dead before they reached 6 years. Out of the 60 survivors another 40 would suffer from serious malnutrition with its risks of irreversible physical or mental damage. Only 12 would complete an elementary education and only 3 a secondary education. When they reached adulthood, at least 20 out of the 60 would be unable to find work or would merely eke out a living with odd jobs". 44/

195. These figures indicate the extent to which human resources are wasted in developing countries. It also points to the necessity of developing those resources and utilizing them in order to improve the prevailing conditions. Human resources may be developed in a variety of ways. These include:

44/ MacBean and Balasubramanyam, op. cit., p. 31.

(a) Formal education, beginning with primary education, continuing with secondary education, and then higher education including colleges, universities and higher technical institutes;

(b) On-the-job training, through formal or informal training programmes in employing institutions, adult education programmes and membership in various political, social, religious and cultural groups;

(c) Self-development, through correspondence courses, reading and informal contacts;

(d) Improvements in the health of the working population, through better medical and public health programmes;

(e) Improvements in nutrition, which increase the working capacity of people, on a man-hour basis as well as over a working life.

The last two - improvements in health and improvements in nutrition - are obviously intimately related. These and the first three may be both a cause of economic growth and a result of it, and this illustrates the coupling between cause and effect referred to earlier in this section. 45/

196. If education, both formal and informal, is regarded as a method of developing human resources for accelerated scientific and technological growth, the colonial era ended by leaving Africa with an educational system ill-suited to African needs. That system was elitist, examination-ridden, general, desk-work-oriented - in short, inconsequential when viewed against the background of Africa's developmental problems. As a result, everywhere in Africa today, educational reform is necessary. The following two facets of that reform are worth considering:

(a) Educational reform should seek an equitable distribution of educational inputs among districts, social groups and the two sexes. The goal of achieving general literacy for the whole population must be elevated to the highest significance;

(b) Educational reform must also critically consider what is taught, with what intention, in what spirit, and with what effect - for instance in respect of willingness to perform manual work.

197. If we briefly consider each of these two facets in turn, and particularize them to the development of human resources for scientific and technological growth, we must first note that literacy, as is widely recognized, is an instrument by which higher skills - including scientific and technological skills - can be acquired. This is why it is essential both to expand it and to democratize it to ensure national growth. Literacy when made available to the whole population has a great multiplier effect on available skills. And as "take-off" in development seems to require an initial "big push", the entire population of the country must participate to the utmost of their powers. Development must be both indigenized and democratized if there is to be take-off. Development pioneered by a small élite, whether local or foreign in origin, cannot set the massive ball of growth rolling - because it lacks the required big push.

45/ F. Harbison and C.A. Myers, Education, Manpower, and Economic Growth (New York, McGraw Hill, 1964), p. 2.

198. In Africa, if a random sample of 100 school-age children is taken, only about 40 of them can expect to receive primary education; the remaining 60 will never learn to read or write. Of the 40 who attend primary school, only about 8 will go on to secondary school; of these 8, only 1 will reach university. 46/ Thus, of the initial 100, about 90 receive only primary education or less. In an environment of near-total illiteracy among adults, school leavers with only primary education are likely to be weighed down and to relapse in time into illiteracy. This points to the great importance of adult literacy campaigns, as a means both of enabling adults to acquire higher skills and of reinforcing their children's education. And here a nagging problem is encountered. Precisely how can the adult segment of the population be given training in science and technology, given that such training requires not only a high degree of literacy but also the provision of many and costly elements of infrastructure such as teaching personnel, laboratories and apparatus?

199. One of the greatest challenges in the expansion and democratization of education - especially scientific and technological education - is the fact that in Africa the scientific and technological potential of women is rarely tapped, and when it is, it is often not used effectively. This is a world-wide problem, of course, but it attains its worst proportions in Africa, as can be seen from table 8. The imbalance portrayed by these figures ought to be an issue high not only on the agenda of women's liberation movements but also on the list of priorities in national attempts at educational reform.

200. Apart from the expansion and democratization of education, educational reform must also address itself to a second requirement - that of effecting change in what is taught and how it is taught. The educational system inherited from the colonial era, as many will concede, was designed primarily to produce functionaries to serve the imperial machine, with near-total disregard of local developmental requirements. Consequently, the nations of Africa are faced with the task of disengaging their curricula from their colonial heritage and giving them a new orientation consonant with local circumstances and requirements. Yet precisely what does this new orientation involve?

201. The majority (80 per cent) of African children who attend school at all (about 40 per cent of all school-age children) never go beyond primary school. Some countries, such as the United Republic of Tanzania, conclude from this that the education given in primary schools must be complete in itself. Instead of the primary school activities being geared to the competitive examination which will select the few (20 per cent) who go on to secondary school, they must be a preparation for the life which the majority of the children will lead. 47/ For 8 out of every 10 children, that life will be on a rural farm. Agriculture must therefore feature prominently in primary education. Similarly, secondary schools must not be simply a selection process for higher education. They must prepare students for life and service in the villages and rural areas. This principle, of course, also applies to higher education. It provides one basis for curriculum reform.

46/ See Education in a Rural Environment, op. cit., p. 16.

47/ J.K. Nyerere, Education for Self-reliance (Dar es Salaam, Government Printer, 1967), p. 15.

202. It has been estimated that, in Africa, developmental activities which are likely to benefit most from the application of science and technology fall in the following sectors and to the degree known by the number of countries, indicated beside each sector, in which such sectors were regarded as most dependent on science and technology:

19 Agriculture	6 Energy
16 Health	5 Environment
12 Animal breeding	4 Education
11 Water	3 Manpower
10 Mines	2 Construction
8 Industry	1 Post and telecommunications. 48/
8 Communication (including transport)	

This provides a second basis for reorienting curricula in Africa towards accelerated scientific and technological growth. Such a reorientation, of course, would have to face up to many obstacles, not the least of which is the inertia which has institutionalized the existing curricula.

203. Concerning the other two ways of developing human resources - improvements in public health and improvements in nutrition - it is recognized that the incidence of disease and malnutrition must affect the well-being of a population. It will also affect their capacity for work, showing up in absenteeism and lack of stamina. It therefore poses a serious problem. The solution lies in action in the following three areas:

(a) Popular education - aimed in particular at passing on practical information on health and nutrition while people are learning to read and write. Here the mass media can be mobilized and used to great advantage;

(b) Public health services - which are democratic in nature and stress prevention over cure while, because of financial constraints, emphasizing self-reliance through appropriate self-help projects;

(c) Agriculture - activities aimed at producing greater quantities of more nutritious varieties of food crops.

3. Development of material resources

204. The preceding paragraphs have dealt with human resources as a specific area requiring certain inputs aimed at triggering scientific and technological growth for over-all national development. We will now turn to a second area - material resources. Material resources include non-renewable natural resources (such as available arable land and the minerals underneath) as well as man-made resources (such as communication and transport systems, and inventories of raw materials as well as intermediate goods). Material resources development involves the following three major activities:

48/ UNESCO document SC/CASTAFRICA/3, chap. III, para. 45.

(a) Determination of available material resources and compilation of detailed and accurate inventories of such resources;

(b) Choice and development of the most appropriate means of exploiting available resources;

(c) Selection of the best ways of using the proceeds from such resources to promote greater well-being.

205. With regard to the first task, it has already been pointed out that a major prerequisite for rational development planning is improved statistics on the magnitudes of the factors of development, including material resources. Such information constitutes the set of initial conditions from which development must proceed. Now it remains only to indicate ways in which this information may be improved with regard to material resources - especially natural resources. Valuable suggestions on this are contained in the chapter of the African Regional Plan on natural resources development. They include:

(a) Elimination of existing deficiencies in mapping and surveying services through the development, expansion and improvement of national cartographic and geological services;

(b) Systematic and comprehensive investigation for minerals aimed at identifying new minerals, estimating the quantity, form and commercial value of available minerals, and recommending, on the basis of laboratory tests and pilot processes, further possible development;

(c) Preparation of a general inventory of the proved, probable and possible reserves of mineral resources as well as an estimation of the inferred reserves;

(d) Development or strengthening of government machinery for co-ordinating national policy on mineral exploration; promoting the mineral processing techniques best suited to the country's mineral wealth; and drafting national mining legislation. 49/

206. The second task in material resources development, the choice and development of appropriate means of exploiting available material resources constitutes perhaps one of the greatest challenges - certainly the most immediate - to science and technology in the developing nations of Africa. Precisely what types of science and technology are best suited to the development and exploitation of the material resources of these nations? It seems appropriate to devote a few paragraphs to this question.

207. There is almost total agreement that developing countries must each develop indigenous scientific and technological capacity. One of the arguments for the indigenization of science and technology (already presented above) is that economic take-off requires a big push which no group of foreign experts can provide, because matched against the magnitude of the inertia involved their

49/ African Regional Plan, op. cit., paras. 54-55.

efforts are miniscule. That push can result only from a frontal attack through active participation of the entire local population. The problems attendant upon the mobilization of the masses for development will be dealt with below. The second argument for the indigenization of science and technology is that science and technology must be tailored to the country's factors of production - notably, in developing countries, human and material resources. As we have dealt with human resources above, we will now turn to the need to select and develop scientific and technological capacity appropriate to the exploitation of the country's material resources, especially natural resources. As minerals have been considered, the main emphasis will be on agriculture.

208. Agriculture is the main activity of 70 to 80 per cent of the population in Africa, and this confers special importance on land as a resource that supports agriculture. Because agriculture requires factors which are generally plentiful in Africa - namely, land and labour - it has naturally come to occupy a central place in the development strategies of many nations in Africa. How, then, can science and technology be best applied in agriculture in Africa? Here there is a special need to consider the problems of low crop yields per unit area, leading to serious nutritional deficiencies; low yield rates of traditional crops; inefficient agricultural methods which quickly degrade the soil; and considerable crop losses caused by insects, animals, plant diseases and poor storage methods.

209. Valuable suggestions towards the solution of these problems are contained in the chapter 3 of the African Regional Plan on food and agriculture. They include the following:

(a) Conservation and improvement of land already under cultivation as well as development of new land;

(b) Water development for irrigation;

(c) Genetic improvement of main crops and animals;

(d) Better protection of crops and animals;

(e) Research, development and use of improved agricultural techniques for both traditional and new crops;

(f) Better storage and preservation of agricultural products. 50/

210. In agriculture, there is so much scope for the wider application of known techniques, involving hardly any capital investment, that, in the initial period at any rate, progress can be very rapid. Why, then, has progress in African agriculture been slow and uncertain?

211. First, there is the fact that agricultural technology in developing countries has to be labour-intensive, while in developed countries it has become extremely labour-saving. This implies that in agriculture modern technology cannot be taken over as directly as in industry. Adjusting agricultural technology to factor proportions in developing countries therefore becomes very important. The various research tasks which must be performed in order to adapt modern technology to the circumstances of developing countries, however, raise demands on financial and personnel resources which cannot be met by the developing countries themselves - certainly not on a scale equal to the needs. This obstacle represents one of the strategically most important requirements for foreign aid from the developed countries.

50/ Ibid., para. 100.

212. Secondly, even when agricultural techniques (such as artificial insemination of cows, use of fertilizers, and so on are directly applicable, there is still the fact that millions of peasants must be induced to use the new techniques. Inducing them to do that, and getting them to raise their technology from the present primitive level, requires an educational effort of gargantuan dimensions. This difficulty is compounded by the fact that it is almost never a question of learning to do one specific thing in a new way, but of accepting and giving effect to a whole package of induced changes. For example, irrigation becomes really effective only in a system of double or triple cropping. In the same way, fertilizers are largely ineffective without water, while in turn irrigation does not pay except in conjunction with fertilizers. Likewise, improved seeds require both water and fertilizers. This rule of "complementary changes" is valid for all other improvements of agricultural technology: deeper ploughing, soil conservation and improvement of soil structure, green manuring and the use of natural fertilizers, better weed control, plant protection, improved crop rotation, and so on. 51/

213. Thirdly, widespread sharecropping and other forms of land tenure are conducive neither to technological change nor to increases in the quantity and quality of agricultural labour. Land reform aimed at equitable redistribution of land may be necessary in some African countries. Such reform, when undertaken, should be carried out in the full realization that it is likely to meet resistance from the land-owning class and that, when forced through, it is likely to depress agricultural productivity initially by creating immobilizing uncertainty among the land-owning class who, up to that point, will have been the most productive segment of the population. But there is one requirement which all types of land reform should meet: it should create a relationship between man and land that does not thwart his incentives to work and to invest - if nothing else - his own labour. Attempts to improve agricultural technology and to raise yields will never have significant results if that relationship is not firmly established and assiduously protected. 52/

4. Social organization and attitudes

214. The institutional organization of African societies, as well as the attitudes, customs and values of those societies, constitute a third and final area for activities aimed at scientific and technological growth - and so also at economic growth generally. It seems useful to divide these activities into the following two broad categories:

(a) Activities aimed at changing the organization of society as well as the attitudes and customs of that society so as to pave the way for more effedtive application of science and technology towards development:

(b) Activities whose aim is to change science and technology - at any rate certain aspects of their application - in response either to existing social values which must be preserved or to some undesirable aspects in society which must be eliminated but which for the time being nevertheless exist and need to be reckoned with.

215. For the first group of activities, two strategies seem possible. The first aims at changes which can be effected either by simple administrative action or by legislative enactment. Examples of such changes include:

(a) Desertification of society in order to ensure more equitable use of the country's endowments, facilities and services;

51/ Mydral, op. cit., p. 99.

52/ Ibid., p. 114.

(b) Reorganization of government to produce a problem-solving social system in which decisions are made and carried out at the appropriate level and in which effective linkages exist between the different levels of government;

(c) Persuasive and reasoned - but firm - prohibition of irrational practices (even when sanctioned by tradition) and enactment of others which are rational and fruitful.

216. All social reform, of course, bristles with violent tensions and emotions, and inspired leadership, untainted by suspicions of corruption, favouritism or bad intentions, would seem to be an essential, though minimum, requirement if social reform is to be forged by administrative strategy. In any case, this strategy is best suited to producing changes in social organization. It is near-powerless against social attitudes and customs. Changes in these are best sought from a second strategy - education - which is considered in the following paragraph.

217. One of the important fruits which science has yielded is the emencipation of men's minds from ancient superstitions in which barbarous practices, irrational beliefs and oppressive fears are often rooted. Science has also undermined the intellectual foundations of moral and religious dogmas, weakening in the process the protective cover that the hard crust of unreasoned custom provides for the continuation of social injustices. Finally, and more generally, science has given birth to the gradual development among increasing numbers of a questioning intellectual temper toward traditional beliefs, a development frequently accompanied by the adoption in domains previously closed to systematic critical thought of logical methods for assessing on the basis of reliable data of observation the merits of alternative assumptions concerning matters of fact or of desirable policy. 53/ It is clear from this that science education offers the best strategy for changing social attitudes and customs. This strategy would, of course, have to face up to the challenges already outlined in earlier paragraphs. Such challenges are many and formidable, and they must often seem almost impossible to solve. But the situation in most of Africa is so desperate, and the need for accelerated growth so urgent, that steady and unremitting assaults on these challenges must nevertheless be made.

218. We may now turn to the second group of activities for scientific and technological growth, the aim of which is to change science and technology - at any rate certain aspects of their application - in response either to existing social values which must be preserved or to some cultural elements which are recognized to be undesirable but which for the time being exist and must be reckoned with. The realization that there exist certain elements of African culture which must be preserved and certain others which must be eliminated but which still persist and hamper direct use of technology from the developed world is, of course, one basis for the call for activities aimed at the adaptation of technology from the developed world.

219. There are three strands running through such activities. The first has to do with values which are perceived by the developing nation as being at the heart of the national ethos and, as such, inviolable. Although these values may ultimately be arbitrary, the decision to preserve them nevertheless imposes certain constraints on the application of science and technology. This must be tampered by progmatism, which is the second strand, and entails coming to terms with harsh realities which may preclude the achievement of some social goals and indeed necessitate

their review and revision in the light of what is realistically possible. Development is clearly ill-served by dogmatic insistence on unrealizable social goals which closes all alternative avenues of growth. The third and final strand is social psychology. In Africa, development entails a drastic departure from the familiar past and present, and entrance into an uncertain future. Feelings of uncertainty and insecurity are but natural, and there is clearly a need to show compassion and understanding in enforcing all activities aimed at effecting the transition. This realization must be embodied in the use of the technology that is to be applied in the developing world.

C. Activities at the regional level

1. Building up and strengthening institutions for science and technology in Africa

220. Because of Africa's late start in industrial development manufacturing industry suffers disadvantages essentially due to lack of skills (entrepreneurial, technical and labour), the shortage and relatively high cost of capital, limited internal markets unable to absorb consumer, intermediate and capital goods, and technological and financial limitations. There is, however, great potential for change that can result from the application of science and technology to the production system. Therefore African countries still have an opportunity to give a new direction to industrial development in the region through the formulation and adoption of an integrated economic and technological development policy. To achieve the above objective requires the provision of an adequate institutional framework to guide and nurture technological development on the continent. Institutions are needed at the regional and subregional levels to complement the efforts of national institutions in this direction. World advances in knowledge are now so rapid, pervasive and comple , that no small country can hope to master all relevant aspects. There are also scientific and technological activities, because of the limitations imposed by scarce resources, might not be feasible for one country alone, regardless of their importance to the development process. Combined efforts in intercountry projects, shared costs and co-ordination at the subregional or regional level would help to overcome such constraints.

221. Many African countries face similar problems with respect to technological development, and the growing interdependence of the African economies, especially in such areas as food, transport and telecommunications and education, calls for joint action in tackling these problems. Such action would increase the negotiating power of each of the member countries, since they would present a united front when purchasing foreign technology. In view of the vital role of technology in industrial activities, effective means of acquisition, assimilation, generation and use constitute an important element in the advancement of both internal technological capacity and the total development process.

2. Regional research centres

222. Progress in the application of science and technology for socio-economic development has been very slow in most African countries. This is borne out by figures relating to expenditure on scientific and technical research, which are extremely low in comparison with the amounts spent by the more developed economies.

223. The absence of tangible efforts in this direction is due to the fact that the process of import substitution, adopted by many countries as a way of solving the problems of under-development, did not lay proper emphasis on the vital need for such efforts. Over-dependence on imported technology restricts the use of certain natural resources, slows down general development and is an obstacle to the export of manufactures. This is because research which led to the development of technology in the developed countries concentrated on their own problems, which rarely include the exploitation of local natural resources; indeed, such research is often directed towards replacing raw materials imported from these regions. Moreover, their efforts are unlikely to be relevant to solving the problems arising from the combination of factors of production in developing countries. Besides, the technological dependence of African countries is likely to discourage exports of manufactures, since in most cases such exports are possible only where there are differences in type, quality, costs and prices, which frequently call for ad hoc research studies.

224. Accordingly, the importance of research for industrial development cannot be over-emphasized. It has been fully recognized by the developed countries, whose governments deliberately use scientific and technological research as a promotional tool.

225. It is clear that a number of research centres should be established at both subregional and regional levels to conduct and guide research into some of the problems of technological development on the continent, and particularly problems which ignore national boundaries. Research projects in these centres should be relevant to the needs of the continent. Initially, they could include development of solar energy, thermochemical energy (fuels and combustion), tidal energy and wind energy, meteorology, nutrition, food processing and preservation, agricultural mechanization, fisheries, water supply, irrigation, tropical medicine, and so on.

226. The regional research centre or centres would work in co-operation with national research centres, institutes and universities and interested international agencies in focusing attention on the most urgent technological problems in the region. It or they would be responsible for the co-ordination of scientific and technological research (including promotional and financing functions). Here it is important to recognize that various methods can be adopted for co-ordinating research, such as fellowships and grants to individuals; grants for research projects or programmes; grants to research institutions; and research contracts.

227. The regional research centre or centres would also assist in the formulation of regional science and technology policy. While the formulation of policy will remain primarily in the hands of national science policy bodies and the Regional Centre for Technology, the research centre or centres can also play a part in the process by conducting studies and surveys to obtain the necessary background information.

228. The centre or centres would also help with dissemination of scientific and technological information by organizing symposiums and scientific and technical congresses, publishing journals and reports, and providing documentation services such as abstracts, translations, document reproduction and retrieval.

229. In carrying out its tasks the centre or centres would need to pay particular attention to the need to maintain a balance between applied research and fundamental research, and the need for balanced development of the research network. Co-ordinated development of the institutions and laboratories constituting the regional research network is therefore necessary, since the activities of these establishments are interrelated by virtue of their subject matter and by their common interest in contributing towards the development of the region as a whole. High priority should be given to scientific activities for which the region has unique research opportunities, such as tropical medicine, tropical agriculture, solar energy, and so on; in this way the region would be more likely to retain its outstanding scientific workers and even to attract some from other, possibly more advanced, countries.

3. Regional patent documentation centre

230. Industrial ventures of all kinds are dependent to a great extent on an unhampered flow of information from all fields of industrial knowledge and experience. This flow should include information on know-how and techniques, processes and equipment as well as legislative and administrative measures.

231. The industrially advanced countries sustain powerful and costly research efforts in all branches of science and technology to ensure a continuous output of new ideas for the benefit of their industries. To ensure rapid transfer of research results to economic exploitation, they have devoted more and more attention to the establishment of effective devices for storing and evaluating scientific and technical knowledge and communicating it to industry. The amount of new knowledge needed by the African countries at this stage of their development is extremely small compared to the enormous body of accumulated knowledge and experience readily available for use in the developed countries. What is required, therefore, is an adequate communication system to link areas in the process of industrialization to the well established and highly developed technological information network of the industrialized countries.

232. The main prerequisites for a technical information service are local awareness of the value of an up-to-date information service, particularly among industrialists, and an adequate, accessible collection of technical material in the care of an efficient librarian.

Patents

233. Patent literature is one of the most valuable information sources of a special type. The patent is a juridical certificate establishing the rights of the inventor or his legal successor to monopoly use of the invention for a specified term. A patent description includes a basic description and the typical features of the new device, product or chemical compound and its principal units and components, as well as an explanation of their functions and interaction; the value of the patent specification as an information source is based on the fact that, as a rule, the data contained in it are unknown to a wide circle of users. An application for a patent is forwarded before any publication appears concerning the invention, and usually before industrial application has taken place.

234. Regular study of patent information prevents wasteful effort on technological problems that have already been solved, and makes it possible to proceed, taking into account the existing solutions and the main tendencies of technological development, to work on the most recent level of world experience.

235. These considerations make it advisable for Africa to set up as soon as possible a regional patent documentation centre. Its tasks would be not only to collect but also to analyse and disseminate scientific and technological information. Arrangements should also be made for local services to provide effective links between users and sources of information, so as to assist in the identification of information needs and opportunities, identify and select appropriate sources and motivate users and potential users.

236. The centre should act in concert with African governments in promoting the spread of technological information by such actions as the abolition of customs duties and levies on technical books and magazines. Finally, the centre should offer support for the national development of scientific and technological information by helping interested governments to set up national information systems and if possible by subsidizing the cost of production and dissemination of technical literature.

4. The Regional Centre for Technology

237. An Interagency Mission on the Establishment of an African Regional Centre for the Transfer, Adaptation and Development of Technology was recently organized by ECA and OAU. In its report, the mission took note of the desire of African countries for assistance in solving various problems, including in particular:

(a) The need for assistance in institution building for transfer of technology;

(b) The training of skilled manpower in the analytical and technical aspects of transfer of technology;

(c) The establishment of information systems for more efficient and rapid access to technology;

(d) Specialized advisory assistance in such areas as negotiation and the legal aspects of transfer of technology.54/

238. At a Meeting of Plenipotentiaries held in November 1977 in Kaduna, Nigeria, the recommendation of the mission that a Regional Centre for Technology should be established was accepted, and agreement was reached on the constitution, work programme and finances of the Regional Centre for Technology. The centre would have as its primary objectives the strengthening of the technological capabilities of African countries so as to reduce their technological dependence, promotion of the use of appropriate technology and the formulation of technology policies and planning as an integral part of national socio-economic development. The centre would also aim at improving the terms and conditions for the import of technology,

54/ E/CN.14/ACTT/1 - E/CN.14/ECO/122, para. 82.

promoting an appreciation of the role of technology in national development and promoting regional co-operation in the field of technology through assistance in institution building for the transfer of technology, the training of skilled manpower, the establishment of systems for more efficient and rapid access to technology and specialized advisory assistance in such areas as negotiation and the legal aspects of technology transfer. 55/

239. The principles and functions of the centre as set out in its constitution are very laudable and are in consonance with the needs of Africa in the application of science and technology. The establishment of the centre comes at an opportune moment, and it is hoped that African governments will rally round to make it a success. The centre will need to be strengthened through adequate and timely moral and financial support.

240. For the effective performance of its tasks, the centre will need to establish linkages with national centres for technology, regional research and development institutions, regional and national education and training systems, and so on.

5. Regional training centres

241. One of the greatest constraints to socio-economic development in Africa is the shortage of skilled manpower: professional engineers, technicians and craftsmen. The training of manpower is an area in which there can be fruitful regional and subregional co-operation in Africa.

242. African countries must realize that the availability of scientific and technological skills in any society largely depends on physical and intellectual skills, the acquired knowledge, know-how and problem-solving competences of their peoples. It is therefore imperative that appropriate attention should be paid to, and adequate action taken in, a priority area of training. Any policy on manpower training should ensure primarily, although not exclusively, that a core of competent middle-level scientific and technological manpower will be available after training to provide support services to competent professional staff in the production of goods and services.

243. Co-operation in manpower training and development should lead to the establishment of regional training centres for professional engineers, technologists, technicians and technical teachers. To start with, the following regional training centres should be established:

(a) An Institute for Higher Technical Training and Research;

(b) Multipurpose Colleges of Arts and Technology;

(c) Centres for Mineral Resources Development;

(d) Centres for Marine Science and Technology.

55/ "Report of the Meeting of Plenipotentiaries on the African Centre for the Development, Transfer and Adaptation of Technology" (E/CN.14/ACTT/12/Rev.1), annex, arts. 2 and 3.

244. The Regional Centre for Industrial Design and Manufacturing, whose establishment is also recommended, is dealt with separately below. The curricula in these institutions should be tailored to the needs of the African countries, and there should be a co-ordinated and comprehensive programme of laboratory work so that the students can gain genuine understanding of theoretical principles and at the same time acquire the necessary facility to manipulate equipment, conduct experiments and assess the results.

245. Practical professional training should form an important part of the training at the centres. To make the programme of practical training effective, senior members of the staff should co-operate with senior personnel in industry. In addition full-time training and placement officers at the centres and training and education officers in industry should co-ordinate and guide the trainees' day-to-day activities. In-plant training should be spread over the period of the course in three phases, namely: familiarization with industry and industrial problems; participation in work in a particular industry; and training in supervision. Such training will give a production and design orientation to engineering studies, and will enable the students to assume professional responsibilities more quickly after completing their courses.

246. Other courses in addition to in-plant training can be organized in co-operation with industry. Modern technology is changing rapidly, and the technological outlook of staff working in industry is liable to become outdated. The regional centres can usefully organize short-term refresher courses on locally-important aspects of technology.

247. Another possibility is for the centres to organize post-graduate diploma courses with the co-operation of the industries concerned. This can be done in co-operation with universities in the region, if the centre lacks physical and manpower resources. Examples of such courses could be dock and harbour engineering, heat treatment technology, furnace technology, plastics technology, and so on.

248. Suitably qualified staff members of the centres should be encouraged to work as consultants with industry, and thus become better acquainted with practical engineering problems. This is an excellent way to keep the level of teaching high, and to attract and retain highly qualified staff.

249. Rural economy and agricultural production play a very important part in the life of most African countries, employing a large fraction of the population and contributing a large part of the national income. The application of science and technology is required for the effective utilization of natural and human resources and the imporvement of agricultural methods. The problem here is how to disseminate scientific and technological knowledge to the rural areas, and this requires the training of specialized staff. It requires the establishment of training institutions, probably located near rural areas or farming centres, and offering courses necessary for industrial and agricultural occupations in a particular subregion. The programmes should include training in agricultural extension services. Since agriculture is constantly evolving, those who disseminate knowledge or provide technical services must have a sound knowledge also of the scientific and technical bases of agricultural practice.

6. Regional Centre for Industrial Design and Manufacturing

250. A particular technology is usually the outcome of activities designed to solve a production problem at a particular time in response to a defined need and using available resources and capabilities. The search for new or improved processes and products, commonly referred to as research and development (R and D), is most often conducted in research laboratories designed specially for this purpose. Whatever the ownership of such institutions, the essential requirement is that the outcome of R and D activity should be capable of meeting an identified need at a cost acceptable to those for whose use the technology is intended. The pattern of R and D in one country is thus not necessarily wholly coincidental with the pattern of R and D in another. The pattern of R and D in advanced countries in general, and even more significantly the trends in that pattern, are only partially relevant to the needs and resource availabilities of developing countries.

251. It is therefore necessary for the countries of Africa to undertake R and D relevant to their physical conditions, cultural background and resource availabilities. There is consequently a need for a Regional Centre for Industrial Design and Manufacturing. The regional centre can help, firstly in promoting the establishment of facilities for education and training in engineering (and industrial) design, now conspicuous by their inadequacy in Africa; secondly, in freeing the content and orientation of such education and training from the cultural, resource and economic barriers built into design concepts and processes in advanced industrial societies; and thirdly, in ensuring that education in design is not atrophied by separation from the challenges and realities of production.

252. In addition, the centre should include among its functions:

(a) Engineering and industrial design (including design analysis and preparation of sketches, photographs, blueprints, design models and prototype designs);

(b) Materials testing and research;

(c) Tool design and production;

(d) Pilot plant design and construction;

(e) Standardization and quality control;

(f) Time study and cost evaluation;

(g) Extension and consultancy services;

(h) Education and training.

253. Thus the centre would be physically a large engineering research and development laboratory-cum-workshop, and would be expected to assist in setting up national and sectoral centres. It would need to co-operate closely with the Regional Centre for Technology. It could provide consultancy services to the regional and national centres for technology in such matters as unpackaging of technology and advising on the possibilities of adaptation or of new developments which can make imports unnecessary.

D. Activities at the international level

1. Improvement of current schemes of international co-operation in science and technology

254. In the developing countries, national efforts towards scientific and technological self-reliance are often frustrated by barriers whose elimination raises demands far in excess of what the nations themselves, acting severally or collectively, can possibly muster. Therefore, while it may be true that "in final account, it is only the strengthening and establishment of scientific and technological capacity by developing countries themselves, using their own resources, that may solve the problem of their technological development", 56/ in the initial stages of development, assistance from the developed nations is not only necessary but indispensable.

255. The Declaration and Programme of Action on the Establishment of a New International Economic Order /General Assembly resolution 3201 (S-VI) and 3202 (S-VI)/ recognize this fact. Among other things, the Assembly called for measures designed to eliminate the widening gap between the developed and the developing countries and ensure steadily accelerating economic and social development and peace and justice for present and future generations, and provided a framework for assistance from developed to developing countries. But it is necessary to be realistic and to bear in mind the actual motives behind such assistance.

256. The factors which motivate assistance of the poor by the rich nations are of course many and varied. Chief among them are:

(a) Moral obligation. Increasing numbers of people in the developed nations regard "the problem of the less-developed nations" as "the moral problem of our time". 57/ The challenge to reduce inequality, already widely accepted within nations is being extended to the international community;

(b) Self-interest. The greater part of "aid" takes place under the incentive of commercial or political gain. Even when its terms are "soft", often it aims, for example, at subsequent exports on normal commercial terms. Capitalist nations must eventually arrive at a stage where they cannot absorb all of the output of their industries. They then require, in order to stave off a crisis, to extend their markets through the development of colonies which will absorb the surplus manufactures; 58/

56/ "UNCTAD's programmes in the field of technology and science" (a paper specially prepared by the UNCTAD Transfer of Technology Division at the request of the Secretary-General of the United Nations Conference on Science and Technology for Development), p. 2.

57/ Zbigniew Brzezinski, "A new focus for US foreign policy", Dialogue, vol. 6, No. 3 (1973), p. 62.

58/ MacBean and Balasubramanyam, op.cit., p. 7-8.

(c) World peace. The rich nations have a great deal to lose as a result of serious wars between developing countries, which may draw them into conflict with each other. Aid is sometimes given in order to ward off this spectre. Moreover, access to literacy, circulation of newspapers, the impact of mass communications, increased political participation - all of these are more rapidly transforming the way people think than economic growth is transforming the way they live. The consequence is a heightened awareness of global inequality. Aid to the poor is seen to be necessary if the intensified social strife and global animosity, which are certain to be the results of that awareness, are to be avoided; 59/

(d) Common problems. As a result of the global interdependence among nations, there exist particular areas of economic and social progress (for example, population control, development and maintenance of non-renewable natural resources, international division of labour along lines of comparative advantage, joint ventures in developing countries by private firms, and so on) which give scope for co-operation between developed and developing countries;

(e) Interest groups. Pressure groups - such as transnational commercial firms, church organizations, and so on - may, and often do, agitate for aid programmes.

257. Two observations may be made about these factors. First of all, most motives behind aid have to do with self-interest either directly [factor (b)] or indirectly [factors (c) to (e)]. A corollary to this is that, whenever the donor's interests are at serious variance with those of the recipient country, serious conflict may ensue.

258. Secondly, in practice, the motives for aid do not seem to be especially compelling, either singly or together. The aid contributions actually made are - with a few exceptions, such as Sweden - miniscule (less than 0.5 per cent of the national income in the case of the United States). Even moral obligation, which perhaps ought to be the strongest motive, seems fraught with uncertainties. Is there in practice a likelihood that rich nations will feel a strong obligation to assist the poor nations? The answer to this is not clear - especially since a high standard of living is rarely seen as being dependent on having someone poor to exploit and look down upon.

259. Each of these two observations has had a far-reaching influence on aid policies. The first has led to the multilateralization of aid, whereby aid is channelled through multilateral agencies - notably within, but also outside the United Nations system. This has the consequence of eliminating the tying of aid to the interests and caprices of the donors. It has the additional merit of freeing the donors from the problems of how to allocate aid among the developing countries and, within countries, as between various projects and sectors. Advantageous though it is, this scheme has major, if correctable, drawbacks. First, it tends

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59/ Brzezinski, loc.cit., p. 63.

to breed a bureaucracy which is slow in responding to demands and resistant to evaluation and change. Secondly, a considerable part of the assistance tends to be abosrbed in overhead costs, producing generally low cost-effectiveness. These problems point to one area of possible improvement in multilateral assistance.

260. The second observation has led to a shift in emphasis towards aid programmes designed to strengthen self-reliance in the recipient countries. When regarded in per capita terms or as a proportion of the total gross national product of the developing nations, aid is not very significant. It has been estimated to amount to only about 10 per cent of total domestic capital formation in developing countries.60/ Nor is foreign aid a sufficient condition for growth. Other factors (e.g. the general level of skills, managerial capacity, administrative capacity, law and order, social attitudes, etc.) are as important as capital. If they are absent, capital will be wasted.

261. The shift in the emphasis of assistance programmes towards the strengthening of self-reliance in the recipient countries is gaining wider and wider acceptance. It has been accepted, for example, by the United Nations Development Programme (UNDP), the central organization of the United Nations system for financing technical co-operation programmes and projects. "National self-reliance and collective self-reliance of developing countries in the field of science and technology represent the basic future orientation of UNDP technical co-operation in this area."61/

262. With this shift in emphasis, the need to select judiciously those programmes which are likely to result in scientific and technological self-reliance becomes one of utmost importance. Policy planning for science and technology therefore also becomes a crucial and strategic area of technical co-operation. But even when science and technology policy has been laid down, there remains the problem of evolving from the policy programmes of activities which are designed to achieve the objectives of that policy. This is a complex problem and deserves to be regarded as another area of technical co-operation. In the future technical co-operation must be so oriented as to give these two areas their due weight.

263. Finally, international co-operation, both bilateral and multilateral, can be greatly improved through the elimination of specific barriers which stand in the way of scientific and technological growth in developing nations. The General Assembly made a number of suggestions regarding specific action that should be taken in this regard. For example:

"All efforts should be made:

"(a) To formulate an international code of conduct for the transfer of technology corresponding to needs and conditions prevalent in developing countries;

60/ MacBean and Balasubramanyam, op.cit., p. 136.

61/ "UNDP contribution to overview paper on science and technology" (a paper specially written for the United Nations Conference on Science and Technology for Development), para. 15.

"(b) To give access on improved terms to modern technology and to adapt that technology, as appropriate, to specific economic, social and ecological conditions and varying stages of development in developing countries;

"(c) To expand significantly the assistance from developed to developing countries in research and development programmes and in the creation of suitable indigenous technology;

"(d) To adapt commercial practices governing transfer of technology to the requirements of the developing countries and to prevent abuse of the rights of sellers;

"(e) To promote international co-operation in research and development in exploration and exploitation, conservation and the legitimate utilization of natural resources and all sources of energy."62/

2. Promotion of regional co-operation

264. Though the essence of strengthening the technological capacity of developing countries is contained in action at the national level, much is to be gained by co-operation among developing countries in the context of a policy of collective self-reliance in the field of technology. It is in this respect that subregional and regional centres for applied science and technology could have major impact in promoting the technological transformation of developing countries.

265. The idea of establishing in Africa a network of institutions - each specializing in a branch or branches of knowledge related to the exploitation of natural resources, the development of technology for particular industries, or the solution of specific problems of infrastructural development - has already been endorsed by African States at a number of meetings. The African Regional Plan proposes the establishment of institutions for the following areas:

(a) Applied science and technology;

(b) Earth sciences;

(c) Mineral preparation and extraction metallurgy;

(d) Machine design;

(e) Food technology;

(f) Marine science and technology.63/

62/ General Assembly resolution 3202 (S-VI), Chap. IV.

63/ Op.cit., paras. 30-31.

266. Examples of the forms which these institutions, viewed as intra-African co-operation ventures, are reviewed below.

267. A first possible type of scheme is the creation or strengthening of international organizations within Africa set up under international (often intergovernmental) agreements. The main justification for the establishment of this type of organization generally lies in the need to share expensive equipment and to pool scientific personnel from Africa and elsewhere. In this context, the former East African Community (comprising Kenya, Uganda and the United Republic of Tanzania) has frequently been held up as a successful example. Following its recent demise, the Community may still be held up as good example - this time of how short-term national interests often tend to work against this type of organization.

268. A second type of scheme is the establishment of national scientific and technological institutions with international impact. Essentially, the aim would be to enhance the international status of, and support for, selected scientific and technological institutions in African States. Existing African research institutions, laboratories or units of international repute could, under this scheme, be selected to serve as nuclei of development in their specialized fields.

269. Finally, a third type of scheme is the development of a purposeful programme of international research projects, each of them conducted under the guidance of a Joint Management Committee. The essential advantage offered by this scheme is the great flexibility in starting new (and concluding old) phases of the research programme, and in associating scientists and/or technologists as full participants rather than as "contributing outsiders".64/

270. In conclusion it seems appropriate to draw special attention to two obstacles to which efforts to promote regional co-operation in Africa should be addressed. The first of these is the immobilizing lack of resources (notably personnel and financial provisions). This is aggravated by apathy and lack of will among member States. The second is institutional instability within African countries themselves, and so also within the partnerships they form. The frequent changes in political alliances often mean that previous links must be severed and new ones established in their place. These and other similar problems greatly diminish, at least for the time being, the effectiveness of intra-African co-operation.

3. Utilization of the existing United Nations system and other international organizations

271. The complexity and scope of development, as well as the pressures of particular interest groups, have given birth to several multilateral agencies for development. In addition, some specialized agencies, originally established for other purposes, have assumed important development functions. The proliferation of these agencies has bred a host of new problems, and the need for co-ordination of their efforts is now greater than ever before.

64/ UNESCO document SC/CASTAFRICA/3, chap. III, paras. 145-157.

272. Some of the disenchantment with aid is due to the fact that it has been at the same time too fragmented and too global: divided and aggregated along the wrong lines. The fragmentation is a consequence of the numerous bilateral donors' aid programmes, each inspired by its own complex blend of motives, objectives and criteria. Then there are the specialized agencies of the United Nations, again pursuing their own objectives and jealously guarding their spheres of competence. Finally, at the receiving end, sovereign national governments are usually accepted as the ultimate authorities for aid requests, often with little regard to regional and subregional co-ordination.

273. Because of inadequacies in purely local efforts, however, developing countries still require international assistance - especially during the initial stages of their development. Improvement of the utilization of the sources of such assistance, therefore, is a subject of great importance. The most profitable avenue for such improvement would appear to lie in increased co-ordination all round and a streamlining of the aid-giving machinery.

274. In 1977 the United Nations system had nine agencies with budgets for activities in science and technology - the United Nations itself, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Health Organization (WHO), the Universal Postal Union (UPU), the International Telecommunication Union (ITU), the World Intellectual Property Organization (WIPO), the World Meteorological Organization (WMO) and the International Atomic Energy Agency (IAEA) - although about 80 per cent of the total expenditure on science and technology involves only three agencies- UNESCO (35.6 per cent), WMO (25.6 per cent) and IAEA (18.7 per cent).65/ With the exception of the United Nations proper, each of these agencies is either completely autonomous or at least has its own governing body, separate from the United Nations Economic and Social Council and the General Assembly. Moreover, the Administrative Committee on Co-ordination, which is the major co-ordinating body at the secretariat level operates on the basis of consensus, without strong leadership. Consequently, its decisions tend to represent the lowest common denominator.66/ Against this background, it is not surprising that co-ordination among the agencies is weak. There is therefore a great need for some kind of harmonized science and technology policy for the United Nations system.

275. The need for a co-ordinating policy tying together the assistance programmes in developing countries is not, of course, limited to agencies within the United Nations system. Other international organizations also need to co-ordinate their efforts not only among themselves, but also with United Nations agencies doing similar work. It may be assumed, however, that because of the existing administrative structure - however complex and diverse - that links them, the activities of the United Nations agencies are more amenable to co-ordination. In any case, they appear to be the most logical starting point.

65/ "Draft working paper of the Ad hoc Working Group on Policy for Science and Technology Within the United Nations System" (paper prepared by the secretariat of the Advisory Committee on the Application of Science and Technology to Development, 5 May 1978), para. 14.

66/ Ibid., para. 17.

276. Africa, which more than most regions needs regionally planned and executed programmes, has in fact least enjoyed the benefits of such programmes. The aid effort has tended to reinforce the historical, geographical and political fragmentation of the continent, and the fluctuations of aid over time, its unreliability, and its volatility in response to political forces have aggravated the already difficult problems of co-ordination and forward planning.67/ The answer may well lie in strengthening the Economic Commission for Africa sufficiently to enable it to plan and execute regional development programmes more effectively and on a larger scale than at present. This will require:

(a) Channelling of all aid for subregional and regional development projects through ECA, including consultations with ECA in the planning and execution of such projects;

(b) Devising administrative machinery which would enable ECA to discharge the above functions with minimum time delays and financial waste;

(c) Strengthening the ECA staff and facilities to eanble it to perform its new duties.

277. The following directions of reform in aid are required:

(a) Inclusion of all aid donors in co-operating machinery; the joint concern ought to be development, and co-ordination within this overriding aim should be possible;

(b) Commitment of aid several years ahead, thus guaranteeing regularity and continuity of projects;

(c) Encouragement of regional and subregional development, which transcends national boundaries and follows economic and ecological lines; and provision of aid to promote closer integration and, if need be, compensate the losers from integration;

(d) Testing of all forms of financial and technical assistance against the criterion of whether they contribute to fuller mobilization of indigenous resources.

67/ Paul Streeten, Aid to Africa - A Policy Outline for the 1970's (New York, Praeger, 1972), pp. 163-164.)

VI. PROGRAMME OF ACTION

278. Science and technology seem destined to be the prime movers in the hoped-for progress towards a new international economic order. However, the creation and exercise of scientific and technological capability involves many different approaches and many different institutions. Hence there is a need for careful planning and co-ordination. In addition, the choice of appropriate technologies is dependent on the conditions prevailing in each country and the characteristics of each economic sector. The choice must also be based on the full utilization of national resources. It is in the interests of the world community as a whole that the efforts of the African countries to acquire greater scientific and technological capabilities should be supported, and that the present gaps and distortions in the availability of technologies should be reduced. This chapter contains recommendations for action at the national, regional and international levels for the proper application of science and technology to development in the African region.

A. Institution building for the effective utilization of science and technology for development

279. (a) National level

(i) Creation of national structures for policy-making and planning in science and technology;

(ii) Introduction of science and technology planning as an integral part of national planning;

(iii) Establishment or strengthening of national R and D institutions;

(iv) Creation of an informed public in science and technology matters;

(v) Organization and mobilization of science and engineering communities;

(vi) Establishment of information and documentation services;

(b) Regional level

(i) Sustained support for the African Regional Centre for Technology;

(ii) Organization of exchange programmes for scientists and technologists from African countries;

(iii) Organization of joint research programmes in co-operation with neighbouring States and other countries with similar or related problems;

(iv) Establishment of regional institutions for advanced training and research;

(v) Establishment of subregional and regional information and documentation centres;

(vi) Regional symposia on industrialisation in Africa and the potential of science and technology as a tool for socio-economic development;

(c) International level

Assistance from international organizations in executing the above programmes at both national and regional levels.

B. Education and training for the application of science and technology to development

280. (a) National level

(i) Improvement of science teaching in primary and secondary schools by:

a. Review of objectives, methods and approaches to science teaching;

b. Development of relevant course material;

c. Development of inexpensive laboratory equipment;

d. Training of science teachers;

(ii) Introduction of technological education at both primary and secondary level by:

a. Development of objectives and policies;

b. Development of appropriate course material;

c. Establishment of workshops for the teaching of technology;

d. Training of teachers for technological education;

(iii) Improvement of the technological content of vocational training programmes;

(iv) Strengthening of applied science programmes in existing universities;

(v) Review of objectives and policies for university-based research;

(vi) Review and re-design of university courses in engineering, medicine and environmental studies;

(vii) Establishment of technological universities;

(viii) Planning for national investment in science and technology education;

(ix) Determination of technological manpower needs in all sectors, and the mix of professional manpower requirements;

(x) Introduction of more women into science and technology;

(b) Regional level

(i) Exchange programmes for students and teachers of science and technology;

(ii) Training and fellowship programmes for Africa;

(iii) In-service and in-plant training programmes;

(iv) Development of multipurpose colleges of arts and technology;

(c) International level

(i) Training and fellowship programmes in science and technology;

(ii) Programmes of technical assistance to African scientific and technological institutions;

(iii) Exchange programmes for students, teachers and research workers;

(iv) International consultations and exchanges of ideas and information on science and technology.

C. Transfer, adaptation and development of technology in Africa

281. (a) National level

(i) Studies of the technological needs of existing and planned national development activities;

(ii) Surveys of sources, costs and conditions of supply of technology;

(iii) Promotion of local consulting expertise and consultancy services;

(iv) Promotion of R and D capabilities in local industrial concerns;

(v) Establishment of national centres for the transfer, adaptation and development of technology;

(vi) Establishment or strengthening of national information and documentation services;

(vii) Establishment of national policies for the import of technology;

(b) Regional level

(i) Establishment and strengthening of subregional and regional centres for technology;

(ii) Preparation of preferential agreements for the development and transfer of technology;

(iii) Establishment of subregional and regional information and documentation centres;

(iv) Establishment of an African Regional Centre for Industrial Design and Manufacturing;

(v) Promotion of subregional and regional indigenous consultancy and contracting associations;

(c) International level

(i) Assistance in the establishment of national, subregional and regional centres for technology;

(ii) Assistance in the setting up of subregional patent and documentation centres;

(iii) Control or regulation of restrictive practices by transnational corporations in connexion with their operations in the region;

(iv) Establishment of policies providing incentives to suppliers of technology who transfer such technologies to developing countries on equitable and just terms;

(v) Establishment of a risk capital fund to finance technological development projects in the developing countries;

(vi) Facilitation of the utilization of transferred technology in such a manner as to assist the countries in the region in attaining their trade and development objectives.

D. Food and agriculture

282. (a) National level

(i) Improvement of land already under cultivation, and development of new land;

(ii) Development of water resources for irrigation;

(iii) Genetic improvement of main crops and animals;

(iv) Establishment of centres for producing high-quality seeds;

(v) Establishment of centres for research into the adaptation and genetic improvement of livestock;

(vi) Programme to disseminate knowledge on the improvement of poultry and pigs;

(vii) Protection of crops and animal health through the establishment or improvement of centres for research into cereal and tuber diseases, insect pest control and livestock diseases;

(viii) Research on and development and utilization of improved agricultural techniques for both traditional and new crops by:

a. Establishment of programmes for the introduction of appropriate technologies in farming;

b. Establishment of centres for the development of farm mechanization;

c. Study and research programmes into the use of chemical and other fertilizers;

(ix) Research on and development and application of stock farming and animal nutrition techniques;

(x) Improvement of storage and preservation of agricultural products;

(xi) Development of fisheries, including the preservation of products;

(xii) Development of forestry through appropriate programmes of forest resources development and conservation;

(xiii) Establishment and/or strengthening of food technology institutions, and development of new processed foods from existing agricultural products;

(xiv) Education and training of supervisory, extension and other workers for agriculture;

(xv) Equitable redistribution of land;

(b) Regional level

(i) Establishment of subregional bio-climatological centres;

(ii) Co-operation in water development projects for irrigation;

(iii) Establishment or strengthening of subregional and regional centres for agronomic research;

(iv) Establishment or improvement of insect pest control centres;

(v) Establishment of centres or programmes for the control of the major livestock diseases;

(vi) Establishment of tsetse fly eradication programmes;

(vii) Research on and development and utilization of improved agricultural techniques for both traditional and new crops;

(viii) Research on and development and application of stock farming and animal nutrition techniques;

(ix) Establishment of centres for marine science and technology;

(x) Establishment of research centres for the genetic improvement of the main tree species;

(xi) Educational and training centres for supervisory, extension and other workers in agriculture;

(c) International level

Assistance in implementing the above programmes at both national and regional levels.

E. Housing and urban development

283. (a) National level

(i) Provision of technological know-how for producing low-cost housing through:

a. Development of better suited designs;

b. Development of traditional and new building materials based on local resources;

c. Development of more appropriate methods of construction;

d. Establishment of National Building Standards Bureaux for the standardization of building materials and components with regard to dimensions, composition, quality, performance, methods of manufacture and testing;

(ii) Research projects on local building materials;

(iii) Urban planning and settlement design;

(iv) Provision of adequate sewerage and waste disposal systems;

(v) Improvement of domestic water supply;

(vi) Provision of adequate urban mass transport systems;

(vii) Training of manpower for housing and urban development;

(viii) Encouragement for the formation of indigenous consulting organizations to help to develop appropriate technologies in the area of design and construction and to promote the effective transfer of technologies relevant to local needs;

(ix) Promotion of the establishment of small-scale manufacturing units for the production of building materials and components;

(b) Regional level

(i) Establishment of training centres for personnel in tropical architecture, urban planning, building and construction technology;

(ii) Research on and development of local building materials;

(iii) Subregional and regional arrangements for planning, design and construction of housing projects;

(c) International level

(i) Assistance in implementing the above programmes at both national and regional levels;

(ii) Exchange programmes in the area of building and construction technology

(iii) Encouragement of efforts for the development of appropriate technologies in the field of urban development, housing and construction.

F. Health and sanitation

284. (a) National level

(i) Provision of potable water for human consumption, and control of diseases transmitted by water and food;

(ii) Control of transmissible diseases by: vector control; diagnosis and treatment of diseases; programmes of immunization; programmes for the control of cerebro-spinal meningitis;

(iii) Improvement of national health planning and plan evaluation;

(iv) Programme of public health:

a. Health education of the public;

b. Improvement of the health infrastructure;

c. Improvement of nutritional status and maternal and child care;

d. Research on drug safety and drug dependence;

(v) Research on medicinal plants;

(vi) Training of health personnel;

(b) Regional level

(i) Research centres for medicinal plants and traditional drugs;

(ii) Control of transmissible diseases at subregional and regional levels;

(iii) Joint water development projects for the provision of potable water;

(c) International level

(i) Control of communicable and transmissible diseases;

(ii) Training of medical and paramedical personnel;

(iii) Assistance in implementing programmes at both national and regional levels.

G. Transport and communications

285. (a) National level

(i) Improvement and extension of road transport services through:

a. Establishment of national road research institutes;

b. Establishment of national centres for road planning and design;

c. Improvement of road transport services;

d. Improvement of the organization of road maintenance;

(ii) Development of machinery for the assessment of road transport needs and the planning of national road transport systems;

(iii) Strengthening of railway transport through:

a. Improvement in the operational efficiency of existing rail routes;

b. Development of methods to achieve the linking of railway systems of different technical specifications;

c. Development of improved handling facilities at railway terminal points;

d. Improvement of maintenance services for railway equipment;

(iv) Development and improvement of inland waterways and maritime shipping;

(v) Improvement of efficiency of port operations;

(vi) Improvement and development of air transport facilities;

(vii) Development and improvement of telecommunications networks and services through:

a. Improvement and expansion of national networks;

b. Development of technical criteria for the planning of national telecommunications networks and services;

c. Improvement of telecommunications links with neighbouring African countries;

d. Maintenance of telecommunications networks and equipment;

(viii) Training of personnel in all areas and at all levels of transport and communications;

(ix) Introduction of programmes for standardizing transport equipment and networks;

(b) Regional level

(i) Development and improvement of regional road networks and services;

(ii) Development and improvement of subregional and regional telecommunications networks and services;

(iii) Development of methods to achieve the linking of railway systems of different technical specifications;

(iv) Development of the telecommunications and electronics industry;

(v) Harmonization of the various highway codes, road signs and signals and axle load limits, so as to permit infrastructures and equipment to be built in future in such a way as to render intercountry transit as easy as possible;

(vi) Development of multinational inland waterway and maritime shipping lines;

(vii) Establishment of subregional and regional engineering aircraft maintenance services;

(viii) Establishment of a subregional technical services centre for air transport;

(ix) Establishment of multinational air lines and the improvement of air freight and air mail;

(x) Establishment of regional facilities for the training of personnel in all areas of transport and communications;

(xi) Introduction of programmes for standardizing transport equipment and networks;

(xii) Encouragement of co-operation between neighbouring African countries in research on and development of means of transport and communications;

(xiii) Organization of subregional and regional conferences, seminars and symposia in transport and communications improvement, research and development;

(xiv) Modernization of port statistics and introduction of performance indicators in African ports;

(xv) Harmonization of port administrative, customs and immigration formalities and adoption of identical nomenclatures, documentation and maritime legislation by all countries in the region;

(c) International level

Assistance in implementing the above programmes at the national and regional levels.

H. Natural resources

286. (a) National level

(i) Establishment of a basis for the inventorying, development planning and management of the national resources of each African country;

(ii) Conduct of national surveys of potential sources of and demand for energy, identifying:

a. conventional and non-conventional sources of energy available in each country and their present utilization;

b. The possibility of supplementary supply of energy through advanced technology;

(iii) Development and rational utilization of natural resources;

(iv) Training of national personnel to perform the required specialized services in the development of natural resources;

(v) Establishment of national documentation services to collect and disseminate information on natural resources;

(vi) Improvement of management in the field of exploration and development of natural resources;

(vii) Research on and development of non-conventional sources of energy, such as solar energy, wind energy and geothermal energy;

(b) Regional level

(i) Subregional and regional surveys of potential energy sources and needs;

(ii) Promotion of regional co-operation in natural resources research, particularly in the exploration and utilization of the natural resources of the continent;

(iii) Development of research, education and technical training in the domain of natural resources by the establishment of subregional and regional training institutions and research centres;

(iv) Creation and promotion of African multinational companies and institutions for the exploration of mineral resources and the utilization of energy and water resources;

(v) Establ shment of subregional mineral resources development centres;

(vi) Establishment of multinational centres for marine science and technology;

(c) International level

Promotion of international co-operation in the field of exploration, development and utilization of the natural wealth of the continent.

Follow-up activities

287. It is vital that the momentum generated by the preparatory activities for the Conference on Science and Technology for Development should be maintained and that activities should be continued in the region even after 1979. Appreciation of and reflection on the role and potential of science and technology in development should be a continuing process. ECA has an important role to play in the implementation of the programmes of action, particularly at the regional level. It is therefore recommended that the finances and staff of the Science and Technology Unit of the ECA Natural Resources Division should be strengthened to enable it to pursue the necessary follow-up activities.

Table 1. Enrolment by level of education in Africa, 1960 and 1972 (millions)

Total enrolment	First level	Second level	Third level	Total
1960	19.2	1.9	0.18	21.4
1972	37.4	6.0	0.60	44.0

Source: "Survey of economic and social conditions in Africa 1976-1977 (part I) "/E/CN.14/690(part I)_7, table II-4.

Table 2. Annual average growth rates of educational enrolment by developing region, 1960-1972 (per cent)

	First level	Second level	Third level	Total
Africa	5.7	9.8	10.5	6.2
Latin America	5.0	10.5	11.9	6.1
Asia	4.1	5.3	9.5	4.5
Arab States	5.9	10.2	11.0	6.8

Source: "Survey of economic and social conditions in Africa 1976-1977 (part I)" /E/CN.14/690 (part I)_7, table II-5.

Table 3. School enrolment, enrolment ratios, secondary vocational studies, pyramid and pupil/teacher ratios by subregion, around 1972

Subregion	School enrolment			Enrolment ratios		
	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary
	(thousands)			(per cent)		
North Africa	10 296	2 990	446.0	69	22	6.0
West Africa	8 584	977	53.4	42	7	0.6
Eastern Africa a/	8 355	874	36.8	48	7	0.5
Central Africa a/	5 576	614	26.6	87	12	0.7
Southern Africa b/	365	38	0.7	86	15	0.5

Subregion	Proportion of secondary students in vocational studies	Pyramid ratios		Pupil/teacher ratios		
		Secondary/ Primary	Tertiary/ Secondary	Primary	Secondary	Tertiary
	(per cent)	(per cent)	(per cent)	(pupils per teacher)		
North Africa	15	22	15	39	24	17
West Africa	9	11	5	35	25	9
Eastern Africa a/	7	10	4	43	23	12
Central Africa a/	17	11	4	46	26	11
Southern Africa b/	8	10	2	42	22	6

Source: "Survey of economic and social conditions in Africa 1976-1977 (part I) [E/CN.14/690 (part I)], table II-3.

a/ The country coverage does not correspond to the ECA subregions.

b/ Botswana, Lesotho and Swaziland only.

Table 4: Policy-making bodies for science and technology in African countries (May 1973)

Country	Ministry of Science or ministerial science policy committee	Science planning body - general	Multi-sectoral body for co-ordinating scientific research	Co-ordinating bodies for scientific research					
				Natural sciences research	Agricultural research	Medical research	Nuclear research	Industrial research	Environmental research
Algeria	X a/		X b/					X c/	
Benin			X		X	X		X	X
Burundi									
Central African Empire			X						
Chad			X						
Congo			X						
Egypt	X		X	X	X	X		X	X
Ethiopia			X	X d/	X	X d/		X d/	
Gabon			X d/						
Ghana		X e/	X						
Guinea	X		X e/						
Ivory Coast	X		X		X e/				
Kenya f/									
Lesotho									
Liberia		X							
Libyan Arab Jamahiriya									
Madagascar			X						X
Malawi					X				
Mali g/		X			X				
Mauritania									
Mauritius									
Morocco					X		X		
Niger		X e/	X		X				
Nigeria		X	X	X	X	X		X	
Rwanda									
Senegal		X	X						
Sierra Leone									
Somalia									
Sudan		X h/	X h/		X	X		X	
Togo									
Tunisia	X i/	X							

Table 4: Policy-making bodies for science and technology in African countries (May 1973)
(continued)

Country	1	2	3	4	5	6	7	8	9
Uganda f/		X e/	X						
United Republic of Cameroon		X	X		X	X		XX	
United Republic of Tanzania f/		X	X						
Upper Volta					X				
Zaire		X	X		X e/		X e/		
Zambia		X e/	X		X	X	X e/	X	

Source: "Science and technology in African development" (UNESCO document SC/CASTAFRICA/3); table I.

a/ Ministry of Higher Education and Scientific Research.

b/ Provisional.

c/ Government Department of Mining and Geology.

d/ Projected.

e/ Situation not altogether clear.

f/ Close relations with the scientific bodies of the East African Community.

g/ There is a National Resources Research Committee which undertakes co-ordination.

h/ National Council for Research

i/ Ministry of Planning covers science policy and R and D.

Table 5. Scientific and technical potential of institutions in Africa

Principal disciplines or groups of disciplines	Number of African institutions working in the disciplines indicated
Fundamental sciences	
Mathematics	34
Atomic physics and nuclear physics	18
The states of matter	20
Physics (specialization not determined)	21
Chemistry (specialization not determined)	51
Nuclear chemistry	9
Inorganic chemistry	30
Organic chemistry	73
Biochemistry, biophysics, cell-biology	53
Genetics	90
General physiology	82
Plant biology (botany, taxonomy, etc.)	134
Animal biology (zoology, taxonomy, etc.)	130
Radiobiology	15
Other biological sciences (ecology, conservation, etc)	122
Earth and space sciences	
Geomorphology, geodesy, cartography	83
Gravity, magnetism	44
Mineralogy, petrography, etc.	75
Geology, vulcanology, hydrogeology, etc.	109
Palaeontology, palaeobotany	15
Research on internal structure (seismology, etc.)	31
Meteorology, climatology	70
Hydrology	48

Table 5. (cont'd)

Principal disciplines or groups of disciplines	Number of African institutions working in the disciplines indicated
Earth and space sciences (cont'd)	
Astronomy, astrophysics	7
Oceanography	37
Hydrobiology	37
Other disciplines of earth and space sciences	4
Medical sciences	
General	177
Fundamental sciences	72
Human biology and anthropology	36
Contagious diseases and vectors	35
Chemotherapy, antibiotics, antiseptics medical chemistry, pharmacology	61
Nutrition	54
Water, soil and air hygiene	34
Surgery	12
Other disciplines of medical sciences	46
Food and agricultural sciences	
Soil management	179
Agricultural hydrology	70
Crop production	192
Crop protection (general)	183
Crop protection: agricultural entomology	83
Crop protection: phytopathology	61
Forestry and forest products	60
Animal production and animal products	109
Animal health	84
Continental fisheries	33

Table 5. (continued)

	Number of African institutions working in the disciplines indicated
Food and agricultural sciences (cont'd)	
Maritime fisheries	20
Human nutrition and food technology	66
Application of isotopes as tracers in agriculture	23
Fuel and power	
Power (general)	24
Thermochemical energy	20
Hydroelectric power	14
Nuclear energy	7
Solar energy	14
Electric power transmission	8
Industrial research	
General	94
Metallurgy: ferrous metals	13
Metallurgy: non-ferrous metals	13
Industrial chemical products	16
Textile industry	10
Mechanical engineering	8
Electromechanical engineering	6
Transport engineering	8
Telecommunications	10
Applications of automatic devices	10
Building and civil engineering	67
Building materials	57
Principal sciences applied in the building industry	22
Main building techniques	21

Table 5. (continued)

	Number of African institutions working in the disciplines indicated
Economics	
Social and human sciences	
General	46
Geography	38

Source: "Science and technology in African development" (UNESCO document SC/CASTAFRICA/3), para: 62.

Table 6. Distribution of research workers

	Full-time research	Part-time research	Total
Fundamental sciences	655	1 643	2 298
Earth and space sciences	1 410	219	1 629
Medical sciences	589	1 318	1 907
Food and agricultural sciences	2 637	1 072	3 709
Fuel and power research	87	62	149
Industrial research	375	587	962
Economics a/	79	18	97
Social and human sciences a/	216	126	342
Total:	6 048	5 045	11 093

Source: "Science and technology in African development" (UNESCO document SC/CASTAFRICA/3), para. 63

a/ In specific relation to the sciences covered by the survey.

Table 7. Various phases of a technology project

Phases of a project	Type of activities: Core technologies	Type of activities: Peripheral technologies
Project preparation	- Specific knowledge for technical and economic feasibility studies	- Financial analysis techniques or others
	- Specific bargaining knowledge	- Project evaluation criteria - Information system as to technological alternatives and their sources, and concerning other inputs
		- Data processing techniques
Plant construction and start-up	- Specific knowledge about basic engineering and about pertinent process technology	- Foundation, sell, structural engineering, etc. - Design and detailed engineering
	- Selection, location and co-ordination of equipment in space and time	- Architectural design and engineering - Equipment design
	- Technical assistance for start-up	- Information system concerning availability and characteristics of inputs
		- Ability to read blueprints, including some knowledge of foreign language
Production	- Basic process technology	- Detailed engineering, training in use of instruments and quality control
	- Physical and mechanical properties of materials	- Inventory and supply control - Mechanical engineering; transport, blending, storage systems

Source: Technology Policy and Economic Development (Ottawa, International Development Research Centre, 1976), table 3.

Table 8. Percentage of women among total numbers of students in the early 1970s

Region and number of countries	Natural Science	Engineering	Medicine	All tertiary education
Black Africa (6)	10.8	0.5	19.5	14.2
Arab countries (8)	19.0	4.6	24.1	17.9
Developed West (21)	25.6	3.9	31.5	34.3
Asia (8)	33.1	3.0	38.6	30.5
Central and South America (9)	45.6	6.8	37.6	34.3
Eastern countries (8)	52.2	23.2	58.6	43.4

Source: A. Kelly, "Women in physics and physics education" (Trend Paper No. 18 prepared for the International Conference on Physics Education, held at the University of Edinburgh from 29 July to 6 August 1975), table 3.

Note: Figures refer to the years 1969, 1970 or 1971.