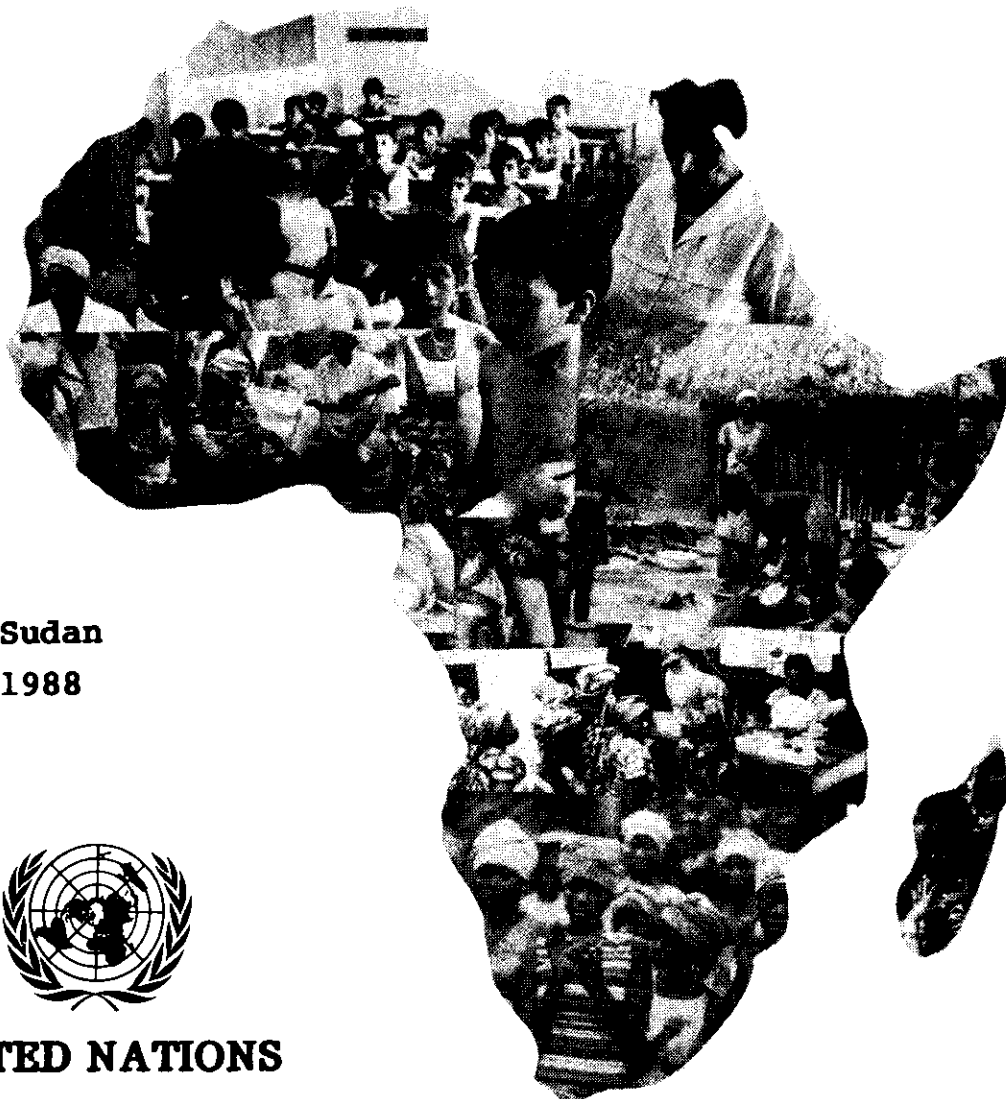


INTERNATIONAL CONFERENCE ON THE HUMAN DIMENSION OF AFRICA'S ECONOMIC RECOVERY AND DEVELOPMENT

STRENGTHENING THE SCIENTIFIC AND TECHNOLOGICAL CAPABILITIES
IN AFRICAN COUNTRIES FOR INDUSTRIAL DEVELOPMENT

by

United Nations Industrial Development Organization
(UNIDO)



Khartoum, Sudan
5-8 March 1988



UNITED NATIONS

International Conference on

"The Human Dimension of Africa's
Economic Recovery and Development"

Khartoum, Sudan, 5-8 March 1988

**STRENGTHENING THE SCIENTIFIC AND TECHNOLOGICAL CAPABILITIES
IN AFRICAN COUNTRIES FOR INDUSTRIAL DEVELOPMENT^{1/}**

by

**United Nations Industrial Development Organization
(UNIDO)**

UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA, ADDIS ABABA, ETHIOPIA

^{1/} This document has been reproduced without formal editing.

CONTENTS

	<u>Paragraph</u>	<u>Page</u>
EXECUTIVE SUMMARY	1 - 13	(vi)
<u>Chapter</u>		
I. INTRODUCTION	1 - 30	1
A. Role of science and technology in economic and industrial development	1 - 3	1
B. Inter-relationship between science and technology industry	4 - 8	1
C. Problems encountered in African countries in the development and utilization of science and technology for industrial development	9 - 30	3
- Lack of a well developed industrial environment	13	3
- Lack of well defined national science and technology policies and plans	14	4
- Inadequate regulation of technology flows	15	4
- Underdeveloped national machineries and institutions for industrial and technological research and development	16 - 19	5
- Underdeveloped national machineries and institutions for the selection, evaluation, acquisition and transfer of industrial technology	20 - 22	6
- Inadequate allocation and utilization of financial resources	23 - 27	6
- Lack of suitable science and technology information systems	28 - 30	8
II. PROPOSED FRAMEWORK OF ACTION FOR STRENGTHENING THE SCIENTIFIC AND TECHNOLOGICAL CAPABILITIES IN AFRICAN COUNTRIES FOR INDUSTRIAL DEVELOPMENT	31 - 144	9
Objective	31 - 32	9
A. <u>Elaboration and implementation of the framework of action by African countries</u>	33 - 72	9
National science and technology policies and plans	40 - 43	11
National machineries and institutions for the development, selection, acquisition and regulation of technology	44 - 63	12

- Development and commercialization of indigenous industrial technology	47 - 52	12
- Selection of appropriate industrial technology	53 - 55	14
- Acquisition of foreign industrial technology	56 - 58	14
- Transfer of industrial technology	59 - 60	15
- Regulation of technology flows	61 - 63	16
Industrial and technological information	64 - 66	17
Establishment of technological institutional linkages	67 - 72	18
- Linkage with Governmental planning machinery	68	18
- Linkages with the industrial and business communities	69	18
- Linkages with other national institutions	70	18
- Linkages with institutions outside the country	71 - 72	19
<u>B. International co-operation in strengthening the scientific and technological capabilities in African countries for industrial development</u>	73 - 98	19
Technological co-operation with other developing countries	74 - 90	19
- Industrial and technological information	77 - 80	20
- Sharing of technological services and institutions	81 - 84	21
- Negotiation of technology agreements	85 - 87	22
- Joint acquisition of industrial technology	88 - 90	23
Technological co-operation with developed countries	91 - 98	23
- Liberalization of technological negotiations and transfer at enterprise level	92 - 93	24
- Increased flow of technology to African countries	94 - 96	24
- International mechanism for technology acquisition	97 - 98	25
<u>C. Mobilization and utilization of financial resources for strengthening the scientific and technological capabilities of African countries for industrial development</u>	99 - 113	26
Mobilization of financial resources	99 - 105	26
Utilization of financial resources	106 - 113	27
<u>D. UNIDO's support to the framework of action for the development and utilization of science and technology for industrial development in Africa</u>	114 - 140	30
UNIDO's mandates in the field of science and technology	114 - 116	30

(v)

UNIDO co-operative programme of action on appropriate industrial technology	117 - 119	31
Major activities of UNIDO related to strengthening the scientific and technological capabilities of African countries in industrial development	120 - 140	31
- Development of industrial technology policies, plans and programmes	121 - 122	32
- Development, adaptation, choice and acquisition of industrial technology	123	32
- Development and adaptation of industrial technology	124 - 127	33
- Choice of industrial technology	128 - 129	33
- Acquisition of industrial technology	130 - 131	34
- Development of technological institutions	132 - 134	34
- Development of technological capabilities	135	35
- Development of industrial and technological information	136 - 140	35
E. <u>Strategy for the implementation of the framework of action</u>	141 - 144	36
III. CONCLUSION	145 - 148	38

EXECUTIVE SUMMARY

1. The African Heads of State and Government, in adopting the Lagos Plan of Action for economic development, were unequivocal in agreeing upon measures to ensure the development of an adequate science and technology base and the appropriate application of science and technology in spearheading economic development. The Lagos Plan of Action therefore emphasizes the paramount importance of systematic and integrated development and the use of science and technology by the countries of Africa in order to accelerate their self-reliant development process with a view to raising the standard of living of its peoples complementary with the resource endowments of the continent. In the contemporary society, the level of development of science and technology is commensurate with its level of industrialization. The underdevelopment of the African continent therefore reflects the underdevelopment of its science and technology base and, consequently, its level of industrialization.

2. An important outcome of this historic conference, therefore, would be to advance and recommend actions on the most appropriate manner in which the chapter on science and technology in the Lagos Plan of Action could be translated into practical measures and programmes. In order to assist the conference in this task, UNIDO has prepared, for its consideration, this paper on "Strengthening the scientific and technological capabilities in African countries for industrial development". The paper is in three chapters, namely: introduction; proposed framework of action for strengthening scientific and technological capabilities in African countries for industrial development; and conclusion.

Introduction

3. In the introduction (chapter I) it is noted that, in African countries, the significant role of science and technology in economic and industrial development has not always been fully emphasized. The role of science and technology as the vehicle for economic and industrial development is comprehensively analysed. In precise terms, the application of science and technology for industrial development is appreciated as a means to an end, the end being the attainment of the development goals of each country. In Africa, therefore, the application of science and technology would have to combine access to and the application of modern and foreign technologies with the use of indigenous technologies, especially those more suited to the small- and medium-scale industrial sector.

4. It is only with the above reoriented pattern that science and technology can make a meaningful contribution to accelerated industrial growth consistent with the overall development goals and the attainment of the Lima target of at least 2 per cent of the contribution by African countries to world industrial production by the year 2000. There is thus a vital need for integrating science and technology in economic and social development through linkages with development goals as well as the development of effective mechanisms to promote the development and utilization of science and technology.

5. Because of its low level of development and inadequacy of the requisite infrastructure, particularly human resources, the development and application of science and technology for socio-economic development has encountered numerous problems in African countries. The most important of such problems include: the lack of a well developed industrial environment; lack of well

(vii)

defined national technology policies and plans; underdeveloped national machineries and institutions for industrial and technological research and development and for the selection, acquisition and transfer of industrial technology; inadequate financial resources; underdeveloped technological manpower; and lack of suitable industrial and technological information.

Proposed framework of action for strengthening the
scientific and technological capabilities in African countries
for industrial development

6. In chapter II of the paper, proposals are advanced for a framework of action for strengthening scientific and technological capabilities in African countries for industrial development. At the national level, such a framework is aimed at enhancing the ability of the country to exercise a greater control over its industrial and economic development. It is considered desirable and indeed very urgent for each African country to elaborate a science and technology action plan not only at the national level, but also at the subregional and regional levels within the spirit of intra-African co-operation. In this regard, cross-references are made to document ECA/ICHD/88/45/Add.1 entitled "Development of human resources for industrialization in Africa" and document ECA/ICHD/88/45/Add.2 entitled "Accelerated development of indigenous entrepreneurial capabilities for small- and medium-scale industries in Africa".

7. In elaborating the action plan, particular attention needs to be accorded to national machineries and institutions for the development, selection, acquisition and regulation of technology; industrial and technological information; and establishment of technological institutional linkages including, in particular, linkage with the business community. The framework of action also underlines the fundamental importance of the contribution from the international community, through co-operation with other developing and developed countries as well as with international organizations in its implementation. In respect of co-operation with other developing countries, such co-operation could involve the sharing of industrial and technological information and services as well as joint negotiations and acquisition of technology. Co-operation with developed countries is expected to result in the liberalization of technological transfer at the enterprise level, and increased flow of technology to African countries.

8. It is expected that the full implementation of the programme of action would greatly contribute towards increasing the efficiency of the African economy; accelerating the pace of industrialization on the continent, thereby increasing its share in world manufactured products; cutting down on the dependence of individual countries on foreign technologies; optimizing the utilization of funds invested for science and technology development; and to reducing the enormous amount of the foreign debt of African countries.

9. With reference to the role of the international organizations in assisting the African countries in the implementation of the programme of action, the organizations of the United Nations system, especially, UNIDO, UNESCO, UNCTAD and ILO, have vital roles to play. On the part of UNIDO, based on various mandates and responsibilities assigned to it through its legislative authorities, UNIDO has a well defined programme in support of the efforts of the African countries in the development and utilization of science and technological capabilities for industrial development. Such mandates have been further enhanced with the proclamation of the Industrial Development

Decade for Africa (IDDA) which gave UNIDO the prime responsibility for monitoring and providing technical assistance to the African countries in the elaboration and implementation of their programme for the Decade.

10. The UNIDO co-operative programme of action on appropriate industrial technology also provides an important contribution to the African countries in developing capabilities and capacities in the various subsectors of industrial technology. The important objective of the UNIDO programme, apart from implementing specific activities, is the consolidation of efforts in this field and the mobilization of interest on a world-wide scale in support of the endeavours of African countries and organizations.

11. The major activities of UNIDO relating to the development and utilization of scientific and technological capabilities encompass assistance to African countries in areas such as: formulation and implementation of technology policies, plans and programmes; strengthening of existing and establishment of new technological institutions and centres of excellence at all levels; provision of technological information relating, in particular, to the selection, acquisition and adaptation of industrial technology and to the development and commercialization of indigenous technologies for practical application in industrial development; and promotion of technological co-operation not only among African countries but also between them and the developed as well as other developing countries.

12. An issue of critical importance, treated in this chapter of the paper pertains to the strategy for the implementation of the framework of action. In this connection, a very pragmatic and realistic approach based on a careful assessment and selection of priority actions to be carried out on the short-, medium- and long-term basis is proposed along with concrete suggestions for mobilizing financial resources for its implementation. Urgency in addressing the problems of developing scientific and technological capabilities for industrial development in Africa is underlined, and the proposed framework of action as well as the strategy for its implementation should pave the way and lay a solid foundation for the effective development and utilization of the scientific and technological capabilities required for attaining the objectives of self-reliant and self-sustained development in Africa.

Conclusion

13. In the concluding chapter III, it is appreciated that the task facing the African countries in the development and effective utilization of scientific and technological capabilities for industrial development is tremendous. African countries and organizations are called upon to accord an appropriate amount of resources, both financial and human, to this endeavour. At the subregional and regional levels, there is an urgent need to pool resources together and to translate, in practical terms, the spirit of solidarity emphasized in the various declarations and resolutions adopted by African leaders on the economic and social development of the continent. There is a need to intensify industrial and technological co-operation among African countries as well as with other developing and developed countries. The role of the international organizations in assisting the African countries to develop their scientific and technological capabilities for industrial and economic development need to be intensified. In this regard, the special role of UNIDO in assisting African countries and organizations in this important field is emphasized.

I. INTRODUCTION

A. Role of science and technology in economic and industrial development

1. The application of science and technology for industrial development is a means to an end, the end being the development goals of each country and, in particular, the acceleration of economic development. This is emphasized in the Lagos Plan of Action, the programme for the Industrial Development Decade for Africa (IDDA), Africa's Priority Programme for Economic Recovery (1986-1990) and the United Nations Programme of Action for African Economic Recovery and Development (1986-1990). All these programmes highlight the fact that to achieve overall development goals, the pattern of industrial growth in African countries would have to combine a rapidly growing modern industrial sector, side by side with a sound and efficient decentralized industrial sector. Concomitantly, the application of science and technology would have to combine the access to and the application of modern and large-scale technologies, with the use (after upgrading, if need be) of technologies more suited to the requirements of the decentralized industrial sector. Only with such a reoriented pattern can science and technology make a meaningful contribution to the accelerated industrial growth consistent with overall development goals and the achievement of the Lima target of at least 2 per cent world industrial growth to be attained by the African countries by the year 2000.

2. Thus the vital need for integrating science and technology in economic and social development through linkages with development goals is, in a sense, more important and fundamental than the mere consideration of mechanisms to be employed to promote development of science and technology. A key element in the process of integrating science and technology with industrial development is the stimulation of interest and the sensitization of all partners and decision-makers in the process of industrial development. It is only through such integration, both conceptually and in practical terms, that the application of science and technology can make the most effective contribution to industrial and economic development.

3. The application of science and technology for development is not only to be derived from national development goals but also has to be matched with the resource endowments of the country. Science and technology is in fact not applied in isolation but as part of the performance of an economic activity that contributes to development. In such an activity, say industrial development, science and technology are again applied not alone but matching with investment, skills, resources and other related factors. In other words, the application of science and technology cannot be divorced from the total process of industrial development.

B. Inter-relationship between science and technology industry

4. Perhaps no other single branch of economic activity influences or gets influenced by science and technology more than industry. Industrial development often paves the way for the initial scientific and technological development of a country and thus contributes to the development of scientific and technological skills. Furthermore, the application of science and technology in other sectors often requires the manufacture of products on an industrial scale and may determine the technology to be adopted for such

manufacture. It also affects the pattern of industrial development, the centre piece of the development process, hence, the pattern of overall social and economic development.

5. It is only within the framework of the above basic considerations that science and technology can be applied realistically and effectively. To promote such application, three major elements are therefore of particular importance for national and international action. First, the linkage of science and technology to industrial development, and through industrial development to overall development goals, will be successful only in the context of the formulation of relevant policy measures by the national Governments; science and technology policy and planning therefore become important factors. Second, the development of scientific and technological capabilities in each country is a prerequisite for the selection, acquisition, adaptation, absorption or development of technology. This involves, among other things, the building up of technological institutions and the training of industrial and technological manpower. The third element is the appropriate choice of technology, since inappropriate choice will not only be expensive but will also distort the pattern of development.

6. Industrialization and the development and acquisition of technology is increasingly proceeding at a faster pace, but mostly through foreign collaboration, involving importation of know-how and turnkey projects; thus control, direction and application of technology has remained largely with the sources of supply. Viewed historically, the problems of technology acquisition have remained, in essence, the same as during the past decades, when the African countries embarked on the process of industrialization. Such attempts have not generated satisfactory results due largely to the gross shortage of indigenous technological capabilities and productive capacities.

7. The developed countries, on the other hand, control the finance and the technology needed by the African countries as well as the access of the products of such countries to their markets. Furthermore, their technologies were developed essentially for their own use and are therefore not always relevant to the situation in African countries. It has therefore been recognized that the pattern of industrialization in the African countries could not simply be an imitation of that of the developed countries but a total readjustment to their needs and priorities while preserving the cultural identity of their societies.

8. While it is impracticable to adopt a uniform model of industrial development for all African countries, since great diversity exists among them not only in their stage of development but also in their natural and human resource endowments, a pattern of industrial growth needs to be conceived along with appropriate lines of technological development that could be adapted to the specific needs of individual countries. Emphasis needs to be placed on long-term measures and, in particular, on science education and the development of human resources. Political commitments are needed on the part of Governments. The African countries could benefit considerably through collective self-reliance and global co-operation. Multilateral aid, in particular from the United Nations system, could be an important means of helping the developing countries.

C. Problems encountered in African countries in the development and utilization of science and technology for industrial development

9. The most critical constraint in African countries to the development and effective utilization of science and technology for economic and industrial development is the gross shortage of scientific and technological capabilities not only in terms of quantity but also in terms of diversity and level of competence. There are shortages of persons who combine engineering and agricultural expertise with managerial skills, industrial designers, production and process engineers, engineering draughtsmen, food technologists, quality control personnel, management accountants - to name only a few cadres.

10. The establishment of training programmes for personnel engaged in scientific and technological activities in most African countries has been grossly insufficient, in terms of number and variety, to adequately meet the wide range of national requirements. The present educational systems do not provide for a suitable development for technologists. In the area of high-level professional personnel, for example, training programmes in engineering have adhered to the tradition of producing civil, mechanical and electrical engineers. Universities have not taken practical measures to diversify their course options so as to reflect the actual needs of the economy. With regard to the training of technicians, many African countries do not have adequate training facilities. This has resulted in shortages of technical personnel, who are required especially for industrial production, quality control and for the installation, smooth operation and maintenance of industrial machinery and equipment.

11. In many countries officials who do not possess suitable qualifications have been placed in positions where they make policy decisions which have far-reaching repercussions on the attainment of national programmes for the development of scientific and technological capabilities. This has contributed to the problems related to the low social status, salary and compensation schemes accorded to personnel engaged in scientific and technological activities. While some steps have been taken in a number of African countries to remedy the situation, only very few have achieved any degree of success. The limited number of technological personnel, especially the high-level ones, therefore, continue to migrate, either to the industrial and the business communities, or worse still, to other countries, particularly industrialized ones, where better conditions exist.

12. The major problems currently being experienced by the African countries in the development and effective utilization of scientific and technological capabilities for industrial development relate mainly to the lack of a well developed industrial environment; lack of well defined national technology policies and plans; underdeveloped national machineries and institutions for industrial and technological research and development; underdeveloped national machineries and institutions for the selection, evaluation, acquisition and transfer of industrial technology; inadequate allocation of funds; and lack of suitable industrial and technological information.

Lack of a well developed industrial environment

13. In most African countries, industrial development is still part of an imported culture. The local business community still needs to be fundamentally oriented towards the particularities of such a culture. The

industrial environment is therefore generally still at an embryonic stage without sufficient facilities such as fiscal and tax incentives, energy and physical infrastructure, qualified technical manpower and technological information, to encourage investment by entrepreneurs. In most African countries, therefore, the establishment of industries has largely been in the hands of foreigners who generally have set up industries employing their own technologies and managers. In this regard, measures to accelerate the development of indigenous entrepreneurial capabilities for small- and medium-scale industries in Africa are advanced in document ECA/ICHD/88/45/Add.2 entitled "Accelerated development of indigenous entrepreneurial capabilities for small- and medium-scale industries in Africa".

Lack of well defined national science and technology policies and plans

14. If scientific and technological capabilities are to play a significant role in the industrial and economic development of a country, their development must be integrated within the country's planning policy. A viable correlation must be instituted between development planning and scientific and technological capabilities. There is generally a lack of clearly defined and adequate national policies and legislation covering all aspects of the development of scientific and technological capabilities. Although a number of African countries have attempted to develop national science and technology policies, only very few have achieved success in their implementation. This is largely due to the fact that very little attention has so far been paid to the preparation of science and technology plans and programmes as well as the development of the required technological capabilities. The absence of such plans and programmes poses great difficulties in the development of requisite capabilities for the development or acquisition of appropriate technologies required for industrial and economic development.

Inadequate regulation of technology flows

15. In spite of recent recognition in a number of African countries of the need to introduce governmental regulation in respect of the inflow of foreign technology in their countries, the situation is, in general, still very weak. Regulation of technology contracts is practised only in a few African countries, mainly where a significant level of industrialization has been achieved. The usual approach has been to entrust this responsibility to an agency within one of the governmental departments. In some cases, the agency responsible for screening technology agreements is also responsible for scrutinizing foreign investment proposals, while in a few other countries national registries for technology or similar screening and registering agencies have been set up separately for this purpose. The majority of African countries do not have much of these regulatory machineries. Even where they exist, such regulation has, by and large, tended to be exercised only in relatively limited aspects. In practically all cases there is a gross deficiency of the scientific and technological capabilities required to provide a back-up for regulating technology development, acquisition and utilization.

Underdeveloped national machineries and institutions for industrial and technological research and development

16. Interwoven with the problems arising from the lack of well defined national science and technology policies and plans is the lack of a suitable national institutional machinery to ensure the proper co-ordination and effective development use of local scientists and technological capabilities in industrial and economic development. This has given rise to a great deal of duplication of national resources such as the establishment of new scientific and technological institutions to undertake tasks already accorded to existing ones.

17. Also related to this problem is the lack of a national mechanism in practically all African countries for the commercialization of scientific and technological research and development results. Such a mechanism should include appropriate institutional arrangements for the development and commercialization of local technologies, as well as the creation of the required capabilities for the diffusion, absorption and upgrading of not only locally developed technologies but also of imported ones.

18. In connection with the above, it may be noted that scientific and technological institutions in most African countries have emerged, with some exceptions, only within the last few decades. These institutions cover a wide variety of areas such as multipurpose and specialized technological research, standardization and quality control, industrial information, engineering design, patents, regulation of imported technology; industrial management; and consultancy and training. While some of these institutions fulfil important functions, in most African countries, where they exist, their contribution to industrial and economic development is still limited. This is because the establishment of scientific and technological institutions in most African countries has not always been planned to respond to national needs identified within the context of national policies and plans. In some countries they were established initially as subsidiaries or departments of larger institutions to respond to specific needs of foreign countries and their enterprises. With the advent of independence and with the reorientation of scientific and industrial activities towards achieving national goals, it has been found difficult to put some of these institutions into meaningful use, even to change, combine or phase out some of them, especially those whose establishment was politically motivated.

19. Most of the difficulties which existing science and technological institutions face relate to problems of organization, management, recruitment of competent staff and marketing of their services. They have often not been accorded the financial and operational autonomy necessary to facilitate their work. Several of them are operated as, or like, departments of Government ministries. As a result, there is generally a great under-utilization of the existing scientific and technological institutions, especially by the Government, the business community and industry. This problem is essentially caused by a lack of confidence in those institutions whose involvement in industrial and economic activities is generally based on their "track record" and the level of their past success, thereby not providing them a fair chance to prove their worth on important projects.

Underdeveloped national machineries and institutions for the selection, evaluation, acquisition and transfer of industrial technology

20. In their efforts to industrialize, African countries will continue to rely heavily on imports of technology, almost wholly, from developed countries. The implications of such imports extend far beyond those of the discrete individual transactions that occur between the enterprises concerned. It is estimated that technology imports by the developing countries, in terms of fees, royalties and other payments for technical know-how and specialized services, increased from around \$1,000 million in 1975 to over \$6,000 million by 1985. This constituted about 15 per cent of the total trade in technology, which was in the order of \$40,000 million in 1985.

21. In spite of their dependence on foreign technologies for industrial and economic development, the African countries, on the whole, lack the machinery and institutions for the selection, evaluation and acquisition of industrial technology. They are therefore generally in a weak negotiating position due mainly to their lack of sufficient and precise information on various aspects of technology transfer such as: sources of available and alternative technologies; available indigenous technologies; level of research and development of those technologies; comparable information on financial, legal and technical conditions of transfer of technology agreements; information on foreign companies and donors of the technologies, particularly the multinationals; and information on recent developments in international licensing, patents and trade mark laws, compulsory licensing, etc. This has, in most instances, resulted in excessive payments, restrictive and tie-in clauses, and grant back provisions, just to mention a few of the unfavourable terms.

22. The African countries are particularly deficient in the machinery for the development of capacities and capabilities for the absorption and upgrading of the technology related to large turnkey projects which essentially involve the purchase of off-the-shelf technology and know-how. This involves the selection and proper use of technology from the existing "technology shelf", an act which requires technological capabilities of the same general order as the act of creating new technology. To negotiate with machinery salesmen and select the most economical and advantageous equipment, to purchase process technology on equitable terms and conditions; to examine tenders for development project; to enter into various licensing arrangements; to evaluate project proposals associated with a given technology; to negotiate effectively with foreign investors; or to be familiar with the various aspects of industrial property - these are but some of the complex acts involved in selecting technology from existing processes which require a high degree of national technological capacity usually not available in developing countries in sufficient quantity.

Inadequate allocation and utilization of financial resources

23. It has been observed that while African countries have invested significant amounts of funds from both local and external sources in the establishment of investment projects, especially in the industrial sector, only very small, almost insignificant funds have been allocated for the development of the necessary national scientific and technological capacities and institutions to ensure not only a smooth operation of those projects but

also their backward integration for economic development. The problems of financing science and technology activities is directly and mostly related to the financing of scientific and technological institutions. In this regard, it is generally known that once the initial funds have been allocated for the establishment of these institutions, they generally run into financial problems, after the initial period of their establishment. These problems are closely related to the degree of utilization of their services, especially vis-à-vis those provided by foreign institutions. In this connection, it is to be noted that the long-term investment required for the development of science and technology, although recognized by decision-makers in African countries, has not been reflected in the national budgetary allocations in the magnitude that is compatible with the role its results are expected to play on the development of the national economy.

24. While many African Governments are increasingly allocating more funds from their national budgets for the development of science and technology, it has however been noted that, in spite of these investments, the returns have often not been commensurate with the needs and requirements of the countries. A closer examination of the reasons for this reveals, among other factors, that there has been an imbalance in the allocation of financial resources among the major components of science and technology development programmes. In most countries, such financing has concentrated largely on the development of the physical infrastructure, e.g. buildings for various institutions. Only a small proportion of the resources has been allocated to the development of science and technology education and training programmes, training of instructors, fellowships, laboratory equipment and instruments, acquisition or development of training/learning facilities and aids; and student welfare.

25. The subject of financial resources for the development of science and technology needs to be seen from the point of view of real investment (teachers and instructors, teaching/learning aids, equipment, educational materials, buildings). A cursory examination of the number of nationals of African countries who are likely to need education and training in general, and in some specific sectors in particular, reveals the fact that only a small percentage of them have the opportunity to be educated and trained in developed countries. This is due to the limited capacity in the developed countries, especially when account is taken of their own needs. Furthermore, the curricula of training institutions in developed countries are increasingly becoming inappropriate for the current needs of African countries since these curricula are being adjusted to developments in new and advanced technologies.

26. The cost of science and technology education and training in the developed countries, especially of non-nationals, is rapidly mounting. Even if, in some way, the capacity limitation were to be avoided, the cost factor could not be overcome. There is also the problem of "brain drain" from the African countries since highly qualified graduates and trainees opt to remain in the developed countries. The rapid development of capital/labour substituting technologies in the developed countries has necessitated the replacement of certain categories of human industrial skills by machines. This has brought about a major adjustment in the structure and content of education programmes in the developed countries, making them less relevant to the needs of African countries. Furthermore, there is an increasing reluctance by industry in developed countries to take in trainees in specialized fields from abroad due to the need to protect confidential information.

27. Finally, it should be noted that only a very small proportion of the working population in each African country can be trained abroad. Their impact will thus depend on the ways in which they are selected and the ways in which they are deployed. These considerations lead to the conclusion that if the needs of the African countries, in respect of science and technology development, are to be met, the bulk of science and technology education and training, especially for engineers, technologists, industrial managers, floor supervisors and workshop operators, will have to be carried out in the African countries themselves. They have no alternative but to consider how this can be done very rapidly and at a low cost. Furthermore, past experience clearly shows that the people trained abroad tend to find it difficult to fit into the local environment on their return. Even where such foreign training is envisaged, the priority areas of training have to be determined and the countries chosen should have competence in those areas for training. Otherwise, the mismatch between foreign training and local needs would continue, leading to further "brain drain".

Lack of suitable science and technology information systems

28. The effective utilization of science and technology for development essentially involves the collection and processing of scientific and technological data from various sources and combining them to produce the desired technological input for the implementation of national industrial and economic development projects. Many African countries lack the capabilities of an appropriate institutional framework, such as a national technological information network with a well defined focal point. While a great deal of effort has been expended world-wide in developing information systems and services aimed at meeting the needs of scientific personnel, concrete and meaningful results have yet to be achieved.

29. In most African countries there is a general lack of scientific and technological information, data and statistics, without which planning and forecasting the development of relevant sectoral and national targets are impossible. There is also a lack of technological and other information, which is required for a continuing analysis of market and technological trends; identification of new opportunities stemming from market changes and new technologies; identification of changes stemming from revised national and sectoral plans; and assessments of the short- and long-range industrial and economic trends of the country and its changing needs. To a great extent, the weakness in most African countries in the area of science and technology policy formulation, planning, programming and institutional development is a reflection of the weakness of the development and technological information structure and expertise.

30. The problem of industrial and technological information is particularly acute with regard to knowledge and information on alternative sources of technology; the existence of alternative technologies in various fields; alternative modes, terms and conditions associated with the acquisition of technology; and on the consequences of importing technology. At the national level, there is no organized information as to the existing technological capability in terms of both manpower and institutions, while at the subregional and regional levels there is a lack of proper channels for exchange of information among countries on experiences in science and technology and especially in the acquisition of foreign technology. Science and technology information is a specialized field requiring specialists who

generally are grossly lacking in Africa. Information acquired from external sources, which is often in a form which users at the domestic level cannot understand, necessitates the services of a "decoding" agency. Even in cases where the information is easily comprehensible, it may relate to the production of goods which are either too sophisticated for the domestic market, or involve technological processes out of the range of the domestic investor, thereby requiring adaptation. The medium of exchange of the information may often be inappropriate in the sense that it may require the user to learn new skills or incur greater costs in order to have access to the system as, for example, is the case with most electronic data systems.

II. PROPOSED FRAMEWORK OF ACTION FOR STRENGTHENING THE SCIENTIFIC AND TECHNOLOGICAL CAPABILITIES IN AFRICAN COUNTRIES FOR INDUSTRIAL DEVELOPMENT

Objective

31. The overall objective of any national programme of action for strengthening the scientific and technological capabilities for industrial development would be to enable each country to exercise a greater control over its industrial and economic development by developing a sound indigenous scientific and technological capacity and capability for the development or acquisition, adaptation, absorption and diffusion of technology. This would involve increased use of existing and future indigenous scientific and technological capabilities and institutions in the total spectrum of the industrialization and economic development process.

32. In the absence of an indigenous scientific and technological capability, the development of science and technology would be like a house built on sand. It is therefore desirable and indeed very urgent for African countries to elaborate a Science and Technology Action Plan not only at the national but also at the subregional/regional level. The implementation of these programmes would require significant contributions from the international community. It is expected that the achievement of the objectives of a programme of action would contribute towards improving the efficiency of the African economy through accelerated industrialization, increasing their share in world manufactured products; cutting down on the dependence of individual countries on foreign technologies; optimizing the utilization of funds invested in science and technology programmes, especially in the acquisition, adaptation and absorption of foreign technologies and/or development and commercialization of local ones; and consequently to reduce the enormous amount of foreign exchange being currently used.

A. Elaboration and implementation of the framework of action by African countries

33. Any national action plan for strengthening national scientific and technological capabilities for industrial development needs to place the highest priority on the development of human resources and skills. This would necessitate long-term programmes of a comprehensive nature ranging from the provision of sound educational facilities and reorientation of curricula to vocational training, the creation of specialized cadres of technicians, scientists and managers and specific training related to the selection, acquisition, adaptation and development of technology. Such programmes

should, in addition, take note of the requirements of the decentralized sector and of the need for engaging women in households in productive work. The human being is indeed the centre of the innovation process. Experience has shown that innovations often sprang from groups of individuals, working closely together and developing skills and experience in a specialized area. Proposals for accelerating the development of human resources for industrialization in Africa are elaborated in document ECA/ICHD/88/45/Add.1 entitled "Development of human resources for industrialization in Africa", which constitutes an important background document to this paper that focuses on only one critical category of human resources, i.e. technological capabilities required for industrial development.

34. The establishment and operation of training programmes for the development of the wide variety of technological capabilities required for the development, acquisition, adaptation, absorption and diffusion of industrial technology is therefore very basic if the African countries are to make a breakthrough in the effective utilization of industrial technology for their social and economic development. Actions required in the area of training would need to be directed towards the development of personnel in technological institutions, personnel in other institutions whose activities either have a direct influence or relationship with those of technological institutions, and technological staff of relevant departments of industrial enterprises. In each of these categories, various levels of personnel ranging from top management to the technical level have to be developed. In this connection, it may be noted that the management of technological institutions has been widely recognized as a profession for which special competence needs to be developed.

35. In view of the present situation in which Governments are already allocating large proportions of their budgets to education and training, it is necessary to explore better ways of utilizing these resources in order to produce the right types of skilled personnel needed for the African economies. In order to achieve this, Governments need to take measures to actively involve industry in all forms of training and resolve the problems of shortages and imbalances in manpower. In addition, the process of importing technical skills should be viewed in a much larger perspective than at present.

36. The actions required for developing appropriate personnel for industrial technology need to start at the fundamental stages. The industrial and business communities need to be fundamentally oriented with the particularities of industrial development. Intensive action, initially at the national level and internationally assisted, needs to be undertaken in reforming the educational programmes at the university and pre-university educational institutions in the technical fields in order to imbed in potential technologists, at an early age, a fundamental appreciation of technology.

37. The establishment of special training institutions, on a multi- or mono-sectoral basis, might be considered in some African countries. Such centres could be developed to provide services to other countries of the region. In addition to the formal training programmes which need to be developed to meet specific needs, there is also a need to establish a systematic approach for in-service training.

38. Intimately linked with the programme for the development of national personnel for technological activities is the need to establish the status as well as appropriate salary and compensation schemes to encourage a greater proportion of the business community to take up technological activities.

39. In the elaboration and implementation of a national science and technology action plan, the following important aspects need to be considered:

- Development and implementation of national science and technology policies and plans;
- The establishment of appropriate and effective national machineries, programmes and institutional frameworks;
- Development of appropriate and effective national systems (networks) for the acquisition, processing and storage of scientific and technological information (including economic data) and its dissemination to users;
- Development of effective and viable working arrangements and linkages not only among the national technological institutions but also between science and technology institutions, and other relevant institutions, Government agencies and business and industrial enterprises; as well as the development of international co-operation in science and technology.

National science and technology policies and plans

40. Each African country needs to take action not only to develop such policies, plans and programmes, where they do not exist, but also to reassess existing ones and streamline them in line with national objectives. The adoption of science and technology policies, legislative measures, plans and programmes is essential to ensure a systematic and co-ordinated approach for the development and effective utilization of national scientific and technological capacities and capabilities.

41. Concerning national policies, in particular, they should indicate more clearly the degree of science and technology capacity development needed; the extent of involvement of various local scientific and technological institutions; the mechanism and mode for acquiring technology; and the extent of utilization of foreign sources of expertise. The policies should also provide clear guidelines on such aspects as financing of scientific and technological activities; development of scientific and technological capacities, capabilities and skills; measures for the promotion of scientific and technological activities, especially for the commercialization of research and development results.

42. National policies also need to be developed, or existing ones improved, for the selection, acquisition, adaptation and regulation of imported technologies. It is equally necessary to emphasize that such policies should also allow for the horizontal transfer of technologies within each country since this would in turn require the improvement of existing technologies, in particular the traditional ones.

43. Science and technology planning and programming are rapidly emerging as new areas of activities for which special capabilities need to be developed in the African countries for co-ordinating the preparation and implementation of

national plans and programmes, with international assistance, as required. Not until such programmes, prepared on the basis of well defined science and technology policies are available, will scientific technological activities related to the design, development, acquisition, absorption and diffusion of technology be properly guided and directed towards well defined objectives to produce the expected results.

National machineries and institutions for the development,
selection, acquisition and regulation of technology

44. An important approach to the development of national scientific and technological capabilities is to involve local indigenous scientific and technological personnel and institutions in the entire industrial and economic development process. A national system and machinery needs to be developed to ensure the proper co-ordination, regulation and effective use of local scientific and technological expertise in national development. An important aspect of such a national system and machinery is the establishment of scientific technological institutions, where these do not exist, and/or the strengthening of existing ones to cater for the inputs of science and technology at each point of the industrialization and economic development process.

45. Although the titles of the individual institutions may differ, they can be broadly classified into general purpose institutions and specialized institutions. The former provide a set of specialized services to all industries in various areas such as testing and analysis; standardization, quality control and meterology; product development; and general advisory and information services. The latter are institutions specialized in areas such as iron and steel, leather, textiles, cements, building materials and petrochemicals. They help in sustaining the technical capacities of the specific industries they serve. In many African countries, these institutions constitute the major elements of the industrial and technological infrastructure.

46. Prior to the establishment of new institutions, there is a need to exhaustively review, with international assistance, as need be, the existing institutional set-up to ensure that the tasks to be accorded to the new institution cannot be undertaken by an existing one in its present or modified form. Action, with respect to this aspect of national efforts in technology acquisition, might be more appropriately channelled in four directions: development and commercialization of indigenous industrial technology; appropriate choice of industrial technology; acquisition of appropriate foreign technology; and transfer of technology.

Development and commercialization of indigenous industrial technology

47. Over 95 per cent of the world's research and development is carried out in developed countries. This research, with minor exceptions, is meant primarily for application in the developed countries and, as such, is limited in relevance to the African countries. On the other hand, the small amount of research conducted in the African countries suffers from its own drawbacks. From the African countries' point of view, what is needed is more research, more relevant research and the application of research results.

48. The capability for adapting and improving existing technologies and developing indigenous technologies suitable to an individual country's conditions is a major step towards reducing technological dependence and as such requires priority action. A strategy for this purpose if properly applied could release the innovative capacities in the African countries and benefit in particular the rural economy. A primary action, found wanting in most African countries, is the systematic identification and improvement of technologies already used in a country. Particular attention needs to be given to measures directed at a reorientation of existing research in African countries, the commercialization of the results of such research and the involvement of industry. The capacity for detailed engineering design has to be built up. Though there are several reasons for the lack of research and development work by private companies, measures have to be initiated by which there is increased involvement of the private companies in indigenous research. These measures again require a set of Government policies and hence an examination of existing policies becomes a matter for national action.

49. An important aspect in the development of science and technology is the establishment of an effective machinery, where this does not exist, for carrying out industrial and technological research and development work and the selection and adaptation of foreign technologies. Such a machinery should include appropriate institutional arrangements for the development of indigenous technologies in private or Government institutions, as well as in universities and research and development departments of industry, as appropriate. In the context of such a machinery, new technological institutions may need to be established and existing ones strengthened. In the establishment of new and the expansion of existing institutions, care needs to be taken to relate them to national industrial objectives and to align their programmes to the priority industrial and economic sectors identified in the national industrial and economic development and technology plans. The action required should aim at improving the existing national machinery, reorienting national programmes towards the needs of the country.

50. In connection with the existing technological institutions, action needs to be undertaken, with international assistance, if required, to review their structure, programmes and modes of operation in order to realign them to the current needs of the country and in accordance with national technological policies, plans and programmes, if these exist. Such a review would also be expected to provide recommendations for effective ways of financing and managing technological institutions as well as for acquiring and retaining competent staff at the institutions. Action would also be required for the economic utilization of funds for setting up buildings, equipment and facilities which could easily be adapted to meet the changing needs of the institutions in response to the requirements of the industrial and business community.

51. Of particular relevance to this subject is the need to develop suitable mechanisms for financing the commercialization of successful locally developed technologies and/or the financing of the absorption and diffusion of imported technologies. While some African countries have initiated action towards developing a workable arrangement on this matter, the majority of them have yet to make a start. This is an area for which action at the national and international levels is extremely essential, since it has significant implications on the development of the national capacity for industrial technology.

52. In several African countries, as in other developing countries, traditional indigenous technologies are being discarded without any examination. The application of modern science and technology to upgrade such indigenous technologies could be a major factor in the betterment of the rural population. The attitudes of the local technologists and decision-makers need to be changed so that the industrial and technological development programmes and the methods of drawing them up are reoriented towards national needs. More information on the technologies available from the developing countries has to be obtained and disseminated. Innovative capacities in the African countries needs to be encouraged.

Selection of appropriate industrial technology

53. Action to improve the choice of technology should focus on the decision-making, the stage at which the decisions are made, and the support that is needed to make them. Decision-makers in enterprises, Government agencies and financing institutions have a role to play in the choice of technology. There is often inadequate awareness at the stage of decision-making of the implications of the choice of one technology rather than the other. All too often, the alternatives are not known, let alone considered.

54. The primary task is therefore to sensitize the decision-makers to the problems of choice of technology and to provide them with the tools to facilitate such choice. The process of sensitization could be carried out through meetings and training programmes and by case studies conducted preferably within the country itself. The decision-makers have to be further supported by the supply of methodologies for evaluation of technology, and by information on alternative technologies. The role of consultants is important in major industries. The growth of indigenous consultancy services and the association of such services with foreign consultancy services where the latter have to be necessarily employed, are therefore matters on which action is needed.

55. The choice of technology occurs as part of the establishment of a factory or a production programme within a factory. Technological choices are made, some times explicitly and often implicitly, as a part of other decisions. The stage of feasibility study is a crucial stage for technology choice. The choice can however be modified by the foreign investors, the views of financing agencies and the requirements for governmental approvals. The identification of the stage of actual technology choice is linked to the larger issue of the influence of Government policies on technology choice. Industrial, trade, fiscal and monetary policies influence technology choice considerably. Besides, social objectives vary from private considerations of profit. Hence an examination of the effect of the Government policies and the evolution of a consistent set of policies is basic to the improvement of the choice of technology.

Acquisition of foreign industrial technology

56. Each African country needs to develop a national system and an appropriate institution, where these do not exist, for the acquisition of technology. The terms of reference of such an institution should allow it to work closely with the national technological institutions and be treated as an independent entity with the private sector for the purpose of negotiating

terms and conditions of the acquisition of foreign technologies and for promoting and facilitating their inflow and utilization. The national plan of action should aim at developing the capability, machinery and institutional framework on various aspects related to the acquisition of foreign technologies, such as sources of available and alternative technologies; comparison with indigenous technologies, where applicable; technological research and development activities in the country necessary to diffuse and update the technology; comparable information on economic, financial, legal and technological conditions of transfer of technology agreements; information on foreign companies, donors of the technologies, particularly the multinationals; and information on recent developments in international licensing, patents and trade mark laws and compulsory licensing.

57. As the manufacturing activities of the countries grow and diversify, the inflow of foreign technology is bound to increase rather than decrease, at least in the short run, with a progressive shift to more sophisticated technologies. Hence, the acquisition of foreign technology is a problem for immediate and practical action. The major objective of any action in this field will be to strengthen the bargaining position of each African country, so that the right technology would be chosen on equitable terms and conditions, and the transferrer performs his due obligations. Here again, the question is one of sensitizing the decision-makers, both at the enterprise and Government levels, and/or providing them with the necessary tools and training for the negotiating and drafting of technology contracts. At the enterprise level guidelines for the acquisition of technology need to be provided and the entrepreneurs helped by the provision of model contracts as well as by the supply of information on sources of technology. At the level of the Government, where regulatory mechanisms for industrial approvals and/or for technology acquisition exist, the Government officials concerned have to be trained to examine the issues of technology acquisition. Guidelines for screening and evaluation of technology contracts would need to be evolved and applied as individual country conditions would require.

58. In the acquisition of technology the private and national considerations may not often coincide. Each country has therefore to examine the need for adopting a policy for technology acquisition and for setting up regulatory mechanisms as appropriate. Broad policy guidelines should be established on the terms and conditions in which technology inflow would help both the buyer of technology as well as its seller. Over a period such policies and mechanisms, properly applied, would help rather than hinder the flow of technology.

Transfer of industrial technology

59. Whether the technology is locally developed or acquired from foreign sources, the national technological machinery should facilitate its absorption, diffusion and updating - in other words, to carry out its effective total transfer. The technological assessment of foreign technologies, licensing arrangements, etc., can be an important role for technological institutions, keeping in mind the need to develop a local technological capacity. It is to be recognized that such action is extremely time sensitive and the institutions must also be sensitive to this need. An important aspect of the work would be the development of the capability to analyse key technologies being brought into the country and the status of raw materials needed in processing and production. Each country also needs to

develop the capacity and capability for the appropriate indigenous absorption of the imported technology and its rapid diffusion to other situations and industries.

60. With regard to the absorption and diffusion of industrial technology, complementary action by the suppliers of technology is essential, if not obligatory; and training and skilled manpower are prerequisites. The total absorption and diffusion of industrial technology requires research and development capabilities. For a number of reasons, including the size of enterprises and the lack of compelling circumstances, enterprises in African countries have not established research and development units of their own. For this reason, as well as with a view to utilizing indigenous raw materials, African countries have attached particular importance to the establishment of industrial research institutes. The problem is, however, how to make the institutes active and effective participants in the process of transfer of technology. In particular, the links between industry and the institutes have to be strengthened and a close relationship established between the needs of industry and programmes of research. In most countries, the institutes are not associated in any way with the process of import of technology.

Regulation of technology flows

61. In order to promote a greater flow of foreign technology and to exercise full control over such flows, there is a need for each African country to establish some sort of a national machinery or agency for this purpose. Experience of the functioning of such regulatory bodies indicates that a fairly similar pattern has generally evolved. Most of them have hitherto primarily viewed the question of foreign technology in relation to specific contractual terms and conditions under which such technology is imported by enterprises operating within a country. Considerable literature has emerged in recent years on various restrictive conditions often imposed by licensors and technology suppliers and the need for strengthening the weak bargaining position of domestic enterprises, and regulatory agencies have largely tended to ensure such restrictive conditions with certain broad national objectives. The degree to which such regulation can be effectively exercised without unduly affecting the inflow of required foreign technology inevitably depends on various factors, including the level of industrial development, the capacity of domestic enterprises, and policies on foreign investment with which technology inflow is often closely linked, particularly in earlier stages of industrial growth. Considerable knowledge and awareness has, however, undoubtedly developed in respect of the intricacies of technology contracting in countries where such regulation has been introduced, together with the implications and constraints of such regulation in the context of particular country situations.

62. The impact and experience of foreign technology regulation in the African countries, where such regulation has been introduced, has been fairly positive and has, in fact, highlighted the essential need for such regulation. In most of these countries, technology regulation has resulted in significant improvement in the terms and conditions of specific agreements for import of foreign technology and know-how, together with technological services. Apart from considerable savings in the direct costs of foreign technology agreements, various restrictive conditions sought to be imposed by technology suppliers have been excluded or minimized, placing domestic enterprises in a much stronger position to adequately absorb and adapt foreign technology for

their effective growth. In some countries, such regulation has also greatly assisted the growth of technological service capacity. In some countries, technology regulation has also focused attention on the close relationship between foreign investment and technology and the technological implications in respect of enterprises having significant foreign capital participation, including foreign-controlled subsidiaries and affiliates.

63. The issues and considerations relating to technology regulation in African countries must, however, necessarily be viewed in the context of overall industrial strategy and policies relating to a country's industrial and technological development. The regulation of foreign technology constitutes an integral part of the overall framework of national technological development and it is necessary to relate the various issues and implications of technological development with the more detailed consideration of selection, evaluation and acquisition of technology, be it locally developed or imported.

Industrial and technological information

64. The development and acquisition of appropriate technology essentially involves the collection and processing of technological data from various sources and combining them to produce a new indigenous technology. An appropriate framework for this would involve the establishment of a national technological information network with a well defined focal point. While a great deal of effort has been expended world-wide in developing information systems and services geared to meeting the needs of scientific personnel, the lack of adequate "industrial" and "engineering" information and the inability to effectively utilize the available information are problems encountered in many of these systems. Improvement in the use of scarce research and development resources is possible only when the capacity to collect, store, retrieve, interpret and use the available knowledge - through information on the type needed by the engineers and technologists in the industry, the content of which is more than the type of information needed by pure researchers or scientists - has been created.

65. The supply of information is a vital prerequisite for the development, choice, acquisition and transfer of industrial technology. Such information has to be furnished to the decision-makers by national information institutions which may themselves require establishment or strengthening. Information has to be evaluated and packaged suitably if it is to be of use to the decision-makers. Since technology is available on a world-wide scale, national institutions require a constant flow of outside information and support.

66. Any action programme for the development of a sound technological information and data base in the African countries should take advantage of existing international technological information systems, such as the UNIDO Industrial and Technological Information Bank (INTIB). It may, however, be noted that a significant amount of work will still need to be done in determining the actual requirements of the various uses of technological information in each country, and to develop a system or network linked with foreign sources in order to provide information required at each phase of the industrialization process in an efficient manner and at the time required. This is also an area which lends itself to international co-operation, particularly through inter-institutional linkages.

Establishment of technological institutional linkages

67. Technology development and application is a multi-disciplinary activity requiring inputs from various institutions, disciplines, sectors and activities of the economy. In their central function of providing technological inputs for industrial and economic development, technological institutions need to develop a network of linkages if their contributions are to be accepted and effective. The linkages which technological institutions need to develop consist of linkages with national industrial and economic planners; industrial enterprises and the business community, other relevant institutions in the country; and linkages with technological institutions in other countries.

Linkage with Governmental planning machinery

68. In their planning functions, national industrial planners require technological inputs generally provided by institutions from more advanced countries. A close working relationship with the national industrial planning machinery is essential in order to provide an opportunity for local technological institutions to contribute by providing these required technological inputs. Where the technological institution has not acquired the level of competence to make an effective contribution, a natural approach would be for such an institution to link with an appropriate more advanced one. Decision-makers and national industrial and economic planners also need to encourage indigenous technological institutions, where these already exist, by making greater utilization of their services in the full spectrum of industrial and economic development.

Linkages with the industrial and business communities

69. Although several efforts have been made at the national and international levels to close the gap that exists between technological institutions and industrial and business enterprises, the degree of success so far achieved is still very limited. Concerted efforts at the national level, with international assistance if need be, would be required to develop suitable approaches to promote a greater utilization of the services of technological institutions by the industrial and the business community.

Linkages with other national institutions

70. Linkages with other relevant national institutions are directly related to the development of a national machinery and programme for industrial technology. With a suitable policy framework and national machinery which clearly defines the functions of each institution, linkages between the various technological institutions in a country, particularly between multi-purpose and specialized institutions, would be easier to establish and implement. An action programme in this area would necessarily have to be within the framework of a programme for the establishment of a national policy, plan, programme, machinery and institutional framework for industrial technology. However there would be certain specific situations where action would be required to develop working arrangements between institutions, either on joint projects or for complementing and supplementing each other's activities. The action to be undertaken in this connection would also help to develop a project management system to ensure smooth implementation.

Linkages with institutions outside the country

71. With the rapid pace at which science and technology is changing and with the rapid rate of industrial development taking place in various countries, the establishment of close contact among organizations devoted to technological activities would need to break national boundaries and establish viable and dynamic international linkages. Such linkages would exist between institutions not only within the developing countries themselves but also between developed and developing countries.

72. Linkages between technological institutions in developing countries with those more advanced foreign ones in other countries would help to build more confidence in the local institution since it gains experience by working with the more experienced one. The linkages, if they involve consultants and/or technological institutions which already enjoy international recognition, would also help in the efforts of technological institutions in developing countries to win the confidence of their clients.

B. International co-operation in strengthening the scientific and technological capabilities in African countries for industrial development

73. The continuing technological gap between developed and African countries and the rapidly-growing needs of the latter in respect of industrial technology necessitates significant enlargement of the scope and content of technological co-operation between African and more advanced countries.

Technological co-operation with other developing countries

74. Increased co-operation between African and other developing countries is necessary because of the considerable similarity in the problems and issues related to the strengthening of scientific and technological capabilities for industrial development facing many of these countries. To some extent, training of experts from African countries is already being carried out in a number of developing countries. This, however, has so far been a very limited programme since such training has normally been linked with the overall technology supply arrangements entered into with licensors and suppliers from industrialized economies. It would be desirable to develop training programmes for African experts in a number of selected industrial subsectors and areas which could be jointly undertaken in one or more developing countries.

75. There is also a need to establish closer direct relationships between enterprises in African and other developing countries that would be particularly advantageous in the exchange of information on the terms and conditions for the commercial acquisition of industrial technology from enterprises in developed countries. In addition technological services capability, including consultancy and engineering services, has also grown considerably in many developing countries which can be suitably extended to African countries. The arrangements for commercial transfer of industrial technology from enterprises in other developing countries to African countries should, however, ensure that technology supply is made in a manner and on terms and conditions which are suitable and appropriate for African countries.

76. Specific areas for consideration in the promotion of technological co-operation between African and other developing countries would include the following:

- Enhancement and development of African capabilities, particularly engineering and consultancy services, in the identification, evaluation and selection of foreign industrial technology;
- Rationalization and monitoring of industrial technology flows into African economies with emphasis on the regulatory and promotional functions of technology regulatory agencies and the exchange of information as well as the techniques and guidelines used in this regard;
- Strengthening of the negotiating capabilities of governmental institutions and industrial enterprises in African countries for the acquisition of industrial technology, including exchange of experience and information on the terms and conditions of technology acquisition contracts;
- Assistance to African countries in the formulation of policies and programmes for the development and application of industrial technology, including the development of joint programmes for research and development in specific industrial subsectors and branches; and
- Development and promotion of African indigenous technological capabilities, including the development of technological institutions engaged in industrial and technological research and development activities; the upgrading of appropriate indigenous processes and techniques; and the provision of technological service capability.

Industrial and technological information

77. The exchange of information and experience between African and other developing countries regarding the terms and conditions of technology contracts would greatly strengthen the bargaining position of African countries because of the greater information put at their disposal. There is generally a tacit understanding between licensors and licensees that the terms of technology agreements should be kept confidential even among technology regulatory agencies also. Technology contracts, however, are purely commercial arrangements and so long as proprietary or confidential technical information is not divulged, there is no legitimate objection to the sharing of information among national technology regulatory institutions. The claim of licensors that special provisions are being made for particular countries, which is often quoted as the justification for keeping the terms confidential, should be able to stand the test whether this is actually so. The disclosure of commercial terms by one national technology regulatory agency to another would not normally injure the interests of licensors or licensees but would rather enable the technology regulatory agencies in African countries to take decisions in the light of the wider experience available in other developing countries.

78. There is also a need to promote an exchange of information in respect of legislative or administrative measures introduced in other developing countries; guidelines for technology evaluation being compiled; and information on indigenous technologies and services which could be utilized by

African countries. In this connection and in order to facilitate such exchange of information and to enable effective analysis and dissemination among African countries, UNIDO could undertake the responsibility of receiving, processing, analysing and distributing the information which would be supplied by developing countries.

79. In view of the historical preference for the acquisition of industrial technology from the enterprises in developed countries, particularly from transnational corporations, it would be desirable for technology regulatory agencies in other developing countries to specifically encourage enterprises in their respective countries to make available to African countries their available technologies and know-how, where this may be applicable. This would be particularly relevant in sectors where conditions in respect of raw materials, local skills, plant size, etc., are similar. Unless positive measures are taken to encourage the flow of technology and know-how from other developing countries, enterprises in African countries would continue to be limited in their search for technology to industrialized countries even in sectors where adapted technology from other developing countries may be more suitable and appropriate.

80. The development of appropriate technologies is an area in which African countries could obtain great benefit from the work already carried out by other developing countries. The exchange of information on available indigenous technologies and on the research and development programmes of their institutions can help to maximize the utilization of scarce resources and to promote the pooling together of experience. Joint research possibilities could be identified and promoted.

Sharing of technological services and institutions

81. In a number of developing countries there has been a considerable development of industrial consultancy and engineering services capabilities. Since the growth of such capabilities has taken place in the context of local requirements and skill endowments in the developing countries, these may prove more adaptable to conditions in African countries. This would be particularly suitable in the production of light consumer goods and intermediates, certain categories of capital goods and equipment, and a wide range of small-scale industrial products. While there has been some exchange of technological services between some developing and African countries, only a beginning has so far been made and there is considerable scope for the expansion of such co-operation.

82. In order to enhance the development of technological services capability, the African countries need to set up certain national facilities, an endeavour which undoubtedly would provide for very fruitful co-operation between African and other developing countries, not only in strengthening existing facilities but also in setting up new ones where they do not exist. Some linkages have already been established in this direction primarily at the enterprise level between African country licensees and foreign parent organizations and technology licensors from industrialized nations. Such linkages need to be extended to similar institutions in other developing countries.

83. The potential for greater co-operation between African and other developing countries is particularly relevant in respect of industrial consultancy services and detailed engineering facilities. There is

considerable scope for setting up joint industrial consultancy and engineering services, either on a regional basis or between groups of countries at a similar stage of industrial growth. The first step in this direction is the greater use by African countries of industrial consultancy and engineering services available in certain developing countries, followed by the creation of appropriate consultancy services in Africa on a national, subregional, regional or subsectoral level.

84. A number of institutions engaged in various types of R & D, including multi-disciplinary research, have been set up in several developing countries. There appears to be a pressing need and considerable possibility of greater co-operation in joint R & D activities between such institutions and those in Africa. New fields of technological breakthrough such as electronics and biotechnology/genetic engineering, represent important areas of research, in addition to the traditional areas of basic interest to a number of African countries such as agro- and agro-related industries, chemical, metallurgical and building materials industries and energy.

Negotiation of technology agreements

85. While the commercial transfer of technology and know-how and of technological services should take place to a greater extent between African and other developing countries, it would perhaps be both appropriate and necessary that new norms of conduct in respect of such technology supply arrangements, which would be followed by technology-supply agencies from those developing countries, should be elaborated and agreed upon. The determination of a new set of guidelines and norms in respect of such arrangements between enterprises in Africa and those in other developing countries would greatly facilitate technology flow. Licensor enterprises from those developing countries should not adopt the same role as is often assumed by technology licensors from developed countries who impose unduly harsh and restrictive contractual conditions on African countries licensees.

86. On all critical negotiable issues such as the extent of foreign holding, duration of agreement, technology remuneration, technical service support and other contractual conditions, new standards and principles should be set and agreed upon based on a maximum degree of co-operative partnership. A model set of guidelines need to be prepared, which, after consideration and adoption by Governments in the African countries and those in the co-operating developing countries, should be applied by licensor-licensee enterprises from their respective countries. With the greater degree of regulatory control exercised by governmental agencies in African countries over the productive sector, it should be feasible and practicable that such guidelines and principles, as are agreed upon at intergovernmental level, will be universally applied in technology and investment-cum-technology transactions between enterprises in the countries.

87. While the adoption of a uniform code of conduct in respect of technology supply arrangements would help to ensure greater uniformity in contractual arrangements, African countries need to ensure that technology suppliers, particularly transnational corporations, do not create a competitive situation between them and other developing countries in respect of specific projects and technology supply arrangements. This is especially relevant in respect of projects of fairly large magnitude. It would be desirable that a system of information and consultation is developed between the African and the

developing countries concerned to ensure that no undue advantage is taken on this account. In this respect, it would appear useful to adopt uniform policy guidelines covering the inflow of foreign technology in certain sectors to the developing countries so that undue competition among the countries themselves can be minimized.

Joint acquisition of industrial technology

88. Though seemingly difficult, the joint acquisition of technology and know-how for use in more than one project could hold out considerable possibility in the future. There is considerable commonality in industrial programming in countries at comparable stages of development and projects in the same field may be undertaken in more than one developing country at around the same time. Such projects can range from large-scale industries such as iron and steel, petrochemicals, fertilizers, chemicals and machine tool complexes and the like to medium-size plants for textiles, sugar, cement and agro-industries to small-scale units covering a wide range of intermediate and consumer products. In a number of these cases the acquisition of foreign know-how on a collective basis for more than one project could be considered. This would enable more detailed evaluation and consideration of technological alternatives by African countries and would reduce technology costs, apart from securing better contractual terms.

89. Such an approach towards collective bargaining would have particular significance in countries geographically contiguous to one another, as in the case of the Andean group or regional country-groups in Asia and Africa. Significant collective action has so far not been initiated in the acquisition of technology primarily because this issue has been viewed in national terms and left to the initiative of individual enterprises. With the growing realization of the inter-relationships in technological growth, a joint or collective approach in technology acquisition has dynamic possibilities for co-operation between African and other developing countries in the future.

90. The institutional arrangements for joint acquisition of technology also need to be considered. These could either take the form of joint negotiations for identified industrial subsectors and branches in which African and other developing countries are interested or the establishment of an international mechanism through which technology can be acquired and transferred to projects in more than one African country. The former approach necessitates close collaboration and co-ordination between African and other concerned developing countries and the identification of common technological needs in specific industrial subsectors and branches after which an appropriate mechanism could be set up for evaluating, negotiating and acquiring selected technologies in the identified fields. The second alternative requires the creation of an appropriate mechanism through which such joint technology transactions could be channelled.

Technological co-operation with developed countries

91. While there is a great need and potential for technological collaboration between African and other developing countries, it must be emphasized that such co-operation does not preclude co-operation with developed countries. For quite some time to come enterprises and institutions in industrialized nations will continue to be the major sources of industrial technology to African countries. There is an increasing recognition in the developed

countries of the necessity for more rapid technological growth in the African countries as a prerequisite for global industrial restructuring of industry. This needs to be translated in terms of a more sympathetic appreciation of the genuine problems and difficulties in the African countries requiring concrete action programmes by enterprises and Governments in the developed countries to achieve more effective technological co-operation.

Liberalization of technological negotiations and transfer at enterprise level

92. Except for the centrally-planned economies, ownership and knowledge relating to industrial technology in developed countries largely rests with individual enterprises or industrial groups. Technology flow into Africa takes place through various mechanisms, ranging from supply of capital goods and licensing arrangements to joint ventures and foreign affiliates with varying degrees of foreign ownership. In almost all cases, technology transfer takes place through contractual arrangements between enterprises in these countries and those in the African countries. There is, however, an increasing recognition by African Governments to exercise greater control over such technology flows. A number of African countries have therefore put into operation elaborate screening procedures with a view to eliminating the restrictive and unreasonable provisions which have hitherto been part and parcel of technology contracts.

93. It would thus be desirable for representative bodies of technology suppliers and licensors in developed economies to adopt such new approaches and guidelines in technology supply and contracting consistent with the requirements of the African countries. Governments in those countries also need to readjust existing and adopt new policy measures not only to promote but also to control the flow of technology from enterprises in their countries to those in Africa on more favourable terms and conditions. It is only then that the present trend towards confrontation would be more effectively resolved and a more appropriate climate created for investment-cum-technological collaboration at enterprise level.

Increased flow of technology to African countries

94. Hitherto, investment-cum-technological collaboration with African country enterprises has largely been concentrated in the hands of relatively few transnational corporations having close trade or industrial links with a number of African countries. Technological knowledge and capability in various industrial subsectors and branches is, however, available with a much larger number of enterprises in industrialized countries, particularly medium-sized manufacturing units. The field of technological choice would be considerably widened if such enterprises were also brought within the ambit of technological collaboration with enterprises in African countries.

95. In order to facilitate a greater flow of technology from the developed to the African countries, it would be worthwhile considering, firstly, to establish appropriate mechanisms at both the international level and in individual developed countries to ensure that technology-supplying enterprises from these countries comply with guidelines for technical collaboration or investment-cum-technological collaboration with enterprises in African countries. Secondly, greater incentives should be given to enterprises exporting technology to African countries. These could take the form of tax relief or subsidies in respect of incomes accruing from supply of technology

or technical services to these countries. Thirdly, greater technological co-operation should be ensured through governmental and semi-governmental institutions dealing directly or indirectly with R & D in various production branches with corresponding institutions and enterprises in African countries.

96. Furthermore, it is necessary for the developed countries to financially support and encourage a greater flow of technology to African countries. Even if a small percentage of the income generated from external technology supply could be set aside by these countries to financially assist the flow of industrial technology to African countries, a significant beginning would have been made in generating adequate resources to ensure a substantial increase in the supply of technology and expertise to African countries. Such resources could be channelled through an international mechanism, such as UNIDO, which would represent a practical and tangible expression of greater international technological co-operation.

International mechanism for technology acquisition

97. The mechanisms suggested above to accelerate and increase the flow of technology to the African countries could be considered in the form of an "International Technology Bank for Africa". The functions of such a bank could be to:

- (i) Assist in identifying technological needs of African countries, particularly the specific technical needs in priority industrial subsectors and manufacture enterprises;
- (ii) Assist enterprises, institutions and other bodies in African countries in identifying technological alternatives, evaluating such alternatives and in negotiating for the acquisition of industrial technologies on equitable terms and conditions for production/manufacturing activities;
- (iii) Acquire licensing rights for technological processes, production techniques, trade secrets and know-how, both patented and unpatented, for selected industrial production branches and products, for the purpose of transferring such technology and know-how to enterprises in the African countries other than wholly-owned or majority-owned foreign subsidiaries and affiliates, on appropriate terms and conditions, for production/manufacturing activities;
- (iv) Assist enterprises in the African countries in the initial financing of the cost of technology acquisition for selected industrial production branches and products, either wholly or partially, principally by way of a loan on such terms as may be agreed upon; such financing could also be extended to cover the cost of technological services, but not that of machinery and equipment;
- (v) Provide other assistance to enterprises in the African countries on other matters agreed upon between the International Technology Bank for Africa and the enterprises concerned.

98. It should, however, be emphasized that such an institution would only supplement and not supplant enterprise-to-enterprise transactions in

technology. Technological exchange will continue to take place to the extent practicable and within existing constraints. At the same time, an institution of this nature could well emerge as a significant new channel of technology transfer to African countries over a period of time. Such an institution could also be a very useful instrument to a large number of medium-sized enterprises in industrialized countries, which possess techniques of great value and utility to African countries but which may otherwise be unable or hesitant to enter the field of technological collaboration with enterprises in the African countries.

C. Mobilization and utilization of
financial resources for strengthening the scientific
and technological capabilities of African countries for
industrial development

Mobilization of financial resources

99. At present the most common forms of financing the development of scientific and technological capabilities in African countries are budgetary: provisions for science and technology education in secondary and trade schools, polytechnics and universities, accompanied by scholarships and bursaries. In some countries Governments may also reimburse the costs of training by industrial enterprises and allow tax exemptions on expenditures by those companies on science and technology development. In connection with direct Government support to science and technology, it may be recalled that the Lagos Plan of Action and Africa's Priority Programme for Economic Recovery (1986-1990) calls on each African Government to consider allocating at least 1 per cent of its GDP to the development of science and technology.

100. Several African Governments have financed the development of science and technology education and training facilities through gifts and technical assistance from abroad and soft loans. In a number of countries, non-governmental organizations have made substantial contributions, and so have "better off" nationals assume greater responsibility for the training of their children and relatives. In recent times some African Governments have begun to set up, as in other developing countries, Science and Technology Councils and special funds for science and technology development. They are increasingly calling for the inclusion of training provisions in technology transfer and investment contracts.

101. Several observations can be made about this mixture of methods and means of financing science and technology development. Firstly, it is not easy to calculate the total volume of expenditures involved. Secondly, there is no way of knowing the distribution of these expenditures by area of specialization nor has an easy means been found to bring private voluntary fellowship grants into balance with projected science and technology demands, though several Governments now insist that fellowship awards by non-governmental agencies should be made through a central pool in which specialization is determined.

102. It has become apparent that priorities for the financing of science and technology have to be seen not merely in terms of the physical cash involved but also in terms of the foreign exchange requirements for the building-up, within the country itself, of possibilities for science education. Indeed, this challenge requires that efforts be made to rationalize and upgrade many

of the methods and sources of financing national programmes to accelerate the development of scientific and technological capabilities which, themselves, also have to be given high priority. Without such a rationalization, it would be difficult to decide on how to optimize the use of local funds, especially the foreign exchange resources (export earnings, aids, loans, technical assistance) so as to build up those local capabilities.

103. In order to abate the increasing trend whereby some sources of funds are shrinking and to improve the terms by which funds can be obtained from other sources, a decision on which sources of funds needs to be enlarged to compensate for the decline of others; which ought to be redirected to science and technology education abroad; and on the means to adopt in obtaining external financing for the establishment, improvement or expansion of local training facilities, bearing in mind the mounting costs of importing teachers, instructors, materials, equipment, building components, etc.

104. The potential of increased contribution from industry and the business community has not been fully exploited. Much remains to be done notably by commercial banks and credit institutions whose prime objective is to finance the sale of industrial plants and equipment without according appropriate attention to the training requirements. Yet an important criterion for financing the importation of industrial plants and equipment is the existence of trained managers, engineers, scientists and technicians. This vicious circle needs to be broken. Financial institutions, when they study projects, need to accord high priority to the training of local skills since it is only on the availability of competent manpower that viable projects can be identified and successfully implemented. In connection with the above, the training of manpower should be considered as an essential part of a project financing package rather than as a mere adjunct to a project contract. Consideration should also be given to the provision of training and related training material on concessionary terms and in greater volume by equipment suppliers.

105. In addition special mixed credit arrangements should be considered. Commercial and investment banks should be encouraged to consider granting special loans for science and technology education which could greatly assist small- and medium-sized enterprises in meeting their training needs. Additionally, consideration should be given to the establishment of an industrial training fund whose revenue could initially come from special taxation on industrial products and raw materials as well as on industrial and technology contracts.

Utilization of financial resources

106. It has been recognized that investment in the development of scientific and technological capabilities is indeed investment in real terms for capital formation and for industrial and economic development. In this regard, it is essential for the African countries to establish appropriate priorities among the various components of science and technology programmes. Thus, rather than perpetuating the existing situation whereby a larger proportion of resources is allocated to the financing of buildings and infrastructure, more emphasis should be given to the financing of science and technology education and training programmes, especially those related to the development of instructors and new training processes, methods and aids, student programmes including fellowships, R & D; training facilities and equipment, especially

those possessing a demonstration effect, as well as programmes in favour of the rural masses.

107. The question of finance leads, in turn, to consideration of the extent to which local production capacities of education and training materials can be built up in substitute for imports. This itself would depend on the extent to which foreign exchange resources (including foreign aid and technical assistance) are deliberately allocated to building up local education and training capacities on a national, subregional or even regional basis. For such allocation to be made, there should exist some quantified calculation of requirements, however rough, in order to provide a more realistic basis for planning and programming. Definite efforts need to be made for the local production of books, films, materials and other equipment for science and technology education and training in order to reduce the burden on national budgets arising from the high cost of sending large numbers of students and trainees to developed countries.

108. In their negotiations for foreign aid and technical assistance related to the financing of science and technology programmes, African countries need to give greater priority to the training of trainers and to the redeployment of industrial capabilities for the local manufacture (on a national, subregional or regional basis) of books, films and other materials and equipment for science and technology education and training. Consideration should be given to the possibility of setting up new production units or rehabilitating existing ones at the subregional or regional level as training companies, whose principal function would be the replication of teaching and training capabilities. Foreign aid and technical assistance should also be sought for the establishment or strengthening of existing R & D capacities at the national, subregional and regional levels relating, in particular, to the development, commercialization and marketing of educational materials and equipment especially for science and technology education and training.

109. One of the most effective means of coping with the sheer volume of science and technology education and training needs is the establishment of the teaching companies mentioned above. The teaching company is analogous to a teaching hospital. Whilst engaged in every aspect of production (procurement of raw materials and other factor inputs, processing, marketing, standardization, quality control, R & D, etc.), as well as in providing extension and consultancy services, its main vocation would, however, be the training of technical or managerial skills. International organizations, particularly UNIDO, could assist African Governments in identifying existing modes or production units (e.g. railway engineering and other workshops) which could be upgraded to teaching companies.

110. There is an urgent need for the African countries to undertake the establishment and financing of such teaching companies. The cost/benefit of investment in these companies would justify the need to accord high priority to financing their establishment, taking into account the mounting costs of educating and training nationals from African countries in developed countries, on the one hand, and their overall socio-economic benefits, on the other hand.

111. An important point to be taken into account by African Governments when considering the financing programmes for strengthening scientific and technological capabilities is the emergence of an international market for

training under the auspices of training companies mainly in developed countries. African countries need to take advantage of this recent trend and UNIDO could be requested to prepare a directory of such training companies showing, for example, their organization; the scope of training services they offer; their mode of operation and financing; and the particular strengths of individual ones. Such a directory could be of great assistance to African countries in setting up their own training companies. So vast are the anticipated needs that existing companies need not fear being crowded out of the market. Indeed, they could initiate the establishment of joint training companies with public or private entrepreneurs in developing countries.

112. The problems related to the utilization of financial resources for science and technology identified above and the steps proposed to deal with them are complementary to measures to be taken on other aspects or areas of science and technology development. In order to ensure optimum utilization of resources, African Governments should take the following measures into consideration when deciding on their financial allocations to the development of scientific and technological capabilities:

- Allocation of a lesser portion of scarce foreign exchange and other resources to buildings and more to measures for the improvement of teachers and instructors, teaching/learning techniques and aids;
- Acquisition of materials, equipment, programmes for science and technology education; the application of micro-electronics for that purpose; restructuring of subject offerings, especially in universities, to reflect higher priorities for the development of the natural resources/raw material industries and the production of specialists for policy research, planning, management, manufacturing, R & D, marketing;
- Fuller use of existing facilities, especially laboratories;
- Deliberate introduction of textbook writing, associated with the establishment of national or multinational enterprises for the production of textbooks and other educational literature, films, video cassettes;
- Active promotion of science and technology libraries and exhibitions, not only in the capital city and few towns but also in rural areas; and
- Expansion of the use of the mass media, especially radio and television programmes for mass education in science and technology.

113. The above proposals are really not new and many of them are already being applied in some African countries. What seems to be required is a concentrated effort on the part of all African countries, not only individually at the national level but also collectively at the subregional/regional level, in ensuring the full implementation of at least most of them. International organizations such as UNIDO, UNESCO, ILO and other agencies outside the United Nations system could be of great assistance in this respect.

D. UNIDO's support to the framework of action for
the development and utilization of science and technology
for industrial development in Africa

UNIDO's mandates in the field of science and technology

114. General Assembly resolution 2152(XXI) which established UNIDO calls upon UNIDO to undertake operational activities, action-oriented studies and research programmes to promote the industrialization of the developing countries. It further calls upon UNIDO to "play the central role in and be responsible for reviewing and promoting the co-ordination of all activities of the United Nations system in the field of industrial development". In view of the fact that science and technology is an integral part of industrial development, the resolution underlines UNIDO's role, *inter alia*, in "building and strengthening of institutions and administration in the developing countries in the area of industrial technology..." and "dissemination of information on technological innovations originating in various countries and, for the developing countries, assistance in the implementation of practical measures for the application of such information, the adaptation of existing technology and the physical, social and economic conditions of developing countries through the establishment and improvement, *inter alia*, of technological research in these countries". Since the adoption of this resolution, activities to promote the development and transfer of industrial technology have been a major component of UNIDO's activities and as such have received particular attention both in operational activities and in discussions in the policy-making organs of UNIDO, viz. the Industrial Development Board (IDB), and the General Conference.

115. Both the Lima and New Delhi Declarations and Plans of Action adopted by the Second and Third General Conference of UNIDO envisage that developing countries should reach a share of at least 25 per cent of the world industrial production by the year 2000. Africa's share of that target is 2 per cent. Recognizing that the achievement of this target would imply the development and application of science and technology on a massive scale, UNIDO pays particular attention to the building up of indigenous technological capabilities of the African countries and the measures necessary, at national, subregional/regional and international levels, for the development and acquisition of technology.

116. Endorsing the Lima and New Delhi Declarations and Plans of Action, the United Nations General Assembly also asked UNIDO to establish a system of consultations between developed and developing countries and among developing countries themselves in order to facilitate the achievement of the goals set forth in the field of industrialization, including the redeployment of certain productive capacities existing in developed countries and the creation of new industrial facilities in developing countries. Since such consultations include the associated technological aspects, UNIDO is specifically called upon to accord priority to activities in the field of technological information and operational activities relating to the development, acquisition, adaptation and transfer of appropriate technologies, including exchange of industrial know-how among developing countries.

UNIDO co-operative programme of action on appropriate industrial technology

117. The UNIDO's Co-operative Programme of Action on Appropriate Industrial Technology which has received international acceptance, identifies the following areas of activities to be undertaken not only by UNIDO but also by national Governments as well as by private agencies and regional and international organizations: evaluation and comparison of alternative industrial technologies; promotion of technological research; collection and dissemination of practical experience; application of technology to rural development; technologies for alternative sources of energy; national and international policies and institutional infrastructure for appropriate industrial technology; and training programmes in appropriate industrial technology.

118. The important objective, apart from implementing specific programmes, is the consolidation of efforts in this field, and the mobilization of interest on a world-wide scale. The objective would be achieved by stimulating policy- and decision-makers, enterprises and research institutes in African countries to promote the application of appropriate industrial technology; stimulating suppliers of technology and equipment in industrialized countries to undertake the necessary adaptation and redesign to suit the needs of African countries; stimulating Governments and donor agencies in industrialized countries to increase their assistance to African countries in the area of appropriate technology; and mobilizing existing research capacity in developing and industrialized countries, including research organizations, universities, private enterprises, particularly small companies and individual inventors, in support of the efforts being deployed by African countries.

119. For the mobilization of interest, UNIDO organized a series of meetings at the national, regional and global levels relating to appropriate technology. These meetings, which were all attended by policy-makers at the ministerial level and practitioners as well as interested organizations in the United Nations system and donor and aid agencies, provide the opportunity to establish personal contacts and exchange information on the work being done and the problems encountered. A number of African countries have been participating in these meetings.

Major activities of UNIDO related to strengthening the
scientific and technological capabilities of African countries
in industrial development

120. UNIDO's efforts in assisting African countries in the development and utilization of scientific and technological capabilities for industrial development take the form of operational and supporting activities relating to the following priority areas:

- Formulation and implementation of technology policies, plans and programmes, including the identification and implementation of measures for the development, acquisition and transfer of industrial technology;
- Strengthening of existing and establishment of new national, subregional and regional technological institutes and centres of excellence, including strengthening technological extension and field services;

- Provision of technological information to African countries, including the establishment of technological information modes at the national, subregional and regional levels and their linkage to information centres outside Africa through the Industrial and Technological Information Bank (INTIB) operated by UNIDO;
- Selection, acquisition and adaptation of industrial technology to local economic and social conditions in African countries and the development and commercialization of indigenous technologies for practical application in industrial development; evaluation from the technical, economic, commercial and legal point of view of industrial technology transfer agreements and contracts;
- Training at national, subregional and regional levels of African technological capabilities in the development, acquisition, adaptation and transfer of technology, including the evaluation and negotiation of technology contracts; and
- Promotion of technological co-operation between African countries and the developed as well as other developing countries, including the identification of joint projects that can be implemented with the technical resources of those countries.

Development of industrial technology policies, plans and programmes

121. UNIDO has been urged and is according priority to assistance to the African countries in the formulation of policies and the elaboration of policies and programmes for the development, acquisition and transfer of industrial technology. Towards this end, UNIDO is assisting Governments, at their request, to review, formulate and improve, through the provision of methodologies and mechanisms, their policies in regard to national technology development as well as through comparative studies of national experiences in this field.

122. Common to all the projects is a field survey of the actual conditions in each country concerned, followed by a national workshop with the local policy-makers. A major project on similar lines is envisaged in three sets of developing countries: countries with no explicit technology policies or plans; countries which have established mechanisms for regulation of imported technology; and countries which have formulated technology plans.

Development, adaptation, choice and acquisition of industrial technology

123. UNIDO's activities relating to the development, acquisition, adaptation and absorption of technology, whether imported or indigenous, are aimed at ensuring development of indigenous technologies as well as a greater flow and utilization of technological information for the building up of local capabilities for the evaluation, selection and acquisition of technology and equipment. In the acquisition of technology where the African countries remain unequal partners vis-à-vis the developed countries, UNIDO activities extend beyond training, technical assistance and technical publications to certain new initiatives designed to strengthen the collective bargaining position of the African countries.

Development and adaptation of industrial technology

124. With regard to the development of indigenous technologies, UNIDO has adopted primarily two approaches. One is the better use of existing research capacities, particularly by the stimulation of co-operation among research institutes in the developing countries. Various expert group meetings organized by UNIDO have revealed the possibilities of several types of co-operative action and proposed measures to be taken to promote such co-operation. As a result, UNIDO has identified joint research projects and also, where possible, helping to secure the seed money for stimulating such co-operation. UNIDO is also helping to promote local technologies developed in African countries in areas of common interest to several countries. A typical example of this activity is the project financed by UNIDO to develop a prototype of the gari-processing equipment developed by the Federal Institute of Industrial Research in Nigeria for application in other African countries.

125. Another approach being adopted by UNIDO is to promote the enlargement of available information on industrial technologies through a systematic identification of technologies, including the traditional ones, available in African countries themselves. With this in view, projects have been initiated in selected African countries to carry out, through national research institutes, systematic surveys of indigenous technologies in selected branches of their food-processing and preservation sectors. The surveys are expected to bring out material on the basis of which some of the existing technologies could be upgraded and some others transferred for adoption by other countries. It will also provide a methodology for systematic action by research institutes in African countries in the elaboration of their research programmes.

126. In connection with the above, UNIDO is also establishing a system for the exchange of information among research institutions of African countries for the systematic dissemination of the results of research already done, being carried out, or planned for the future. This system is so devised as to include interaction, at a later stage, with institutions in the African countries carrying out industrial research of relevance to developing countries. With a view to stimulating the interest of researchers in universities, UNIDO is also promoting as a pilot project linkages among universities, research institutes and industry on the basis of carefully identified projects.

127. Attention is also paid to strengthening African capabilities in the judicious selection and application of new technologies in such fields as micro-electronics and biotechnology/genetic engineering. An expert group meeting sponsored by UNIDO in Swaziland in 1984 on this subject advanced concrete proposals for implementation at the national, subregional/regional and international level.

Choice of industrial technology

128. Assistance in the choice of industrial technology forms an important aspect of UNIDO's activities. These activities encompass a series of actions covering the following aspects: comparison and evaluation of alternative industrial technologies; promotion of technological research; collection and dissemination of practical experience; application of technology to rural development; technology for alternative processes and energy; national and

international policies related to appropriate industrial technology; institutional infrastructure of appropriate industrial technology; and training programmes in appropriate technology.

129. The appropriate choice of industrial technology presupposes the existence of alternative technologies for production and knowledge and information about them. One of the first tasks of UNIDO is to assist African countries to enlarge the flow of available information. With this in view, the evaluation and comparison of alternative industrial technologies are being undertaken in selected branches of industry. The information made available is fed into the Industrial and Technological Information Bank and made available to African countries upon request. In this connection, UNIDO has also initiated a programme for the preparation and publication of technical publications in selected industrial branches such as sugar-processing, fertilizer, pharmaceutical, solar energy, mini-hydro plants, etc.

Acquisition of industrial technology

130. UNIDO's efforts in helping the African countries in the acquisition of industrial technology are focused on raising the capabilities of Government officials and enterprises in the acquisition of technologies. UNIDO has published various documents on this subject, including a new publication entitled "Guidelines for the Evaluation of Technology Transfer Agreements". Several training programmes are conducted every year with appreciable results.

131. Complementary to such activities is the provision of short-term advisory services, on request, to African countries. UNIDO has already provided such services in selected cases for the acquisition of technology (e.g. in Egypt and Nigeria) with significant benefits to the countries concerned. These activities are being expanded. In addition UNIDO has been instrumental in helping the development of national institutional capabilities in the acquisition and regulation of technology through technical assistance projects, e.g. in Nigeria.

Development of technological institutions

132. Institution-building for the development, acquisition and transfer of industrial technology is continuing to be a major activity of UNIDO. These activities include technical assistance, networking, training, meetings and studies and pertain to programmes at the national and subregional/regional levels. Judged by the number of requests, national institution-building is an important element of the technical assistance activities of UNIDO in Africa. At the regional level, for example, UNIDO actively participated in the preparatory work for the establishment and operation of the African Regional Centre for Technology (ARCT), the African Regional Centre for Engineering Design and Manufacturing (ARCEDEM) and the African Regional Standardization Organization (ARSO) and has maintained active collaboration with those institutes.

133. The approach adopted by UNIDO for assistance in institution-building at the national level is governed by the actual requirements of each country, avoiding a fixed and monolithic institutional solution for all countries. It pays particular attention to their effective location in the governmental structure and the formation and maintenance of active links among them and with the decision-making processes in the Government and in industry. The

assistance provided by UNIDO in the development of technological institutions include a large programme of technical publications such as on the design of research institutes, evaluation of research institutes, and national offices for transfer of technology.

134. An important component of the assistance provided to African countries in the development of technological institutions is related to the strengthening of existing and/or the establishment of new technology regulatory machineries or agencies. UNIDO has initiated and is implementing projects in a number of African countries in this area. The activities carried out by UNIDO also include the organization of national workshops on technology and the establishment of links among the national regulatory agencies within the framework of its assistance to the ARCT. Within the framework of the IDDA, UNIDO has sponsored a number of regional projects aimed at establishing links among technology regulatory agencies in African countries within the framework of ARCT. An African Technological Information Exchange System (TIES) is also being established at the ARCT.

Development of technological capabilities

135. UNIDO's activities related to the development of technological capabilities focus on technical assistance activities, including fellowship operations and group training programmes. The technical assistance activities are aimed at strengthening the capabilities of technical and other categories of personnel through training at national and enterprise levels. In-plant group training programmes are aimed at improving the technological competence and skills of the participants in specific subsectors and branches of industry. Several types of training programmes for the selection and acquisition of industrial technology have been developed and put into operation at national or enterprise levels. UNIDO also publishes a "Guide to Training Opportunities for Industrial Development" which has been found very useful in many developing countries.

Development of industrial and technological information

136. As part of its technical assistance activities, UNIDO has implemented several projects of a national or subregional nature to assist the African countries in the greater flow and utilization of technological information. In addition, UNIDO is implementing a series of important headquarters activities to assist Governments, institutions and enterprises in African countries in a practical way in regard to concrete problems of industrial and technological development.

137. UNIDO has, over the years, been active through its Industrial Inquiry Service in providing assistance to African countries by way of practical information on specific questions concerning industry. A great deal of inquiries are being answered every year by the Inquiry Service of which about 50 per cent relate to equipment or technology. In addition, guides to information sources have been published for about 25 subsectors and branches of industry. The establishment of an "industrial opportunities" column in the UNIDO Newsletter has enabled some African country enterprises to publicize their specific requirements of technology.

138. With a view to promoting a greater flow of information permitting the proper selection of technologies, an Industrial and Technological Information

Bank (INTIB) has been established at UNIDO headquarters in Vienna. The INTIB is primarily concerned with the selective processing of technological information, thereby providing the developing countries with a basis for making decisions. In addition to information procurement, a major element of the Bank is the assessment of that information. It is also engaged in the consolidation of UNIDO in-house information and in the development of effective links with users and suppliers of technological information.

139. A component of INTIB, which involves international co-operation in a significant manner, is the system of exchange of information among the national registries of transfer of technology on the terms and conditions of technology contracts. This provides, through international co-operation, access to information not hitherto available but which is of great value to African countries in the acquisition of industrial technology. In this connection a particularly important new dimension to INTIB is the mechanism it provides for greater technological co-operation between developed and developing countries in the field of small-scale industry. This mechanism identifies the technologies available with small enterprises in developed countries and facilitates the flow of information on such technologies for the benefit of African countries.

140. UNIDO has also been paying attention to the collection and dissemination of practical experiences available in the developing countries themselves since, in an increasing number of cases, African countries are applying specific technologies in a manner suitable to their own conditions. Transmission of this experience in a practical way calls for a wide spectrum of activities for increasing the dynamic forms of dissemination ranging from documentation and manuals to meetings, promotional activities, pilot plants and demonstration and training centres.

E. Strategy for the implementation of the framework of action

141. The foregoing, especially the proposed framework of action for strengthening the capacity of African countries for the development and more effective utilization of science and technology for industrial development, require action on a long-, medium- and short-term basis. The actions of a continuing and long-term nature relate to the entire work to be carried out by each African country in order to achieve its long-term industrial development objectives. This would concentrate on the development of a national technological capacity which, in turn, calls for the development of a wide range and variety of industrial and technological capabilities and skills, institutions, industrial enterprises and production plants. The implementation of a national plan of action would, however, require a number of policy measures.

142. The medium-term actions, which would help to pave the way and lay a solid foundation for the effective implementation of the long-term plan, would largely consist of the adoption of policies and the elaboration of programmes for the:

- Development and commercialization of indigenous technologies;
- Selection, appraisal, acquisition and transfer of industrial technology;

- Development and training of various technological and industrial managers, technicians, as well as other required capabilities and skills;
- Establishment of new or the streamlining of existing industrial and technological institutional infrastructure, including the strengthening of existing institutions;
- Development of industrial and technological information services;
- Promotion of industrial and technological co-operation not only with other developing countries but also with the developed countries.

143. In order to provide the inputs for the elaboration of the medium-term plan, certain immediate action worth considering by each African country is the identification of national industrial and technological needs and requirements. One way of doing this is through the preparation of national technology plans. The first step in the preparation of a technology plan would entail, inter alia:

- Exhaustively reviewing the national economic and industrial development plan;
- Reviewing the existing industrial policies and structure with a view to identifying critical areas of concern;
- Evaluating the existing technological infrastructure and its linkage with the industrial and economic development goals;
- Appraising existing direct and indirect policies, incentives and disincentives for technological development and/or acquisition;
- Identifying the technological and industrial needs, especially the capabilities and skills, technologies and information required for the implementation of the industrial development plans;
- Defining the amount and types of inputs, especially of technologies and manpower required; and
- On the basis of the above, preparing a national plan, with a clear perspective and a method and schedule of implementation, for the elaboration of the medium-term plan.

144. While the above-mentioned activities are being developed and implemented, the industrial activities of the country would continue since industrial and technological contracts would continue to be signed and factories set up. It is therefore also necessary for certain immediate actions to be taken to provide an interim remedy for the solution of the industrial and technological problems being faced. Such short-term actions would predominantly consist of short-term training programmes aimed at augmenting the skills and experiences of various industrial and technological personnel in dealing with the immediate problems confronting them. The most significant of the problems involve negotiations for the importation of foreign industrial technologies; evaluation, selection, adaptation, absorption and diffusion of appropriate industrial technologies; regulation of technology transfer and technological agreements and contracts; effective utilization of existing industrial

manpower and other resources; management of existing industrial plants; and utilization of the indigenous industrial and technological research institutions.

III. CONCLUSION

145. As clearly evident from the paper, the task facing the African countries in the development and effective utilization of science and technology for industrial development is tremendous. Each African country must be prepared to create the necessary political will; adopt relevant policies, legislation, plans and programmes and establish new institutions, as appropriate, or strengthen existing ones. The implementation of the national and international programmes for which the necessary base has already been created would inevitably require additional inputs of human and financial resources, from both national and external sources, apart from significant expansion of the national organizational set-up.

146. In addition to the measures being taken by African countries, there would be a need to intensify industrial and technological co-operation among the African countries, between the African countries and other developing countries and at the global level. This is therefore an essential component of the action to be undertaken by the African countries, both individually and collectively, for the achievement of their industrial and technological objectives and goals.

147. Major international recommendations on science and technology also point to the same direction. The General Conferences of UNIDO could be expected to provide major recommendations in the field of industrial technology. In addition, the recommendations made by the United Nations Conference on Science and Technology for Development, the United Nations Conference on Technical Co-operation among Developing Countries as well as by UNCTAD and UNESCO also need to be applied and implemented in regard to industrial technology. All these recommendations could provide significant support to the initiatives being taken by the African countries as well as for the intensification and reorientation of international action.

148. The assistance of international organizations, particularly that of UNIDO, is also essential. In this connection, it is worth mentioning that UNIDO is prepared to assist the African countries, upon request and within its limited resources, in responding to their national and continental industrial and technological requirements. Such assistance envisages a comprehensive coverage of the technological needs and objectives of each country, extending to the provision of technological information, including exchange of data and experience with other developing countries in respect of technology contracting and development; formulation of guidelines relating to technological inflow; assistance in the development of indigenous technological capabilities, including technology institutions; and development of domestic technological services; organization of seminars, meetings and national and regional workshops on technology negotiations and contracting; and research studies and pilot activities relating to various aspects of technology transfer.