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GUIDELINES FOR A PROGRAMME ON AFRICAN INDUSTRIAL TECHNOLOGY

A Proposal prepared for UNIDO

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The Fletcher School of Law and Diplomacy

Medford, MA, USA

May 1994

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INTRODUCTION

The industrial development of the African countries has been a major preoccupation of UNIDO for many years. The newly independent countries of the region have been assisted in many ways to cope with the problems facing their emerging industrial activities. UNIDO has carried out a large number of technical cooperation projects throughout the region. It has helped to run a succession of meetings of African Ministers of Industry, in which the main problems of African industrial development have been debated in depth. A special programme, the Industrial Development Decade of Africa, IDDA, fully funded by UNIDO, was started in the very early 1980s and has continued now into the Second IDDA, with a broad range of cooperation activities.

As the IDDA programme unfolds, it has been felt that efforts should be increasingly focused on technology because of the importance this aspect of industrial development has acquired. Technology is rightly considered as a basic enabling factor in industry's search for efficiency and higher competitiveness, at a time when the African countries need to compete in the world markets if they are not to be hopelessly marginalized.

Issues of technology and development in Africa

A new global order has emerged in recent years as a result of major changes in the political, social, economic and technological spheres. It is principally characterized by the consolidation of a new technological and developmental paradigm, with production processes increasingly science-based and technology-intensive, and by the growing importance of technology based trade in a highly interdependent world with expanding globalized production systems.

The position of knowledge as a critical factor of production has been strongly reinforced. With the acceleration of technological development, the changes in the comparative advantage of nations and in the shape of markets, and the deeper integration of the world economy, the technological gap between rich and poor countries is increasing further. This situation calls for special efforts by developing countries to compete in the world markets if they are to avoid further marginalization.

Many countries have reacted by opening up and deregulating the economy, reducing government expenditures, increasingly privatizing public services and public enterprises, and promoting foreign investment as a key source of capital, technology, market access and management knowhow. There is also an increasing concern about the environment and how to protect it.

The new context is having significant consequences for most countries in Africa. Many of them have made profound changes in their economic policies, often prompted by their large foreign debt, and have taken measures to liberalize trade, reduce budget deficits, curtail state spending and the economic activities of the state, privatize public sector enterprises, and do away with most controls on flows of technology and foreign investment while seeking to enhance such flows. A very significant development is the heightened importance of the private sector as a key protagonist of industrial development.

Most African countries are increasingly aware that they will need to restructure and revitalize their productive systems, obtain access to new technologies and increase the capability of their enterprises to participate in global markets that are subjected to dynamic change.

In order to do this they need to analyze how technology is being acquired and utilized, how technological capabilities may be developed, what contributions may be made by the S&T infrastructure, and what are the possibilities for regional cooperation in technology areas. On the basis of such analyses, comprehensive programmes for industrial technology development may be outlined and implemented.

In the first place, the subject of acquisition and utilization of technological capabilities in industrial firms should be explored. Research in the developing economies of Latin America and Asia has shown that an incremental process of accumulation of technological capabilites by enterprises is crucial for enhancing productivity, introducing new processes and products, and achieving competitiveness in overseas markets; the introduction of new technologies, particularly informatics, can help to upgrade production processes and many service activities; better management technologies help to achieve quality and cost effectiveness throughout the productive spectrum.

Though our knowledge of technology capability building in African industry is incipient, there are good indications that this topic is every bit as important as in the other regions. Industrial enterprises have in general not been able to build up their technological capabilities beyond minimum levels, and much remains to be done if they are to reach adequate degrees of productivity and quality to enable them to compete in the world market.

In the second place, issues in the supply of technology in Africa need to be analyzed. There are two principal components here. One is the introduction of foreign technology, under different modalities: licensing, technical services, training, foreign investment, strategic alliances. International transfer of technology is for Africa, as well as for other developing countries, the main source of new industrial knowhow. The choice of such technology, the terms under which it is brought into the African countries, and other key aspects of the technology transfer process are of central importance for industrial development. UNIDO has made important contributions towards the improvement of this process and the training of those involved in it.

The other component of the supply of technology has to do with the scientific and technological activites in the African countries, which are largely concentrated in the science and technology infrastructure made up by universities, research institutions and organizations providing technical services.

In the new global context it becomes urgent for African countries to utilize efficiently the scientific and technological capabilities built up in the recent past, in universities, research institutes, industrial research organizations, technical service institutions and other components of the "science and technology infrastructure". Many African countries have made important investments in this infrastructure, but the impacts on development and on the quality of life seem to have been limited, while foreign technology has continued to be introduced for all modern activities. The "supply push" approach, which assumes that making good science and technology will automatically produce positive results for the economy and the society, has turned out to be insufficient. In most cases the scientific and technological institutions are not properly connected to the potential users in the productive sectors, and the pursuit of scientific results has become an end in itself, rather than a means to support development and improve quality of life. On the other hand such institutions are facing worsening conditions regarding salaries, lack of new equipment, disinterest on the part of industry and growing financial problems. This is leading to serious doubts about their sustainability, at a time when they could play a significant role in upgrading the capabilities of the productive sectors to compete successfully in the world markets.

Finally, African subregional and regional cooperation in science and technology should be considered, since it offers a potentially important means to trascend the small size of national science and technology systems. A number of African cooperation schemes are in existence in scientific areas, but cooperation is only incipient in technology. Joint research and technology development activities among industrial entreprises in the region have not been usual.

How UNIDO can cooperate

UNIDO's cooperation with Africa in technology matters can play a very important role in African industrial development, at a time of significant change in the world techno-economic conditions and in the major policies of many African countries now pursuing structural reforms, opening up their markets and emphasis the development of their private sector.

UNIDO has been active for many years in Africa in projects dealing with technology policy, technology acquisition, development and management, the building up of the science and technology infrastructure, including technological services institutions, and the related fields of enterprise creation and human resource development.

These projects have been aimed at the public sector and its institutions, the usual clients for UNIDO until recently. Private industry having now become much more important as a focus of UNIDO's efforts, some changes are bound to take place in the orientation and characteristics of technology-related projects.

Further, these activities have often been isolated efforts in response to specific demands without being integrated into a national or regional programme. Structured programmes with clear priorities would run a much better chance of producing positive, durable results.

It is timely to analyze what is the present condition of technology capabilities and efforts in different African countries, how they may be improved and expanded, and how they should be oriented so that they may have full impact on industrial development. This could be the basis for a set of programmes of UNIDO cooperation at the national level, with a regional component, which could be add up to a general programme for the African region.

The present author has developed the following guidelines towards establishing a UNIDO Programme on African Industrial Technology. The basic purpose would be to carry out cooperation activities at the national level and at the regional/sub-regional level, in order to make a significant contribution towards enhancing and accelerating industrial development in African countries.

Within this general aim, the main objectives of the Programme would be: (a) to assist industrial enterprises in the private and public sectors to develop their technological capabilities and apply them to improve their efficiency and competitiveness, and (b) to assist in expanding, deepening and making more relevant for industry the S&T effort in African countries, including the restructuring and revitalization of S&T institutions and the enhancement of African cooperation in S&T matters.

The Programme should endeavour to cooperate with other institutions, like the Organization of African Unity, the African Development Bank, the World Bank and IDRC, in developing science and technology capabilities and ensuring their efficient utilization.

I. BACKGROUND

1. AFRICAN INDUSTRIAL DEVELOPMENT

1.1 UNIDO's views

UNIDO has recently examined the salient aspects and problems of industrial development in Africa. The most important UNIDO documents on this probably are *Major emerging trends and issues of industrial development in Africa: Implications for UNIDO*, July 1993, and *Industry in Africa: Challenge and Responses*, GC.5/18, October 1993. We now summarize some of the main points made in them.

The African region faces difficult economic problems. Standards of living are the lowest in the world and have deteriorated in recent years. African economic growth has not been keeping pace with population growth: GDP growth in real terms was 1.9 per cent in 1992, down from 4.8 per cent in 1988, while population kept a 3 per cent rate of growth. Trade is not more than 2 per cent of total world trade and monetary flows into the region are declining. While capital resources and technical and entrepreneurial capacities for industrial development are scarce, foreign entrepreneurs are not too keen on investing in Africa.

However, there are positive aspects: a growing understanding that Africans have to rely on their own efforts, renewed attempts at regional integration, the possibility of cooperation with South Africa when a new regime comes in.

During the 1980s many African countries declined economically as terms of trade deteriorated, the pressure from the foreign debt was felt more strongly, inappropriate economic policies were adopted and little investment took place in infrastructure, education and training.

As a reaction many countries have applied structural adjustment policies under the guidance of the IMF and the World Bank, policies that in their stricter versions are now being questioned because of their disrupting effect on national production and on African integration.

Privatization of state companies is another significant trend, though the scarcity of capable entrepreneurs and technicians may bring about a wide foreign ownership of industry and the risk that profits will not be reinvested locally.

Investment flows into Africa have yet to pick up, and in fact many countries have experienced a flight of capital which is reluctant to come back.

The meager stock of African entrepreneurs and technicians is a major problem, calling for adequate policies in favour of enterprise creation, capacity building and training. We may mention as examples at the international level that the World Bank is increasingly using African nationals as consultants in its projects, while the United Nation's EMPRETEC Programme is helping to promote new enterprises in three African countries (see below).

Africa is receiving important amounts of technical cooperation. Figures for 1990 were about US$ 12 billion for bilateral cooperation and $ 6 billion for multilateral cooperation (of which $ 371 million from the UNDP). Loans from the World Bank were close to $ 4 billion in 1992, and those from the African Development Bank and other regional banks were of the same order.

Turning now to industry, its contribution to GDP was 32.1 per cent in 1991 (the figure for manufacturing was 11.7 per cent), with 45.1 for services and 22.8 for agriculture, not too different a breakdown than ten years before. African manufacturing value added, which accounts for one per cent of the world's manufacturing value added, grew at a rate of 6 per cent per annum in the seventies but this came down to 4.1 per cent in the eighties.

In most countries the industrial sector is concentrated on a few activities. As a consequence there is a lack of the industrial linkages that can be the basis for dynamism. There is much difference in the makeup of industry among the different countries, some of which largely rely on one natural resource: oil, diamonds, copper, sugar or pulp and paper. Attempts at building up heavy industry have often not been successful.

The manufacturing subsector is small in most African countries. Its share of the GDP was 11.7 per cent in 1991, up from 10.1 per cent in 1983.The most important branches are food products, textiles and other non-metallic minerals. Machinery making is minimal, and the positive techological forces associated with this activity are largely absent. There is a high reliance on imports of capital goods as well as a large variety of consumer goods.

Even though industrial statistics are far from complete, enough figures are available to show that the number of factories is very small: 1988 data show 1341 establishments in Zimbabwe, 614 in Kenya, 247 in Senegal, 93 in Congo. While it is likely that a large number of small enterprises are not included in industrial censuses, the information shows that industry as usually envisaged is small in most African countries, and that the industrial sector is made up overwhelmingly of small enterprises. Industrial growth needs the creation of new enterprises because there are very few at the moment. Industrial policy and technical cooperation should put emphasis on the small and medium enterprise sector.

Meanwhile, important changes are taking place in world industry where the forces of technological innovation and globalization are reshaping production, changing the basis of competitiveness away fom low wages, causing a reorientation of national policies, and leading to regional integration. African industry, points out UNIDO, "has little connection with this (new industrial) system, and lacks the dynamism, technological content and management skills needed to compete internationally" (GC.5/18, October 1993).

1.2 An African view: the Mauritius Declaration

This important statement, the full title of which is "The Mauritius Declaration on Africa's Accelerated Industrial Recovery and Development in the Context of the Second Industrial Development Decade for Africa (1993-2002) and Beyond",

was adopted by the African Ministers of Industry at their 7th meeting in June 1993, and summarizes a long process of review and discussion on African industrial development. We note below some of the main points, particularly those that refer to the technological aspects of industrial development.

The Ministers express their concern at the continued obstacles to industrial progress. They recognized that there are many factors that adversely affect the economies of Africa, among them the changing world environment in its political, economic and technological aspects, the high debt load, and the deteriorating terms of trade as commodity prices decline. The increasing globalization of the world economy, with its trend towards global trade liberalization, and the formation of large regional trade blocks is bound to make the task of industrialization more difficult: mechanisms should be put in place to ensure that Africa's fledging industries are not negatively affected.

In view of the accelerating pace of technological change in world industry and the consequent need for increased competitiveness in Africa's manufacturing sector, the Ministers emphasized the importance of technology policies as an integral part of industrial policies, and the need for African industry to have access to the necessary information, skills and technologies, to enable Africa to compete successfully on world markets.

There is a high level of under-utilized capacity in established industries, and many of them are in need of rehabilitation. These problems should be tackled through integrated programmes, which should also cover public enterprises, comprising actions in industrial policy, restructuring, investment promotion and the development of human resources.

The need to create sound market economies was also recognized, bringing along the need to count with stock exchanges, commodity markets, a healthy banking sytem, and standards and quality control institutions.

There was agreement that the private sector has a cardinal role to play in industrialization. African private entrepreneurship should be encouraged, and entrepreneurial skills should be developed. Specific programmes should be addressed to women. Foreign investors should be welcomed for the financial, technological and managerial resources they can bring.

Recognizing that human resources are the critical element in building industrial capability, programmes should be drawn up for the creation of African scientific, technological, financial and entrepreneurial skills.

Finally, the Ministers agreed that there is a strong need for regional and subregional cooperation, in view of the small size of most African states.

1.3 UNIDO's proposals for technical cooperation in Africa

UNIDO has identified a number of key themes for African industrial development in the coming years (GC.5/18):

- *Privatization and the development of the private sector.* Policies in this area should have three main components: a supportive environment, a system of

industrial services, and strategic interventions as appropriate. In view of the small number of industrial enterprises in Africa, the creation of new industrial enterprises is considered as the main task of industrialization, rather than the privatization or the rehabilitation of existing enterprises.

- *Competitiveness.* This is a very important theme in the light of the highly competitive international market which Africa needs to enter. Enhancement of competitiveness may require price reductions, improvements in product design, quality, marketing and distribution, and innovation. Industrial policies to improve competitiveness should pay attention to several components: trade regulations, technology policies (more on this below), human resource development, R&D, standards, institutional development, export promotion, investment incentives, and development financing. As a means of accessing new markets, upgrading quality, and acquiring technology, African firms may seek partnerships with foreign firms.

- *Small and medium industries.* Traditionally African industrialization focused on large industries, but small and medium industries have a number of positive characteristics that make them especially suitable for Africa, such as employment generation, participation of women, development of rural areas and the imparting of increased flexibility to the industrial sector. They require a range of services for which capabilities should be developed in the shape of management consultants who can provide information and assistance.

- *Environment and energy.* The main environmental problems in Africa are desertification, degradation of natural resources, effluent treatment and industrial pollution. Environmental implications of industrial projects should be examined to avoid Africa being used as a dumping ground for polluting industries. Production of environment-related materials and equipment may become a significant growth area. As regards to energy conservation, there is much scope for lowering consumption in industry and to introduce technologies for better use of wood as a fuel.

- *Financial resources.* Appropriate mechanisms should be found for coordination with the financial agencies, and new mechanisms should be developed, principally through equity participation for financing industry, and through the BOT (build-operate-transfer) modality for mobilizing private and international capital for infrastructural investments.

- *Subregional integration.* This should be built in a stepwise manner around specific projects, rather than attempting to adopt a comprehensive approach from the beginning. The role of the private sector should be encouraged through measures allowing it to operate across borders (for instance, through subcontracting arrangements) and through the provision of services to it, such as information and partnerships.

Regarding its cooperation with African countries, the scope of UNIDO support will follow the recently adopted five development objectives for the grouping of demand and services: (a) industrial and technological growth and competitiveness; (b) development of human resources for industry; (c) equitable development through industrial development; (d) environmentally sustainable industral development, and (e) international cooperation in industrial investment and technology.

Cooperation by UNIDO is to be based on the industrial development strategies of individual countries. A general programme has been outlined with ten main areas of cooperation:

(i) Strategies for industrialization in the context of market economies, and policies and mechanisms for private sector development.

(ii) Increased regional industrial cooperation in a number of "horizontal" areas: R&D, standards, quality, human resource development, automation, packaging and design, marketing skills, management skills, repair and maintenance, accounting, inventory control, and production planning. In certain cases UNIDO will strengthen exsting institutions that may play a subregional role, but in most cases the focus will be on building up networks.

(iii) Entrepreneurial training and development, to the stage of preparation of business plans and linking with other local and foreign enterprises.

(iv) Development of small and medium industries, emphasizing policy, institutional support and the provision of necessary inputs (in technology, finance, marketing services) through SME organizations such as chambers of commerce and industry, since UNIDO cannot directly address individual enterprises. Two successful programmes will be enhanced: subcontracting and women entrepreneurship.

(v) Development of sustainable capabilities for industrial services, such a training, information systems, advisory services and technology services.

(vi) Assessment of new technological applications, dissemination of information and provision of technical training and linkages.

(vii) Assessment of interrelations between environmental needs and industrial growth and priorities, development of environmental assessment techniques and regulatory skills, adoption of new technologies more consistent with ecologically sustainable industrial development; industrial energy use, small scale energy generation and use.

(vii) Dissemination of information and provision of advanced management training for local entrepreneurs, and development of sustainable facilities for it.

(ix) Investment promotion activities, using the range of UNIDO's system, with its methods and tools; identification and contact of potential foreign partners on a continuing basis, using an integrated information system; development of national investment offices.

(x) Increased dissemination of industrial information, an indispensable means to familiarize African manufacturers with relevant economic, technological and market issues. This would be done through the expansion of UNIDO's international network of information and the formation of national and subregional information networks, using the best possible technology.

The above constitutes a sort of "menu" of possible cooperation activities, from which elements would have to be selected and tailored for the specific circumstances at hand.

2. RECENT EMPIRICAL RESEARCH ON INDUSTRIAL TECHNOLOGY DEVELOPMENT IN AFRICA

2.1 Studies by IDRC-sponsored African researchers

The International Development Research Centre, IDRC, a Canadian foundation, has sponsored research on African industry for some years. A Research Network on Industrial Policies in Africa, CODESRIA, was created in 1989, based in Dakar. By September 1993 it had produced 11 research reports and had 13 more projects under execution.

Of more relevance to our present subject are the activities of the African Technology Policy Studies Network, ATPS. Two networks for East and West Africa have functioned with IDRC funding from 1981 to the end of 1993. These were united in January 1994, and two other sponsors, the Carnegie Corporation and the Rockefeller Foundation, have joined IDRC in supporting the work of African researchers on technology policy. A Coordinator based in Nairobi has been appointed, as well as an international Steering Committtee. A first Annual Meeting of the Network will take place in May 1994, when project proposals are to be screened.

IDRC has expressed interest in linking the Network with UNIDO, in order to find a channel for applying the results of research. A first working contact may be made during the meeting mentioned above, where IDRC would welcome the participation of a representative of UNIDO.

The research sponsored by IDRC has dealt with the extent, nature and determinants of technical change in African industry. Some 18 studies were made during the mid- to late 1980s, and provide interesting insights. They were reviewed by Herbert-Copley (1992), who related the findings to other empirical work at the level of the firm.

The picture that emerges can be synthesized briefly. There is a growing consensus that industrial expansion in Africa, as in other parts of the world, is critically dependent on the local development of technical and managerial capacity. Empirical research on this question has been extensively made in Latin America and Asia, showing that there is often a process of technical change at the level of the firm as imported technology is assimilated, adapted and improved, leading to increases in productivity. The improved performance depends to a large extent upon the investment made by the firm in developing its technical capabilities.

The research sponsored by IDRC focused on case studies in several countries and branches, and looked at three related issues:

(a) *The process of technical change and learning.* In general the studies found declining technical performance both in large capital intensive firms and in smaller ones in textiles and sugar; but some firms maintained and even

improved their technical performance, and there is anecdotal evidence of some innovations, mainly in product.

(b) *The nature and direction of technical change.* While in Latin America firms showed a broad range of technical efforts and an evolutionary sequence could be discerned, in Africa technical efforts seem to have been directed less towards performance enhancements and more towards product adaptation and innovation, a "process of piecemeal product adaptation", and the sequence of technical changes were not quite evolutionary.

(c) *The determinants of technical change.* Here we have, first, the macro context. Protective trade policies in the 1980s, and an excessive reliance on foreign capital, technology, intermediate inputs and managerial experience, would appear to have been unfavourable to technical activities leading to increased productivity; there were problems of access to imported spares and inputs reduced capacity utilization and this coexisted with excess local demand. Second, there are firm specific variables, such as ownership, market strategy, nature of technology, etc. These "idiosyncratic" characteristics have been found important in other regions. The research carried out in Africa under IDRC auspices did not produce significant results on this matter, but it was clear that there is in Africa a limited stock of the technical and managerial capabilities which are key in promoting technological learning.

Future research, it is suggested, should focus on two main topics. First, technical change and the macro-economy; here an important issue is the influence of structural adjustment on technological efforts at the level of the firm. Secondly, learning in SMEs, which is likely to be different than in larger firms; one of the issues is the influence of government programmes of technical assistance and training.

2.2 World Bank case studies on technology and enterprise development in African countries.

The World Bank is conducting comparative studies on industrial development in eight African countries, with funding from eight donor countries, each of which takes care of one case study through institutions and consultants of the donor country. Methodological and coordination matters are taken care of by the Private Industry Development branch at the Bank. Two special areas of study are Technology and Finance, with a few national case studies in each.

In Technology two reports have recently been issued, on Ghana and Kenya, and will shortly be published as books. One more case study in the area of technology for industry, on Zimbabwe, will be ready by mid-1994.

The case of Ghana

The World Bank report for Ghana (Lall et al., 1993) is summarized in Annex 2. We now briefly review the main findings and conclusions, which are relevant to the subject matter of the present paper

This study surveyed more than 200 Ghanaian enterprises, 32 of which in depth, in four industries: textiles and garments, food processing, woodworking and metalworking. The purpose was to analyze in those firms the process of

acquiring technological capabilities, the technological strengths and weaknesses, and the factors that influence the development of technological capabilities.

It is suggested that technological capabilities are made up of investment capabilities, production capabilities and linkage capabilities (see Table 1 in Annex2). Industrial technology development would depend on the incentive framework governing the demand side (the external environment, notably domestic and foreign competition, and government policies); on supply factors, comprising skills, information and services from a variety of sources, and finance; and on institutions in education and training, science and technology, and SME support. Much of recent technical progress has come through organizational innovations, particularly those required for flexible manufacturing systems.

Ghana has some large modern firms, principally owned by foreign capital and the state, a good number of small scale firms, largely African owned, and the informal sector. Industrial performance has been poor, with "de-industrialization" from 1977 to the mid-80s, and after that a partial recovery. Further growth will depend on adding new capacity and improving technological efficiency, as trade barriers have come down after the start of structural reforms in 1986. Local enterprises do not find it easy to develop the technological and other capabilities that are needed for world class competitiveness. A considerable period of learning would be needed,in addition to considerable assistance from external intitutions.

The reasons for the poor industrial performance are to be found first in the incentive framework: strong protection until 1986, which was not used to develop adequate industrial capabilities and infrastructure, followed by a relatively open trade regime which has exposed industry to international competition, while foreign investment flows have been weak. Secondly, there are shortcomings in skills, in technological effort by enterprises, in industry-related R&D which is small and largely irrelevant to industry's needs, and in technological services

The study found that firms have developed only limited technological capabilities in simple technologies, and relatively few firms have been able to face import competition A few "technologically competent" firms were larger, had carried out efforts to develop their technological competence, paid better wages, had better educated entrepreneurs and production managers, and counted with a higher proportion of scientists, engineers and technicians.

The study looked into the relations between human capital and technology development, and found that few entrepreneurs have sufficient education and experience to face technological challenges. Production managers in the competent firms are better educated, and they sometimes function as "technological catalysts" whose knowledge and efforts are critical to upgrade technology. The numbers of technical staff were found to be low. On the job training varied in effectiveness, and there was little external training in overseas institutions or firms.

Regarding technical effort, very few firms were found trying to improve their process technology by getting knowhow from abroad. Manpower in quality control, maintenance and other specific technical activities was very

scarce. Relations with technology institutes were poor. Firms were not able in general to define their technological needs ("they have to be taught to learn"); overseas sources were used to deal with the more complex matters. The lack of domestic institutional support may be an important cause of weak technological performance.

The incentive structure was considered to be the most important indirect influence on the firms' expenditure in technological capabilities. The rapid liberalization of the economy has imposed costs on Ghanaian enterprises, including those in activities in which the country may be expected to have a comparative advantage, and has caused the closure of many firms, particularly in labour intensive activities using simple technologies like the textile industry. The new incentive structure, while giving strong signals for investing in improved technological capabilities, failed to give the breathing space or provide the sort of supply side measures that were needed for a strong supply and investment response.

The report concludes that in order to promote Ghana's industrial technology and competitiveness there is a need for policy support and new initiatives, beyond the reforms already brought by liberalization into the incentive regime. Infant industry protection would be needed to encourage new activities that require lengthy learning, while seeking to minimize negative effects on the development of technological capabilities. Deficiencies of technical knowhow, skills and support services should be remedied. There is a need to improve and build up existing educational, training, technology and infrastructural institutions. And finally there is the need to put together "a clear and comprehensive vision of the components of a proper strategy, and how to integrate its incentive measures with policies on the development of capabilities". In this way Ghana may achieve an integrated strategy for industrial development.

The case of Kenya

This study (Teitel, 1994) covered 223 firms in four sectors (food, textile, wood and metalworking, basically the same as in the Ghana study) which were covered by a panel survey, and 40 of them were analyzed in detail through interviews and plant visits, which produced a rich account of the processes of technology acquistion, operation, adaptation and development, as well as detailed data on the technical skills available in Kenyan manufacturing establishments. Some of the most interesting finding were:

General characteristics. The manufacturing sector is mainly oriented to domestic demand, and exports are low. Firms mainly work on their own and linkages (as subcontracting or assembly work) are scarce. Less than 50% have professional management.

Technology acquisition. In half the firms no feasibility study took place prior to the initial investment. Selection of the machinery was made by the entrepreneur (in most cases) or by foreign experts; there was little reliance on local engineering personnel. Most of the machinery was imported, new (but a substantial part of the equipment is now 20 or more years old). Almost half the firms needed outside help for commissioning but little use was made of local engineering companies. The survey examined the use made of 3 main channels of technology transfer: foreign licences, technical assistance

agreements and expatriate personnel. It found little use of the first two (except if there was foreign investment), but nearly 50% of the firms (particularly the larger ones) employed expatriates, half in technical and half in management positions.

Operating capabilities. A number of firms had poorly kept plant facilities, and poor equipment maintenance, but less so in food and beverages. Capacity utilization was low, less than 50% in one third of the firms. Troubleshooting (for problems mainly due to machinery breakdown and poor poower supply) was principally carried out in-house. Only one third of the firms had a quality control system, though these tended to be of a simple type and little laboratory work was used. Less than half used standards, the figure being better in food and in metalworking. Most plants required specialized external assistance to maintain their equipment, and less than 40% of the firms surveyed practiced preventive maintenance. It would seem that the absence of higher skills needed for maintenance often prevented the introduction of new, efficient equipment. Insufficient attention was given to productivity and its improvement, to which only sporadic efforts were devoted.

Technological functions. Half the firms in the sample had no technical documentation or technical offices of any kind. In a majority of cases the design of the product was of local origin. Product design changes were done in half of the firms, principally to use local raw materials, and once again half the firms had introduced a new product in the previous five years, mostly developed in-house. Technical changes in the production processes were mainly in new tools, fixtures and machies, in the saving ofv energy and in the adaptation to local raw materials. Little or no research and development was carried out in the firms surveyed. External support services most frequently used were repair and maintenance, instrument calibration, technical assistance, quality control including testing and certification, and training. Small firms did not make heavy use of these services. They were supplied by various local institution and technical firms, as well as by international sources (consultants, as well as headquarters and licensor personnel) in the case of technical assistance. Quality, standards and training were the most demanded services. On-the-job training of workers varied much in intensity. Many firms sponsored technical studies leading to a degree for their middle technicians, but very few did so for professionals.

Plans for technological development. Forty per cent of the firms were planning to invest in machinery and to a lesser extent in technology improvement. Fifteen firms provided information on the amounts to be invested, from a few thousand dollars to several million, for a total of 30 million for all these firms. Motivations were mainly to upgrade the competitive position through better quality, capacity expansion, cost reduction, production for export, etc. Many of these firms foresaw the need to train their personnel for the technical changes envisaged, though this could generally be done in-plant, to introduce organizational changes, and to look for technical assistance.

Skills and technological performance. Kenyan industry does not count with abundant professional and middle level technical skills needed for good technological performance. The proportion of scientific and technical personnel in total employment is quite low, slightly higher than in Ghana but much below other industrializing countries in Asia and Latin America. The

majority of this personnel is concentrated in the largest firms, and there is clear evidence of the relationship between size and technological capability. On the other hand the education of the owner or general manager was not correlated with that capability.

The report concludes with *policy suggestions* in four main areas: industrial policy, trade policy, technological policy and human resources. We refer to them below.

3. APPROACHES TO INDUSTRIAL TECHNOLOGY POLICY IN AFRICA

3.1 Approaches by UNIDO

We will now briefly review two general approaches by UNIDO to the issues involved in technology policy in Africa, and the actions that could be taken. The first dates from 1980 and the second from 1993; the differences between them can be seen readily.

(a) A 1980 paper, *Action in the field of technology policy and planning in Africa* (ID/WG.332/2), defines technology policy as "a basic function of government aimed at creating a framework in which decisions concerning the exercise of technological choice can be made and implemented". A more ample concept is that of technology planning, with a set of goals, objectives and instruments responding to clearly defined development goals.

Four interrelated steps are mentioned: creation of a consensus on technology mix and capabilities; assesment of present status of technological capabilities; formulation of strategy in terms of policies, programmes, institutions, and financial and manpower resources; and coordination and monitoring. Some broad policy options are then reviewed in the main areas of technology selection and acquisition, technology adaptation, absorption and improvement, and technology development.

In its next section the paper takes up the issues of transfer of technology from multinational corporations, and emphasizes the need for unbundling the technology package. Different types of technology programmes are then reviewed, covering the development of the engineering and machine tool industry, the technological development of small and medium enterprises, the development of a capability in technological services and in industrial extension, and the activities of information, technical education and training. Finally, general indications are given on how to set up a programme of action, by defining technology demands, identifying available resources, defining priority industries (in most cases they would include food, agroindustry, engineering and small scale industry), considering the wide variety of technological choices in each of them, and defining the necessary policies, programmes, instruments, legislation, etc. as well as the human and financial resources needed to carry out those programmes.

(b) The 1993 UNIDO paper on "Industry in Africa: Challenge and Response" (GC.5/18), to which we have already referred, has a section devoted to technology within the general chapter on "Competitiveness". There is a

distinct change of approach in regard to the 1980 paper. Technology policy is now viewed as a part of a broader industrial development policy, and its main purpose is *to improve competitiveness in an industrial sector increasingly in private hands.*

The paper emphasizes "the important role of technology... in affecting the degree to which African enterprises can successfully compete at an international level", and states that "the issues of technological development will continue to be crucial for African countries, but it will be essential to have a more action-oriented approach to this question... With a new emphasis on the private sector, considerable attention will have to be placed upon *encouraging the private sector itself to take the main lead* in technological development, in the articulation of policy and in the adaptation of imported technology to suit local needs" (our italics).

The paper points out that there has been a fundamental change regarding the choice of technology, because of the diffusion of automation: "the only technology that can rationally now be chosen... is the most competitive technology... For many products, labour intensive technology will not be competitive on world markets" and customers, domestic and international, will only be found if quality, price and delivery time are right. Furthermore, the range of possibilities has increased enormously because of the prospects opened by automation, biotechnology, new materials, and the effects of the concerns on energy and environment. However "there will always be plenty of scope for the invention, development and application in Africa of new ways to make new things" through the use of local materials or the adaptation of technology on account of local characteristics.

Technology policy will have to deal with (i) information and advisory services, (ii) consultancy services and feasibility studies on appropriate technologies, (iii) demonstration sites for those technologies, (iv) long term programme of support in order to reduce uncertainty, (v) inter-firm collaboration and stronger links science-industry, (vi) modern management techniques, and (vii) greater concentration on education, skills and training at all levels.

There is a need to define priorities, redirect public technology institutions towards relevant tasks and a more intense cooperation with firms and other economic actors, spread information on new technologies (perhaps through CAD and other centres specializing in information technology), help research institutes and other organizations to develop capabilities for gathering information and creating contacts on technologies, assist firms in the adoption and assimilation of technology, create technology awareness programmes, extend more direct financial aid to firms in technology acquisition, and help build capabilities in local firms by involving them in all the steps of technology transfer.

The report finally states that UNIDO will render advisory services on technology choice, support institutions engaged in research and development and other technology work, foster cooperation between these and individual firms, help build contacts and linkages with foreign sources of technology and expertise, and assist in national policy-making for technological development, particularly aiming at integrating it with industrial and trade policy.

3.2 Other approaches to technology policy in Africa

We have thought it useful to give a glimpse of two other approaches to technology policy in Africa that complement UNIDO's latest approach. The first one is a general, top-down view intended for least developed and small developing countries, and, to our mind, applicable to most African countries. The second one stems from very recent applied research on African industrial firms, and brings in clearly the element of "learning" at the level of the firm.

(a) The 1991 Report of the UN Advisory Committee on Science and Technology for Development (UNCSTD), "Science and Technology for Least Developed Countries and other Small Developing Countries".

This report, which is summarized in Annex 1, starts from the proposition that, in order to be active participants in the world economy, countries need to develop their own capabilities in science and technology. An effort is made to assess "the specific characteristics and problems of the least developed countries (LDCs) and what these imply for their S&T capabilities and the potential role of S&T for their development".

A review is made of the major problems facing LDCs, including those that originate from changes in the global context. The report points out that thinking regarding technology is changing, mainly by recognizing that it includes a "soft" dimension relating to knowhow, skills, management, marketing, etc. Expenditure in technology should be regarded as an investment towards long term growth and competitiveness. Technology should respond to the demands of the marketplace and the needs of society.

The report identifies major problem-areas in S&T in LDCs, principally vulnerability, weakness in demand for technology, and limited capabilities for technology supply. Several aspects of weakness in science and technology in the LDCs are explored. A list is shown of key issues that should be examined in order to develop practical measures to improve the contribution of science and technology to the economic growth in LDCs. These include notably the strengthening of endogenous capabilities in S&T, the strengthening of intermediation mechanisms, the relations with environmental sustainability, the better use of local physical and human resources, the utilization of technology to improve the productivity of rural and informal activities, and the cooperation among African countries

The report concludes that "the changing global context and the new definition of science and technology requires a new approach to S&T policy in the LDCs". Four main areas for initiatives are outlined: putting greater emphasis on the soft side of technology; making S&T development and technology transfer more responsive to demand; generating demand for S&T, and building endogenous capabilities. The report cautions that a strategy for building S&T capacity and international competitiveness cannot apply to all LDCs, but should be defined for each particular country.

In a subsequent report on "Science and Technology for Less Developed Countries", issued after its meeting in Burundi, May 1992, the UN Committee recognized the need for a new approach on account of the different global context and of a new understanding of "endogenous capacity" in S&T for development, which should address all aspects of S&T policy. A number of

general long term prerequisites are needed for an efficient S&T policy: a minimum investment in human resource development, political consensus about goals, a careful balance between policy interventions and the degree of freedom needed in the private sector, and the need to review things from time to time. The Committee' recommendations were slightly reshaped in relation to the 1991 report. They now included the following main areas: (i) management of resources and building of endogenous capacities, at the national level and at the suregional/regional level; (ii) infrastructure for technology and linkages for technology, paying attention to social and management aspects of technology; (iii) development of S&T and technology transfer in response to demand, establishing mechanisms to articulate the demand of the private sector; (iv) generation of domestic demand for S&T, through increasing public awareness of the role of S&T and supporting potential users in the private sector, especially SMEs and NGOs.

(b) The policy suggestions in the World Bank study of Ghana

This study points out that, in order to promote industrial technology and competitiveness in Ghanaian industry, there is a need for policy support and new initiatives, beyond the reforms brought by liberalization into the incentive regime, which may not be sufficient to bring about a dynamic technological response in most firms.

Ideally the exposure to world competition should be in line with the speed at which industry may efficiently restructure. Measures would be needed during a "grace period" to improve the supply side. Small scale enterprises should be helped to become technologically efficient. Regarding new industries, infant industry protection could encourage new activities that require lengthy learning, but this protection should be designed and put in place carefully, to minimize negative effects on the development of technological capabilities.

An important point is that protection will not work in the face of large deficiencies of technical knowhow, skills and support services, which should be remedied while at the same time informing and educating enterprises to use these assets.

The report emphasizes the improvement of human resources, which should be an integral part of an industrial development strategy, in view of the general deficiency in skills and in scientific and engineering personnel throughout industry. Firms are often unaware of the need to employ better skills. A campaign would be desirable to enlighten industry in this respect. Firms also require help to use trained manpower efficiently; this may be done through local and foreign "teachers" to demonstrate better ways of doing things. A new, modern entrepreneurial class should be helped to come into being, possibly through entrepreneurial training programmes.

The report then turns its attention to supporting services - information, the S&T system and extension services.

Technology import regulations in Ghana have been relaxed. However, to help firms access new technology, better information support is needed for sourcing and buying technology internationally.

Policies should also be laid out to encourage technical activites within firms, perhaps reaching to the level of formal R&D which is absent today in industry save for some adaptive technological research. This would need efforts of information and persuasion about the benefits of investing in technology, by themselves as well as in collaboration with outside R&D institutions.

Regarding the S&T infrastructure, serious deficiencies are evident in Ghana - the report mentions the nature of the work of institutes, little oriented to industry; deficient facilities and skills; poor linkages with industry; and little knowledge on the part of the latter. These deficiencies need correcting.

The report suggests that "since Ghana will, for the foreseeable future, remain a user of imported, relatively simple technologies", the very limited human and technological resources of the country should be concentrated on making "technology imports as effective as possible and to master the imported technologies as rapidly as possible. The technology institutes should play their part in helping enterprises to obtain and absorb the relevant technologies", which would require the institutes to be strengthened and their activities reoriented.

Also to be strengthened are: (i) information networks related to technology, as well as to standards and technical regulations in foreign markets; (ii) standards services, particularly in relation to the introduction of quality control management systems such as ISO 9000 which will be a necessity for export industries; (iii) S&T institutes, with the condition that policies should be adopted to encourage firms to establish linkages with them, perhaps by subsidizing the purchase of services, giving credits to fund research projects, and helping the commercialization of results, through enterprise creation and incubator schemes.

In sum, the main policy conclusions are: (i) extend infant industry protection to encourage enterprises to enter new activities requiring lengthy learning; (ii) create new skills and services, and inform and educate enterprises about their use; (iii) "build up a variety of educational, training, technology and infrastructural institutions to carry out the tasks that the government has to perform"; (iv) if Ghana is to achieve an integrated strategy for industrial development, there is the need to put together "a clear and comprehensive vision of the components of a proper strategy, and how to integrate its incentive measures with policies on the development of capabilities".

(c) The policy suggestions in the World Bank study of Kenya.

This report contains a number of specific policy suggestions, which are presented as a response to clearly identified issues. The following summary does not refer to the instruments suggested by the author for implementation of the suggested policies.

Industrial policy: (a) demand and investment should both be promoted as a reaction to the negative short term effects of economic adjustment; (b) a local African entrepreneurial class should be developed; (c) small scale industry should be supported technically and managerially; (d) improve the physical infrastructure, particularly regarding power supply and the gradual develop ment of a local capital goods industry; (e) help firm restructuring; (f) facilitate entrepreneur participation in industrial policy decisions.

Trade policy: (a) opening up to international trade should not be indiscriminate: long term comparative advantage may need to be nurtured in some sectors; (b) trade policy should be considered jointly with industrial and technological policy; its implementation requires a qualified government bureaucracy; (c) manufactured exports should be actively promoted, and assistance should be extended for new investments for that purpose and for the improvement of quality.

Technological policy: (a) transfer of technology through licences, technical assistance agreements and expatriates should be promoted, and a central issue is the role to be assigned to foreign investment in the transfer of technology; (b) key technical operating capabilities (trouble-shooting, maintenance, quality control and industrial engineering) should be promoted, and the importance of industrial safety and of environmental control should be stressed; (c) Industrial R&D should be supported through a variety of means in the enterprises and public R&D should be reoriented through the aplication of incentives.

Human resources: (a) educational policies should be revised to emphasize technical and vocational education, plus engineering and the physical sciences, even to the point of creating a supply ahead of the actual demand for the services of these graduates; (b) government and industry should cooperate in devising programmes for the on-the-job training of workers, and for the training of technicians and professionals locally and abroad, giving priority to small locally owned industries.

II. GUIDELINES FOR A UNIDO PROGRAMME ON INDUSTRIAL TECHNOLOGY FOR AFRICA

4. OVERALL APPROACH

We have indicated in the Introduction to this paper that most African countries are increasingly aware that they need to revitalize their productive systems, incorporate new technologies and make an effort to participate in global markets.

Programmes for industrial technology development at the national and at the subregional/regional levels are a key component of such efforts. African industrial enterprises have in general not been able to build up their technological capabilities beyond minimum levels, and much remains to be done if they are to reach adequate degrees of productivity and quality to enable them to compete in the world market.

There are also issues in the supply of technology in Africa that need to be tackled. First, on the introduction of foreign technology - by far the main source of new industrial knowhow - through new equipment, licensing, technical services, training, foreign investment, strategic alliances, etc. Secondly, on the expansion and efficient operation of the science and technology infrastructure that supplies research, training and a wide variety of scientific and technical services. In this regard, African cooperation in science and technology is potentially very important as a means to trascend the small size of national science and technology systems.

Efforts in the area of industrial technology should not be taken in isolation from efforts in other general and specific policy areas, principally macro economic policy, trade policy, industrial development, education and training, enterprise creation, small scale enterprise promotion and support, and so on. It is not easy sometimes to draw clear limits between the area of industrial technology and the other areas here mentioned. Our suggestions below incorporate aspects that could probably be claimed as belonging to other policy areas.

Purpose of the Programme

A UNIDO Programme on African Industrial Technology would refer to what UNIDO can do in the area of technology to support African industrial development, at a time when a change of philosophy is taking place, emphasizing the role of market forces, the development of private enterprises and the privatization of public enterprises.

The Programme would identify and promote cooperation activities by UNIDO and African countries, at the national level and at the regional/subregional level, that would make a significant contribution towards enhancing and accelerating sustainable industrial development in African countries.

Within this general purpose, the main objectives of the Programme would be: (i) to assist industrial enterprises in the private and public sectors to develop their technological capabilities and apply them to improve their efficiency

and competitiveness, with due regard for the environment, and (ii) to assist in expanding, deepening and making more relevant for industry the scientific and technological effort in African countries, including the restructuring and revitalization of S&T institutions and the enhancement of African cooperation in S&T matters.

Structure

The Programme would have three main components, to which we refer briefly below, leaving a more detailed treatment for the next section:

a) In the first place, an activity of *research and studies,* aimed at gathering, processing and developing information and knowledge about different issues of African industrial technology development. This could be done largely through the analysis of the results of research activities and surveys made by various researchers and institutions, and to a much lesser extent by designing and carrying out studies on carefully chosen topics where UNIDO may have a particular advantage in carrying out research, mainly on account of relevant work already done by the Organization.

b) The second, and very likely the most important, component would be a set of *operational activities at the national level,* which would be specified in a carefully prepared *National Industrial Technology Programme.*

It is clear that the orientation and content of such a Programme would be different for each country, and that only general suggestions may be made that will be valid for most African countries. We propose that the National Programme should be derived from a careful programming exercise, for which a *National Industrial Technology Workshop* could be conducted.

We have examined in the previous chapter several approaches to industrial technology policy in Africa, stemming from different views as to the role of technology in African industrial development and the priorities that may be assigned to various policies and actions that seek to favour industrial technology development in particular circumstances. These and other antecedents should be brought to bear when designing the National Programme.

The main aspects to be covered by the National Programme would be (i) the creation of new enterprises, (ii) the development of technological capabilities in industrial enterprises, (iii) the utilization by the enterprise of its technological capabilites, and (iv) the supply to the enterprises of scientific and technological inputs and services by local institutions of the S&T infrastructure. The last three areas would cover actions expected to improve the functioning of enterprises in the direction of higher efficiency and increased competitiveness.

Influences on the areas above may be produced by *explicit policies,* acting through policy instruments of various types. It is also important to look into the *implicit* effects of policies in other areas. Environmental aspects should be explicitly considered in programming the activities.

c) Finally, the third component of the programme would be *operational activities at the subregional and regional level.* Three main areas for UNIDO

cooperation would be (i) the improvement of existing regional scientific and technological cooperation programmes, networks and institutions, (ii) the creation of new networks in key S&T areas, and (iii) the creation of new institutions serving the region, such as a research-based educational institute for the training of scientists and engineers, a full scale African consulting and engineering organization, and an institution for technology acquisition and diffusion.

Cooperation with other Agencies

For the implementation of this Programme, UNIDO should look for the cooperation of other institutions that are also interested in developing scientific and technology capabilities and ensuring their efficient utilization, like the Organization of African Unity, the African Development Bank, the World Bank, the International Development Research Centre, the United Nations Environment Programme, other UN agencies, and donor country institutions.

On developing the detailed component programmes at the national and regional and subregional levels, UNIDO should invite such institutions to collaborate in reviewing the concrete proposals and to choose specific areas in which their cooperation could be brought to bear. This could be done by means of a series of workshops with the participation of those institutionns, in which agreements could be reached for funding and executing selected activities.

5. CONTENT OF THE PROGRAMME.

We will now examine in some detail the components of the proposed Programme.

5.1 Studies

The manifold aspects of industrial development in African countries, and in particular its technological component, are still imperfectly understood and need to be better known if effective, realistic policies are to be designed and implemented.

This would need a systematic effort of exploration and analysis, through a series of researches and studies aimed at some of the key issues found in the different African countries.

We do not propose that UNIDO should sponsor or execute a thorough research programme of this nature. This is not the main objective of the Organization, and on the other hand the scarce resources that can be allocated to cooperation with Africa should aim at more immediate, operational purposes.

The proper thing to do is for UNIDO to be aware of research efforts being undertaken in this field, and to survey and digest the results in order to continuously improve its own operational activities in line with the best knowledge that can be obtained.

We have referred in the first part of this paper to the studies being undertaken by two important international agencies, IDRC and the World Bank. We suggest that there should be an explicit effort to keep in close touch with these research activities.

There is already a willingness to have UNIDO participate in the activities of the African Technology Policy Studies Network, ATPS, which is sponsored by IDRC, the Carnegie Corporation and the Rockefeller Foundation. ATPS supports the work of African researchers on technology policy. A Coordinator based in Nairobi has been appointed, as well as an International Steering Committtee. The first Annual Meeting of the Network will take place in mid-1994, when project proposals are to be screened.

IDRC has expressed interest in linking the Network with UNIDO, in order to find a channel for applying the results of research. A first working contact may be made during the meeting mentioned above, where IDRC would welcome the participation of a representative of UNIDO. The IDRC person to contact is Mr Brent Herbert-Copley at the Centre's headquarters in Ottawa.

The World Bank and a group of eight donor countries are conducting at the present time a series of comparative case studies on industrial development in eight African countries. The studies use a common methodological approach developed jointly by the Bank and the technical teams from the donor countries. Coordination is in the hands of the Private Industry Development Branch at the Bank. Two special areas of study are Technology and Finance, with a few country case studies in each. In Technology two reports have recently been issued, on Ghana and Kenya (see section 2.2 and Annex 1 of the present report). Another case study on Zimbabwe will be ready by mid-1994.

Here too it would be convenient for UNIDO to link up with the sponsoring institutions and with the research teams, in order to profit from the new knowledge that is being generated. The present author understands that the World Bank would be willing to collaborate with UNIDO and pass on to it the results that will be forthcoming. This should be verified and collaborative contacts shoud be established. The World Bank persons to contact are Mr Tyler Biggs, at the Private Industry Development Branch, who coordinates the programme of studies on industrial development, and Mr Simon Teitel, consultant to the Bank, who is in charge of the technology studies. Both are based in Washington DC.

There may be other studies of interest to UNIDO that the present author is not aware of. It would be desirable to carry out a survey of ongoing and planned research and surveys related to industrial technology development in Africa, in order to procure material, analyze it and discuss it within the house and with African counterparts.

In this way UNIDO may use such new knowledge, at a very low cost, for the design and further improvement of its cooperation programmes.

This having been said, it is yet possible that UNIDO would find it advantageous to promote and even execute a few carefully selected studies in certain topics in which strong comparative advantages have been gained by the Organization. Two instances come to mind.

a) Industrial Technology Research Institutes (ITRIs) in African countries. Very recently UNIDO, in cooperation with IDRC, developed a programme to carry out comparative studies of Latin American ITRIs. About ten case studies were made and the results are to be published soon by UNIDO in a paper by A. Araoz entitled *The Revitalization of Industrial Technology Research Institutes in Developing Countries: Guidelines For Unido.*

The "ITRI Project" studied some of the key issues faced by these institutions, such as their relative failure to fulfill their original objective of assisting the technological development of industry; the changing milieu in which they are now operating; the different requirements they are facing as private industry becomes their main client; the need to update capabilities and develop new skills to cope with new technological needs, and the reduction of state support, with repercussions on the scientific personnel resulting in a lowering of quality levels and a loss of motivation, and on the state of installations and library resources, which have become increasingly outdated. Latin American ITRIs were found to be going through difficult times, and find it necessary to increase their sales of R&D and services if they are to survive and fulfill their mission. However, only a minority of the Latin American ITRIs could be considered to be "mature" and effective; in fact, two of them had ceased to exist while a third one was running the same risk.

There is the suspicion that in Africa the situation is bound to be even more acute, and the question is whether some of these institutes may be rescued and transformed - through a process of "revitalization" - so that they may make an effective contribution to industrial technology development.

The "African ITRI Project" here suggested would look into these issues through a series of case studies, similar to what has been done in Latin America. It could however go further, with the purpose of outlining and initiating changes on the basis of the research results.

The effort to carry out such a project would be justified on account of the significant investments already made by African countries and by international and donor organizations in building up these institutions and developing the cadres of well trained scientists and technicians in them. These resources should be employed efficiently in support of national goals: they should not be left idle. The studies proposed would provide a strong basis and a good beginning for the restructuring and reorientation of such institutes.

We have developed an outline for this project, which may be found in section 7.1 below.

b) A second area for research on the part of UNIDO would be a study of the results of investment promotion activities carried out by UNIDO in Africa.

Many hopes are being put on foreign investment as a vehicle for the acquisition of capital and other important inputs, such as technology coming in with the investment, a steady flow of technical advice and services, access to foreign markets, management skills and so on. To what extent are these inputs coming into Africa as a result of UNIDO-sponsored investment projects? In particular, what is the impact of these projects on industrial technology?

UNIDO has "successfully promoted" about 100 investment projects in Africa in the biennium 1992-1993. Information is on hand about the general characteristics of each project at the time of its promotion, but little is known in UNIDO about subsequent developments.

This is a large enough universe for a study that would attempt to produce some insights on the results of the investment promotion activities, and suggestions on how to improve them for a fuller impact, particularly regarding the acquisition of technology.

The moment is appropriate to conduct a study of this nature, in view of the renewed interest of African countries on foreign investment and of the dialogue which was inaugurated at the recent Round-Table of African Investment Promotion Centres, organized by UNIDO in cooperation with OAU and ADB (see Annex 3).

The study could be conducted in-house at UNIDO. The resources already available could be supplemented by a graduate student that could prepare a very promising dissertation on the subject.

5.2 Operational activities at the national level

a) Overview

We propose that a *National Industrial Technology Programme* should be carefully prepared for each participating country, listing the different operational activities to be carried out, which could count with the advice and support of UNIDO.

The orientation and contents of such a national programme would be different for each country, and should be derived from a careful programming exercise.

The following main aspects should be covered:

- *The creation of new enterprises.* The analyses carried out by UNIDO have clearly shown that one of the main problems of African industrial development is the very small number of industrial enterprises in existence, particularly those owned by ethnic Africans. Creating new enterprises and assisting them in achieving a solid technological basis for their activity would appear to be a most important objective.

- *The development of technological capabilities* in industrial enterprises, a necesary (though by no means sufficient) condition for their technological improvement. We have discussed extensively this aspect in preceding sections of this report.

- *The utilization by the enterprise of its technological capabilites* in a variety of activities that have to do with technology, such as technology acquisition, technology development, innovation, etc. This aspect is intertwined with the previous one of capability creation.

- *The supply to the enterprises of scientific and technological inputs and services by local institutions of the S&T infrastructure,* such as research and

development, standards, quality control, preinvestment work, technical assistance and troubleshooting, and so on.

The last three areas would cover actions expected to *improve the functioning of enterprises* in areas such as productivity, quality and other that make for higher production, lower costs and increased competitiveness. In designing such actions the environmental aspect should be explicitly considered, so that on implementing them the possible negative impacts on the environment may be suppressed or at least minimized.

Influences on the areas above may be produced by *explicit policies*, acting through a variety of policy *instruments* such as legal texts, institutional arrangements, mechanisms and programmes.

Of particular importance are the *institutions* that help to define policies, to set up and operate mechanisms and programmes, and to provide services of a technical, economic and administrative nature for the use of enterprises.

It is also important to look into the question of *implicit policies*. Policies in other areas may have indirect effects on technology variables, often amounting to negative influences. Such implicit effects usually are not taken into account when drafting the policy. For instance, a policy of rapid liberalization may promote imports to the detriment of local technology development and indeed of local production, as the World Bank study for Ghana has found. When attempting to define policies in favour of industrial technology development, a survey should be made of other areas of policy to find out about possible implicit effects, and to propose means to deal with them if necessary.

The contents of the National Industrial Technology Programme for a certain country will depend on the particular circumstances and the national goals of the country in question. Examples of this may be found in the proposals in the World Bank report for Kenya, and in the recommendations of the workshop recently carred out in Tanzania.

We may however compile a general set, checklist or *menu* of possible elements of the programme - policies, instruments, institutions - from which a choice may be made during a programming exercise. In subsection b) below we present a partial listing of these elements.

Drafting the National Programme

For the purpose of developing a National Industrial Technology Programme that may be used as a focus for UNIDO technical cooperation efforts, we suggest that a *National Workshop on Industrial Technology* should be carried out in each participating country, preferably with the assistance of UNIDO. The workshop would have ample participation of people from industry, government, science and education, who would debate on two consecutive days around a number of "vertical" and "horizontal" subjects. The characteristics of this National Workshop and the methodology it would employ are indicated in subsection c).

The workshop may use the *menu* as a starting point for identifying desirable operational activities, selecting some of the elements of the list in accordance with the national situation.

After the Workshop has concluded, a team of national experts assisted by UNIDO would use the results and recommendations to draft a National Industrial Technology Programme. This should cover a period of 3 to 5 years, and should clearly indicate the objectives pursued, the activities to be carried out, the institutions to be entrusted with implementation, the human, financial and physical resources required, and the participation of UNIDO (and possibly other agencies).

Once the Programme is approved and funding has been obtained, the Programme would enter into an implementation stage, at the end of which an evaluation of the Programme's results should be made.

Conditions should be created for the Programme to continue on its own after UNIDO's involvement has ceased.

b) The "Menu": A Checklist of Policies, Institutions and Operational Activities for Industrial Technology Development

The purpose of the "menu" is to provide an ample listing of policies, operational activities and institutions on which action may be taken by Africans, and on which cooperation may be offered by UNIDO and other agencies. The menu may be used by the participants of the National Workshop as a source for identifying the components of the National Programme of Industrial Technology.

The items shown below are those that would seem appropriate for the situation in African countries, according to what the present author has been able to identify through his observations in Africa, the discusssions maintained with UNIDO staff members and other experts, the readings he has been able to make, and his own experience.

The present list is perforce a partial one, and it would be desirable to develop a more complete menu. This is a task which UNIDO may choose to undertake.

Some of the items in this list are developed much more fully in the following chapter, under the denomination of "special topics".

1. Policies

1.1 Formulation of *general and sectoral strategies and policies* on technology for industry and on the building up of technological capabilities. This should take into account (a) the effect of "implicit"policy aspects, i.e. the impact on technology of policies in other areas, and (b) problems of environmentally sustainable industrial development, such as effluents, solid waste and industrial pollution. Policies should relate to issues in traditional, conventional and new technologies. There are many aspects to be covered by policies, such as the increase of demand for services from local S&T capabilities (R&D, foreign technology acquisition, consulting and engineering design

productivity enhancement), the promotion of foreign investment, and many other that are mentioned below.

1.2 *Design of policy instruments and measures* for putting into effect the particular activities chosen for the Programme, and for building up the necessary institutions. Training, financial assistance, technical assistance, information, and the provision of specialized knowhow, manpower and equipment, are among the most important means that may be employed to implement activities, and to a greater or lesser degree they may be provided by UNIDO and other international and foreign agencies.

2. Activities at the national and enterprise level for the technological development of industry

2.1 *Diffusion of values favourable to productivity, technological development and S&T activities* through a national awareness programme aimed at students and at the general public.

2.2 *Development of human resources for industry,* particularly in regard to
- technical education
- university education in science, engineering and management
- specialized technical and management training for industry, including the recycling of personnel.

2.3 *Efficient utilization of skilled and high level human resources for industry,* including expatriate Africans that can be brought back temporarily through mechanisms such as TOKTEN.

2.4 *Development of indigenous African entrepreneurs*, and helping them to create new enterprises, through:
(a) a programme such as EMPRETEC (see section 8.1), which could be adapted to a number of different situations:
- Creation of enterprises based on traditional technologies (mainly in the rural areas)
- Creation of enterprises based on technologies developed in Africa, such as is being now attempted by a programme of ARCT, the African Regional Centre of Technology, and by some programmes at the national level
- Creation of enterprises based on imported technologies, conventional and advanced.

(b) *business incubators* as an instrument to help develop new technology based enterprises. Here the experience of the UN Fund for Science and Technology for Development may be reviewed for guidance.

2.5 *Productivity improvement* actions aimed at public and private enterprises. UNIDO has acquired much experience on programmes of this nature, which may include:
- management consultancy for the introduction of modern management methods, use of computers in management, introduction of Just-in-Time, Total Quality Management, and other modern management techniques
- product and process consultancy, including design, industrial automation, pollution control
- active extension services that seek out small enterprises, including those in the informal sector, to assist them in technical and management matters

- design services
- quality services and testing
- metrology and standards
- subcontracting between small and medium enterprises and large industrial firms, local and foreign

2.6 *Technology transfer (or technology acquisition)* in its different aspects - search, negotiation, purchase and adaptation of foreign technology. Training and technical assistance can be given to the entrepreneurs by different national institutions. UNIDO has been very active in this field, as shown in the report of the most recent African TIES meeting.
An interesting aspect would be the use of a procedure to appraise technology imports from the technical, economic and environmental points of view for the purpose of granting explicit support, such as special loans, to the best projects.

2.7 *Explicit use of government purchasing power* as an instrument for technological and industrial development, through the local sourcing of Government purchases, with the purpose of increasing the local content of projects, goods and services purchased, and through this improving local technical capabilities (see section 8.2)

2.8 *Search for maximum positive impacts* on local technological development in (a) investment projects (b) international technical cooperation projects. This requires the unbundling or disaggregation of such projects at the design stage (here the local consulting and engineering capacity has a crucial role to play) with the aim of utilizing local personnel and inputs to the fullest extent. Procedures for this are well known in the case of investment projects, and similar procedures may be developed for cooperation projects. Here UNIDO could have a key role.

2.9 *Promotion of foreign investment* as a means to bring into the country much-needed technology and management skills, in addition to capital and access to foreign markets. UNIDO has been very active in this area in Africa: more than 100 investment projects have been promoted in the past biennium, and institutions in charge of investment promotion in several African countries have been assisted. The recent Round-Table of African Investment Promotion Centres, sponsored by UNIDO, has produced a set of recommendations that should be taken into account at the time of preparing the National Industrial Technology Programme (see Annex 3).

2.10 *Development and enhancement of technological capabilities* in industrial enterprises. This, as we have seen in the first chapter of this paper, is a crucial aspect and many efforts should be allocated by goverment and by industry itself. Programmes for gradually developing capabilities may be drawn up by industrial enterprises, and supported by government. The hiring of skilled technicians and professionals, the specialized training of personnel at home and abroad, the use of consultants and foreign experts, and the access to technical information, are the principal means to be employed. There is an important role for UNIDO in supporting and enhancing this process.

2.11 *Research and development* are activities as yet little practised by African enterprises. They should gradually find their way into at least some of the larger enterprises, first as a means to solve production problems and adapt

foreign technologies to local conditions, and later to improve the efficiency and quality of production, and to bring up new products which may perhaps allow the company to penetrate foreign markets. R&D may be procured from universities, industrial technology research institutes, and other institutions of the S&T infrastructure; but by and large industry should develop its own research capabilities, as a desirable extension of the development of its technological capabilities. Such a process may be helped, among other things, by financial incentives and by improving the mechanisms for linking up the R&D institutions with industry.

2.12 *Introduction of New Technologies* into industrial activities. This may take place through the creation of new production facilites employing new technologies. However, opportunities for this are probably not too frequent in Africa at this point of time. A second modality, the introduction of new, advanced technologies, particularly informatics, into existing industrial activities (and into many other activities such as tourism, banking and administration in general) may be much more accessible. UNIDO has analyzed in detail the use of informatics in African industry, and one African country, Mauritius, is already developing a programme for the introduction of informatics into a wide range of activities.

3. Institutions and Mechanisms at the National Level

3.1 Institutions of the *S&T Infrastructure*. This includes
- industrial technology research institutes
- other R&D centres
- University R&D laboratories and centres.

The present state of these institutions should be reviewed with the purpose of setting up programmes to improve and update them, and to reinforce their links with industry. In some cases a full *revitalization* exercise may be needed, on the lines of that suggested in section 7.1 below. The possibility should be considered of transforming some of these institutions into "centres of excellence", perhaps within the TWAS initiative.

3.2 Creation of *Contestable Funds* to finance (a) strategic, long term R&D, with 100% funding (see section 8.3), (b) applied R&D with, say, 50% funding, the rest being contributed by the institute and its industrial partners. The tendency today goes towards funding R&D outputs rather than inputs, as was formerly the case, in order to orient research towards national demands and needs.

3.3 Development and strengthening of *mechanisms to link science and industry*, in universities, research institutions, etc. A large body of literature exists on this topic, covering different mechanisms that go from simple newsletters and other published information to special units in charge of industrial clients, "demonstration units" for locally developed technologies, business incubators, and science parks.

3.4 *Information and intelligence systems:*

- *Information:*
  - Review the state of industrial information in the country, using this as a

basis to develop programmes for the improvement of national information systems. UNIDO can help in this task through its Industrial and Technological Informatin Bank, INTIB.
- Identify *"crucial technologies"* on which information efforts may be concentrated (see section 8.4)
- Identify and assess *new technological applications* that may be introduced by African enterprises, particularly for export purposes

- *Intelligence:* analyze the feasibility of installing *techno-economic intelligence units* for some industrial branches of great economic importance (see section 8.5). These units may be set up to serve several African countries in branches such as sugar, vegetable oils, energy and construction materials

3.5 Development of *preinvestment services*, from project concept to "financial "engineering", including a *capability to search, access and acquire technology*, particularly foreign technology. This will need, very importantly, the *development and strengthening of African consulting and engineering capabilities*, particularly in C&E organizations (see section 8.6). UNIDO's assistance here could be carried out in collaboration with the African Project Development Facility, the European Union's Centre for the Development of Industry, and other agencies.

3.6 Creation of *financial schemes* to support activities needed for the *application of R&D results*, such as revolving funds and risk-sharing loans, and creation of *financial mechanisms to supply investible resources*, such as special loan programmes, SME investment funds, loan guarantee funds and venture capital funds.

c) National Workshop on Industrial Technology

The workshop here proposed would be carried out at a national level in order to make a first examination of the main problems and issues of industrial technology development in the country, and of the policies and actions that could be envisaged to deal with them.

We propose a very simple scheme, the results of which would allow to identify immediately some concrete suggestions and to lay down the basis for a deeper examination of these topics.

In essence, the proposal is to hold a two-day meeting with the participation of persons from industry, science, university, trade unions and government, who would contribute their specific knowledge and experiences to a structured debate.

The workshop would be organized in the following manner. On the first day participants would convene in parallel working groups, according to the most important industrial activities of the country, for instance:

- construction
- energy
- food and agro-based industries
- textiles and garments

- woodworking
- metalworking and engineering industries
- chemicals and petrochemicals
- mineral processing
- application of new technologies.

The number of these branches should not be higher than ten, in order to allow for a concentration of efforts in the "vertical" areas which are key for the future industrial development of the country.

Each group would meet the whole day, under the direction of a coordinator, who will have previously prepared a concise document to guide and structure the discussion. This report should not be more than six to eight pages long, with a diagnosis of the branch's technology development issues and a set of proposals to cope with them. Other written contributions could be accepted, but they should be distributed for reading and should not be presented in extenso during the meeting, since what is important is the discussion rather than academic presentations. At the end of the day the coordinator would introduce the necessary modifications into the document, to convert it into a report that will reflect the experiences and points of view of the participants in the discussions.

On the second day the same participants would re-group according to "horizontal" topics, such as:

- policies and legislation for technology development
- creation of new enterprises, particularly those based on locally developed technologies
- human resources for industry, including university training of high-level scientists and engineers, management training, technical and vocational training
- research and development
- technology acquisition and mastery
- foreign investment and its promotion
- technological services such as consultancy, standards, quality, etc.
- specialized technical inputs needed by industry, such as industrial engineering, packaging, design, repair and maintenance, automation, etc.

Once again, not more than 10 horizontal topics should be covered, under their respective coordinators, who would prepare a summary document as a basis for discussion.

The reports of the different working sesions in the first and second day should be finished and printed overnight, and given to the participants in the closing session of the workshop, on the morning of the third day. This would mean a strong psychological and practical impact on the participants, the press and public opinion.

A small drafting group would then edit these texts, add complementary material, etc. to prepare a publication that should be out within 2 to 3 months and should receive ample diffusion.

There are two key points in the design of this exercise . First, the selection of the vertical and horizontal areas around which the exercise would be conducted. Second, the appointment of a coordinator for each area, who should be a person with ample knowledge of the topic and a good capacity of analysis and reflection. Each coordinator would be asked to form a small working group, with people he or she would select, to help in the preparation of the basic discussion document.

A general coordinator would be needed to guide the three phases of the exercise (preparatory work, the meeting itself, drafting of the report to be published). It would also be important to hold several discussion meetings among the coordinators, to get them to know each other and exchange opinions and experiences so that each report takes into account the other reports.

It should be stressed that the proposed exercise is useful not only because of the final reports, which would collect the ample experience of the participants from industry, science and government, but also on account of the elements of *learning* and *networking* implicit in the exercise. This would take place in two instances:

First, as the coordinators and their collaborators prepare their papers and participate in the coordination meetings. This could be the basis for the consolidation of a human group, highly motivated and with a strong interaction, which could support the future efforts of technology development for industry.

Second, during the workshop itself, when numerous opportunities will exist for participants to exchange views and interact, not only within each horizontal or vertical subject, but also between subjects as participants visit several of the parallel meetings during the course of the workshop.

Since the results of these exchanges could end up being almost as significant for industrial technology development as the conclusions of the Workshop, the organizers should provide the most favourable conditions to enhance interactions before and during the workshop.

5.3 Operational activities at the Regional level

The third component of the UNIDO Programme on Industrial Technology in Africa would be a set of operational activities at the regional (and subregional) levels. The main areas here would relate to regional/subregional scientific and technological cooperation programmes, networks and institutions, existing or to be created.

On account of the experience it has accumulated through many years in setting up regional programmes and helping to operate them, UNIDO is in a specially good situation to take a leading role in this matter. Consultations with African countries, as well as with regional organizations such as ECA, OAU and ADB, would be particularly useful in drafting the regional cooperation component of the UNIDO Programme.

Several types of regional operational activities may be contemplated:

a) On existing cooperation arrangements at the regional level

There are a number of cooperation programmes, networks and institutions operating in Africa, such as ARCT, ARCEDEM and the African Standards Organization, that enjoy varying degrees of success. In general they show problems that are difficult to solve, since in most cases these problems derive from insufficient funding, or from expectations by member countries that are not easy to fulfill.

In his conversations in Africa, the author was struck by the very heavy load imposed on the managers of such cooperating endeavours by the fact that they have to respond to the member countries' requirements and interests with comparatively few resources. Some interlocutors felt that the usual multi-country ownership of a regional institution is not an efficient way of structuring the institution. They thought that it would make much more sense to have the "regional" institution belonging to just one country but with a clear mandate to serve a number of countries that would be partners (and pay for it) without becoming owners.

In any case, we propose that UNIDO should survey the existing African regional cooperative ventures and draw up a set of operational activities to help them become more efficient and achieve a higher impact. This may become a sub-programme within the larger UNIDO Programme.

b) On new arrangements for regional cooperation

Under this heading we propose first that UNIDO should examine the creation of *new networks in key scientific and technological areas.* The purpose would be to enable weak national scientific and technological systems to complement and help each other.

A very interesting example exists in Latin America, where a "Latin American Common Market in Science and Technology" has recently been created by initiative of the President of Uruguay. The purpose is to establish and operate cooperating networks between research institutions, universities and industrial firms around carefully chosen scientific and technological areas. A coordination unit has been set up at the Organization of American States, and several programmes are being currently developed. UNIDO should follow closely this experience and find out whether it can be applied in Africa.

A promising possibility is the formation of *institutional networks* among national institutions with a similar mandate. Section 9.1 below shows an example for the case of Industrial Technology Research Institutes.

In the second place, *new African institutions* may be created to fulfill cooperatively certain objectives that a country by itself would not find it easy to achieve.

For the reasons indicated above, it may be preferable that an institution of this nature should be based in one particular country, to assure its stability and efficiency, and that its extends its reach to the rest of the region.

We include in section 9 below some detailed proposals for the creation of a number of new institutions serving the region:

(i) An *African Institute of Technology*, for the production of first rate graduates in science, technology and management, incorporating research on African industrial themes as an integral part of the teaching process, such as is done in the best Institutes of Technology in industrial countries (CALTECH, MIT, Ecole Polytechnique, Darmstadt Technische Hochschule, etc.). This proposal is developed in section 9.2.

(ii) A full scale *African Consulting and Engineering Organization* that would eventually operate in the whole of Africa, to design, engineer and implement medium and large projects (section 9.3).

(iii) An *Institution for technology tranfer and diffusion through demonstration enterprises,* for the introduction and demonstration of technologies that are novel to Africa. A very successful institution of this type, the Chile Foundation, could serve as an example (see section 9.4).

Though it may seem farfetched at this time to propose large investments on institutions that may take many years before maturing and producing the desired results, the present author feels that Africans should at least have in mind possibilities such as these. The alternative is to continue depending to a large degree from the outside world in regard to highly skilled scientific and engineering human resources and complex technological services, and in the long run this is bound to be more costly than developing such resources. In his talks in Africa, the author found a surprising degree of agreement on the part of experienced professionals, high ranking government functionaries and senior international civil servants.

* * *

Finally, we will refer to the scientific and technological cooperation between African countries and countries in other regions.

Here UNIDO, through the Programme, could promote

(i) Cooperation on industrial technology between African and foreign institutions and enterprises in the industrial countries. UNIDO could do this through mechanisms such as INTIB, Techmart, the network of Industrial Promotion Services and simply the good offices of the UNIDO staff, with their worldwide connections. The Programme should have a special chapter for this important set of activities, and some resources should be allocated to it.

(ii) Cooperation between African and foreign institutions and enterprises in other developing countries, using the same mechanisms. The topic of technical and economic cooperation among developing countries is a familiar one for UNIDO, which has carried out many projects in it.

(iii) The relations of African scientific institutions with the International Centre for Genetic Engineering and Biotechnology, ICGEB, the International Centre of Science, ICS, and other major promotional projects of UNIDO. This is an important vehicle for the training of scientific personnel in short and long programmes, and for keeping scientists and engineers up to date through

their fluid contacts with those institutions and their periodic stays at them for refresher courses, conferences and participation in advanced research work.

6. DEVELOPMENT OF THE PROGRAMME

In the previous section we have suggested what the UNIDO Programme on Industrial Technology in Africa could consist of. In the present section we will examine the steps needed to bring it into being.

We suggest that a *pilot phase* should be carried out, lasting for about two years, in which a limited number of activities would be planned and carried out under the three main components of studies, operational activities at the regional level and operational activities at the national level, the latter covering a limited number of countries that present a variety of conditions.

With the experience gained in the pilot phase, the original design of the Programme may be reviewed and the desirable corrections incorporated, leading to an *operational phase* which would incorporate additional topics and increasingly cover other African countries.

Preparation of the Programme

The following steps may be suggested for drafting the Programme:

a) The first step would be for UNIDO to examine in detail the present Report and the guidelines it proposes. It would be important to consider how these proposals would fit into the present UNIDO objectives, and how its current and planned technical cooperation projects relating to industrial technology may fit in with the proposed Programme.

b) We propose that the next step should be a two-day Expert Group Meeting or Workshop, that would include participants from Africa and representatives of funding organizations.

The workshop would discuss the proposal for a UNIDO programme on African industrial technology, explore funding possibilities for this programme, and examine how UNIDO and other concerned agencies may cooperate in the coming years around this subject.

The present Report would be a main input to the Workshop, together with contributions from UNIDO staff members, relevant papers from other participants and material from funding organizations.

A very interesting possibility is to organize this event with the cooperation of the Fletcher School of Law and Diplomacy at Tufts University, located near Boston, USA. The Fletcher School is one of the most prestigious institutions on international relations, and has a Centre on Technology and International Affairs where the present author is an Associate Researcher.

There is much interest in Fletcher on the subject of a programme in support of industrial technology in Africa. Fletcher professors and researchers engaged in matters of development and technology, who have mainly centered their

attention so far on other regions of the world, principally the Asian Pacific Rim countries, would welcome an opportunity to become involved in African issues.

It would be of great value for UNIDO to develop cooperation with this prestigious institution. This could lead to the involvement of Fletcher specialists in this and other areas of concern to UNIDO, and to the opportunity for UNIDO to widen its contacts with funding institutions with which Fletcher has built up fluid links.

Professor Denis Fred Simon, Director of the Center of Technology and International Affairs, has been contacted and there is a concrete possibility of holding this meeting at the Fletcher School in its campus in Medford, Massachusets, in the course of 1994. The Fletcher School would contribute to the Workshop its physical facilities and the participation of its professors and researchers. This would help to keep UNIDO's expenditure within reasonable limits.

The Workshop should not be too large, probably about 15 to 20 participants, in order to have a dynamic meeting that will arrive at crisp, useful conclusions. Participants would include UNIDO staff members, Fletcher School professors and research associates, African experts, a few resource persons, representatives of African development organizations, United Nations agencies and the World Bank, and representatives of funding organizations such as IDRC, AID, the Carnegie Corporation and the Rockefeller Foundation.

c) With the results of the Workshop in hand, UNIDO would be able to carry out the third step, the drafting of a final version of the Programme. This should be in the form of a UNIDO Project Document, with all the details this needs.

d) There would follow a stage of discussion and adjustment of the Programme document, within UNIDO, with African counterparts, and with cooperating agencies.

e) Finally, funding and cooperation arrangements with other agencies would be dealt with, particularly for the Pilot Phase.

Pilot Phase

The components of this phase would be:

(i) Studies.

UNIDO should concentrate at this stage on establishing working contacts with individuals and organizations that carry out research on industrial technology and related fields in Africa, gathering research reports and other inputs, and analyzing this material. The output of this activity would be used for the benefit of the Programme. Additionally, a study could be launched in an area where UNIDO holds comparative advantages, such as those mentioned in section 5.1 above.

Opportunities for further networking, and for the launching of other studies, should be analyzed at this time in order to facilitate a fuller agenda of work for the operational phase of the Programme.

(ii) Operational activities at the national level.

We propose that not more than four countries should be covered in the pilot phase. The candidate countries for the pilot phase could include those in which the World Bank has carried out studies on industrial technology: Ghana, Kenya and Zimbabwe.

The advantages of this choice are readily grasped. The research teams of that institution have collected a great deal of information when making the studies, and a network of relationships has been established with local persons and institutions in industry, science and government. These antecedents would make it much easier and efficient to work with these countries. The present author understands that the Regional Program on Enterprise Development of the World Bank would be willing to give UNIDO access to this information.

To these three anglophone countries in sub-Saharan Africa, we suggest that a francophone country in the Northern part of Africa should be added, perhaps Tunisia or Morocco, so that the coverage at this pilot stage comes somewhat closer to the geographical and cultural diversity of the African region.

(iii) Operational activities at the regional level.

We suggest that the activity in the pilot phase should concentrate, first, on a review of existing African regional and subregional cooperation arrangements on science and technology related to industrial development.

Africa counts with regional institutions like ARCEDEM and ARCT, and with various programmes and networks, that count with the sponsorship of African and international organizations, including UNIDO. The review would aim at helping some of them attain higher efficiency, coverage and impact.

UNIDO has been active in the past in sponsoring regional projects, and is conducting at present a number of such projects. Examples are those on the technology of certain industrial branches like leather products, fish products and gari, and on key industrial services such as metrology and standards.

The review would include the identification of regional, subregional and multi-country cooperation activities in industrial technology and related fields, and a diagnosis of those of more importance from the viewpoint of their effectiveness. Another task would be to identify opportunities for creating new networks and institutions.

On the basis of this review a limited set of operational activities may be designed and carried out during the pilot phase. A wider, more ambitious subprogramme for such activities could be developed for the following phase.

Review and preparation of the Operational Phase

Once the Pilot Phase is completed, a second workshop should take place, to review the results and introduce the necessary corrections into the Programme.

After this, the Programme would enter into its operative phase of full implementation. New countries would be incorporated successively into the Programme; new studies would be supported; and a variety of regional cooperation activites could be started, particularly one or more of the large scale projects outlined in section 9.

III. SPECIAL TOPICS

This chapter develops in more detail a number of topics of special interest for the UNIDO Programme on African Industrial Technology.

7. STUDIES

7.1 Outline Of a Study of African Industrial Technology Research Institutes

1. Introduction

Industrial technology research institutes (ITRIs) in developing countries show in many cases a low efficiency and a weak contribution to industrial development. They are also facing a number of problems due to changing economic and technological circumstances and a reduction in state support.

UNIDO has recently conducted, in collaboration with IDRC, a number of studies of Latin American ITRIs that have thrown some light on the issues they are facing. A paper is soon to be published on the revitalization of ITRIs, and cooperation activities on this theme have already begun.

ITRIs in Africa have an important role to play in a situation where industry is building up its technological capabilities and needs support for improving its efficiency and to tackle new production areas. Has this been happening? Are African ITRIs reasonably effective?

These and other questions may be explored through a number of cases studies of African ITRIs, similarly to what UNIDO has done in Latin America. The participation of IDRC as a co-sponsor of the project is very possible. The conclusions from these studies would allow UNIDO to determine the best ways in which it can assist African ITRIs to mature, link up with enterprises and fulfill their expected role of efficiently supporting industrial development.

2. Background

Problematique

ITRIs in developing countries face a set of interrelated issues, principally:

(a) *Relative failure to fulfill their original objective of assisting the technological development of industry.* By not focusing closely on industry, they run the risk of becoming largely irrelevant to the development needs of industrial enterprises. This risk is reinforced by their lag to master new technological fields that are becoming increasingly important for industrial enterprises.

(b) *A changed milieu with different requirements.* The changing technical, economic and policy environment of the nineties makes life difficult for the traditional ITRIs, which were attuned to import substitution and now have to

assist industry in enhancing competitiveness. The new milieu would seem to require a different type of ITRI, more flexible and better able to help industry respond to a new set of challenges, as economies open up and there is need to compete in globalized markets.

(c) *Need to update capabilities and develop new skills,* in order to cope with the new technological realities and the resulting requirements of industry.

(d) *Dealing with new types of issues, such as* environmental protection.

(e) *Reduction of State support,* while the demand from industry has seldom grown enough to compensate for the loss of revenue. This has led to serious doubts about the sustainability of these institutions.

An effective ITRI

If the investment in human, physical and knowledge resources of an ITRI is to be well used, it should become an*effective* institute, with an efficient operation and a high impact on development. It should acquire characteristics such as:

(a) *General features.* The ITRI should have achieved maturity, as well as a size which assures a minimum efficient "critical mass". Its legal status should assure flexibility in its operations (allowing all types of commercial operations) and in the management of personnel. It should have explicit, clear objectives, in line with the country's goals and with the needs of industry. It should avoid the dispersion of efforts and have chosen a limited number of technological areas and types of services, including R&D, to be offered to clients.

(b) *Finances.* The ITRI should count with stable, adequate funding, a high proportion of which should originate in sales to its clients, and in the commercial exploitation of the technology it has developed or introduced into the country.

(c) *Resources.* The ITRI should count with:
- A cadre of capable scientists and engineers, well trained and highly motivated. This staff should be managed carefully in the different aspects of recruitment, training and updating, and evaluation. Annual staff turnover should be low, reflecting favourable conditions regarding work satisfaction and remuneration. The access of scientists to world science and technology should be encouraged, particularly through exchange programmes and the assistance to international seminars and meetings.
- Adequate physical installations (buildings, equipment, computing, communications, etc.); regular updating of these facilities in line with scientific and technical progress.
- Adequate library facilities including subscriptions to reviews,

(d) *Management.* The institute should have sound, modern management practices, including a long term strategic plan and a short-term (2/3 year) business plan. Most if not all work undertaken in research and services should be organized as projects and funding should be assured at the outset. Projects should be managed carefully both at the design and execution stages. Institute managers should be trained in management techniques.

(e) *Outputs.*
- R&D topics should be carefully chosen. In the case of strategic research, choice should be made according to the relevance to long term national needs. In the case of short term research, it should closely follow client demand, ascertained through close contacts with clients and familiarization with their needs, and there should be an effort to produce "technological packages" of direct applicability.
- The product mix of technological services should be dictated by the market. There should be a periodic review of the outputs, suppressing those for which there is little demand and creating new types of services for which demand is growing.
- The institute should assure the quality and timeliness of the research and services produced.

(f) *Clients and marketing.* The institute should forge strong, stable links with industry, through different means such as industry membership in the Board of Directors and in advisory committees, the formation of consortia with industry, periodic visits, the exchange of personnel, public relations efforts, the economic analysis of the client sectors, etc. The marketing of the ITRI's outputs should be a primary task, which may be entrusted to a special department or unit with close relations with the technical units. The institute should fully understand the industrial branch or branches it is serving, and to this end should carry out economic and market studies.

Revitalization of an ITRI

By "revitalization" we understand the process of transforming an existing ITRI into an effective institute.

In actual practice we may find two types of situation. First, ITRIs that have reached a reasonable degree of maturity (in terms of efficient, steady operation) but need to adapt to a change of circumstances, mainly the new techno-economic situation and the policy changes being introduced by most countries. Second, ITRIs that have not yet reached maturity. The latter is perhaps the most common case, and would seem to be the situation with most African ITRIs.

Revitalization in the second case will require considerably larger efforts to help the ITRI complete its development through the acquisition of knowhow, the development of human resources, the increase in the efficiency of management, and other aspects. At the same time an eye should be kept on the new needs stemming from the current developmental paradigm, the new policy environment and the increasing scarcity of state funding, which would call for a change in the original objectives established at the time of foundation. All this would require further investments, and would not seem possible without adequate financing from the state or other sources.

Sometimes the situation may have deteriorated to a point where it may not be feasible to revitalize the institute. For instance, in Latin America three ITRIs have disappeared in recent years, in spite of strenuous efforts to keep them alive, and a fourth one is in danger of doing so.

A revitalization exercise will involve several stages. First, a diagnosis of the ITRI in its present state, identifying the possibilities for improving it. Second, the detailed design of how the revitalized institute should be: its long term objectives, structure, outputs, clients, resources, etc. so that it becomes an effective institute that combines efficiency with high impacts in favour of the country's goals. Third, a programme to go from the present state to the new steady state. Fourth, the necessary funds have to be procured for investment and for supporting operation for a number of years. Finally, implementation of the revitalization proposals.

The transition to a new steady state will follow an "S" curve, and cannot be overly accelerated; the ITRI can only start producing the expected outputs and results when people, installations and proper funding are in place, the new techniques have been mastered, and the clientele has materialized.

Case studies of Latin American ITRIs

In 1992 eight Latin American ITRIs were studied with a common methodological approach, under a project jointly sponsored by UNIDO and IDRC. The findings and conclusions were analyzed at a meeting in July 1993, and a paper was prepared for UNIDO on the revitalization of ITRIs, in which those results were reviewed.

It was clear that these institutions had suffered important changes in their environment, in the support received from their respectve governments, and in the type of services needed by their clients. Three of them had managed to adapt with more or less difficulty to those changes, three had continuing problems (one of them grave) which would require serious attention, and two had been closed down. This was a far from enviable record, showing the vulnerability of these institutions and pointing to the need of applying efforts to make them effective.

Here are short comments on six of these case studies:

Brazil. CODETEC, born within a university and later evolving largely on its own, has undergone a series of adaptations and transformations as it went from a liaison mechanism for Campinas University to an instrument of Brazil's import-substitution policy in the field of pharmaceuticals, and finally to an ITRI that, keeping to the technological field where it has built strengths, is trying to survive and prosper in the new liberal economic regime installed two years ago.

Chile. INTEC has effected a successful transition to the present "liberal" setting. Chile was the first country in Latin America to abandon the import substitution model and open up its economy. This happened ten years ago, and eventually led to a sharp increase in exports and a high and steady rate of economic growth. Adapting to the new model was not easy for INTEC, and the way it was done has interesting teachings for other developing countries.

Chile. The Chile Foundation has created a most interesting mechanism for technology transfer and diffusion through demonstration enterprises. It offers a very interesting contrast to the usual industrial technology research institution in a developing country. It is self-sustaining, shows a strong

commercial outlook, hardly makes research, and has had a strong impact on the productive activities of the country in key export sectors.

Argentina. CIMM is a relatively small public sector ITRI in Argentina, founded in 1963, which has been able to make only limited progress, despite stability of its management and strenous efforts to serve local industrial firms. A careful analysis was made of this ITRI and a number of suggestions were put forth for restructuring and revitalizing it under the new policy environment the country has recently adopted.

Central America. ICAITI is a subregional institution, conceived to serve the industrialization process of the five Central American countries, which 30 years ago agreed to form a Common Market. The characteristics of Central American industry - small scale, technologically backward, oriented towards the local markets, demanding relatively simple services and hardly able to pay for them - have not made life easy for ICAITI, which has relied to a large extent on foreign and international cooperation to build up its capabilities and carry out research and other activities for its member countries. At present ICAITI has to find ways to improve its human, physical and financial resources, its efficiency, and its links to industry.

Colombia. The Institute of Technology Research of Colombia, IIT, was closed down recently and its assets were dispersed, marking the unfortunate end of a long crisis. The case study looked into the process that led to the demise of the IIT, and explored the reasons why industry did not fight to salvage the only general-purpose ITRI in the country.

3. Work to be done

It is proposed that the situation and prospects of African ITRIs be analyzed, principally through a set of case studies

This would require in the first place a survey of these institutions in Africa, with the purpose of collecting basic information about their resources, activities and main problems. The survey should cover all African ITRIs and would be done through a questionnaire. This would be followed by the selection of 4 or 5 representative African ITRIs, which would be studied in detail using a common methodological approach, as was done in Latin America.

It is very likely that the International Development Research Centre, IDRC, would join UNIDO in this project, as it did with a similar one in Latin America. In such a case the number of cases to be studied could be raised to 8.

The sequence of activities would be the following:

Months 1-3: Design of the work, including the drafting and distribution of a questionnaire for the general survey of ITRIs, and the design of common methodological guidelines for the case studies.

Months 4-6: Analysis of the replies to the questionnaire, selection of cases, selection and training of local researchers (one per institution), organization of the field work. At the end of this phase a first meeting of the researchers

would take place to fine tune the methodological guidelines and to impart specialized training to the researchers.

Months 6-12: Execution of case studies and report writing. At the end of this phase a meeting would take place of the researchers, the representatives of the sponsoring organizations, invited guests from African ITRIs and one or two resource persons, to review the findings and extract preliminary conclusions.

Months 13 to 16: Preparation of a synthesis report, and editing of the reports to have them ready for publication.

8. NATIONAL PROGRAMME ON INDUSTRIAL TECHNOLOGY: SOME SIGNIFICANT ELEMENTS

8.1 Creation of Enterprises. An Outline of the EMPRETEC Programme

1. Introduction

EMPRETEC is a programme that provides training, technical assistance, and an institutional base for the formation, expansion and transformation of enterprises. It was created by the United Nations Centre on Transnational Corporations and has been operating since 1988. With the demise of the Centre, in mid-1993, the programme has been transferred to UNCTAD. The following description is based on a recent text by Mr J. Gomez, one of the creators of the programme.

The EMPRETEC programme was designed to identify promising entrepreneurs, provide them with training aimed at developing their entrepreneurial traits and financing their business ventures, help arrange mutually beneficial linkages with larger national and foreign companies, and make available long term support systems to facilitate the growth and internationalization of their ventures. The focus of EMPRETEC is on SMEs and on the educated entrepreneurs who are capable of understanding and mastering technology.

The programme aims at establishing in each country a private sector institutional base for creating, developing and assisting SMEs. Each country programme is planned by a working group drawn from local and foreign businesses and relevant government and multilateral organizations, with the executing organization acting as a facilitator. Similarly, public and private sector representatives assist with parts of the training and support elements of the programme. Rather than duplicate efforts, EMPRETEC arranges for effective cooperation with existing local government, NGO and multilateral agency programmes. By emphasizing public-private sector cooperation and by training local people to carry on the workshops and follow-up support, EMPRETEC is self-sustaining. Further, by charging cost-recovery fees as the programme evolves, EMPRETEC becomes self-financing in 3 to 4 years.

2. Structure

The programme is composed of six modules:

(i) *Institutional base module:* institutional arrangements for wide community support, building a basis for transferring responsibility to national institutions at the end of the four-year involvement of the international executing organization.

(ii) *Entrepreneurship training module,* the heart of the EMPRETEC Programme, is a 2-week entrepreneurship training workshop for carefully selected groups of 25-30 entrepreneurs. The workshop is an intensive programme to build up the participants' potential to initiate or improve their entrepreneurial activities, and to train them in the skills required to develop and operate an SME. The workshop serves as a critical instrument to develop trust and solidarity among participants, creating bonds that are essential for business growth and for building a critical mass of competent, committed entrepreneurs, who become the driving force of the programme and ensure the successful implementation of its subsequent stages.

(iii) *Enterprise creation and development module,* under which promising, innovative project ideas of "Empretecos" (graduates of the 2-week entrepreneurship training workshops) are identified by EMPRETEC staff, developed in cooperation with bankers and business consultants into bankable project proposals, and turned into successfully operating ventures.

(iv) *Regionalization and internationalization module* which capitalizes on the outward-looking, export and international business orientation of the entrepreneurs to make EMPRETEC a regional and worldwide network. By linking up national programmes with regional and international business databases and networks, the programme offers direct access to export and business opportunities. In addition, as strong local joint venture partners emerge and solid investment projects are generated through the various EMPRETEC activities, specific efforts are directed at fostering linkages between domestic SMEs and foreign companies.

(v) *Technology development module,* aiming at improving the international competitiveness of developing country SMEs, and including activities to facilitate the establishment of technology incubators and technology parks. This module has not yet been developed beyond the initial stages because of resource and personnel constraints.

(vi) *Capacity building module,* which includes entrepreneurship development activities in business organizations, universities, high schools, banks and public sector agencies, aims at developing an entrepreneurial culture and building the national institutional and managerial capacity to promote enterprise development on a long-term, self-financing, basis.

3. Results

EMPRETEC started in 1988 in Argentina and is now fully operational in 8 countries, five in Latin America (Argentina, Brazil, Chile, Uruguay and Venezuela) and three in Africa (Ghana, Nigeria and Zimbabwe). Introductory

entrepreneurship lectures were recently given in Albania, Ethiopia and Romania, and there were, in June 1993, 11 additional programmes in the pipeline scheduled to start by mid-1994.

By mid-1993 some 50 entrepreneurship training workshops had been offered in 8 countries. Of the 25,000 entrepreneurs who applied for the workshops, 1600 were selected and trained, and 21 local trainers were certified, in three languages. The programmes have been quite effective in generating new businesses and cross-border ventures among participants in neighboring countries. Over 250 new businesses were started in such sectors as agro-industry, plastics, chemicals, automobile parts, biotechnology, informatics, food processing and textiles. In addition some 300 existing enterprises refocused, expanded or modernized their business operations. Over 70 business linkages were established between Empretecos, some 50 entrepreneurs arranged regional sales agreements and 9 cross-border agreements for transfer of technology, and more than 100 large national and international corporations have established links with EMPRETEC entrepreneurs. New businesses are generated at an increasing rate as the programmes mature.

4. Staff and resources

The overall programme is coordinated by a 6-person team based in UN - New York, with a Programme Manager, two officers for Latin America and the Caribbean, one for Africa and Asia, one for economies in transition, and one for building up and operating the information network. The country programmes are overseen by national Boards of Directors, and are managed by a National Programme Director and an Assistant Director.

The cost of each country programme varies from country to country, depending on the local contribution and existing infrastructure and on the availability of local trained entrepreneurship trainers. When they are not available, the foreign exchange cost of the programme is estimated on average of US$700,000 for three years. The local costs, estimated at about US$200,000 for three years, are contributed mainly in kind by the counterpart organization. When a local team of certified entrepreneurship trainers is available the cost of a three-year programme is reduced to $550,000, and when the programme matures (3 to 4 years) or is so well run that requires little support and monitoring from New York, the cost per year can be kept below US$100,000.

The current budgets of the existing programmes add up to US$4.7 million, and the budgets of the 11 programmes in the pipeline to US$6.7 million. When all these programmes are in place by mid-1994, there will be more than 50 programme directors and staff in the field. In addition to these pipeline programmes, requests for national projects have been received from 10 more countries.

5. Impacts

The programme has been successful in identifying, motivating, focusing and providing training, advice and assistance to entrepreneurs. On the basis of very partial information, the number of businesses that started, refocused, or expanded as a result of the programme is some 620 out of 1030 entrepreneurs trained prior to June 1992. This would indicate that *on average about 60 per*

cent of entrepreneurs trained succeeded in starting or developing their businesses. In the cases of Ghana and Uruguay, two of the most effective programmes where more reliable data is available, the averages are closer to 80 per cent.

In addition, the programme has contributed to energizing the private sector and to improving the business environment. In particular, it has stimulated business associations to enhance and expand support services to their SME members and it has provided an important link between the established business community and the emerging entrepreneurial class, which has been given a voice through associations of Empretecos. The programme has shown that small/medium businesses can be effective agents for regionalization and internationalization. It has produced an awareness of the potential in linkages between subsidiaries of multinationals and domestic SMEs and has developed methods to facilitate those linkages. It has proven that it is possible to establish national institutions to carry on the programme independently from NY and on a self-sustaining basis. And the programme has opened the way to cooperative, productive arrangements with other multilateral and bilateral programmes, thereby enhancing both its and their effectiveness.

There are several areas, such as follow-up training, linkages with foreign companies, and financing of SMEs, that need reinforcing and improvement, and others, such as technology development, which have not been implemented so far. And there is no yet a satisfactory data base on EMPRETEC participants nor a system for tracking their progress. This information is vital for monitoring and evaluating the results of the programmes.

6. Lessons learned

Several lessons have been learned in the course of implementing the programmes. Among them: (i) entrepreneurial acumen can be meaningfully and accurately assessed by measuring the extent to which an individual manifests key entrepreneurial behaviors; (ii) programme flexibility is vital to permit adjustments to the changing needs of the entrepreneur, who is the key actor, not his/her enterprise; (iii) mutual support systems providing the entrepreneurs with a sense of solidarity are crucial to producing desired business results; (iv) SME-foreign company synergy can effectively facilitate enterprise growth and expansion; (v) the entrepreneur is a driving force for regional integration; (vi) government agencies can be more effective in providing a supportive or advisory role than in implementing a programme activity; they are definitely unsuited to manage the programme and counterproductive when they try to control it; (vii) the success of a national programme depends to a large extent on the entrepreneurial talents of the national programme Director; (viii) financial resources for SMEs must be available in the US$50,000 to US$500,000 range required by most SME entrepreneu

7. Prospects

Globalization of the programme is underway with the forthcoming meeting in Brazil (September 1993) of African and Latin American Empretecos. This trend should be continued and extended to include Empretecos from Asia and economies in transition. Also, ways should be explored to extend EMPRETEC

expertise to a much larger population within each country. The traditional EMPRETEC approach is restricted to Empretecos, who number now over 1600. Other approaches, perhaps in cooperation with existing organizations in the country, should be studied to permit a larger impact, for instance by involving the close to 24,000 applicants to the programme who were not selected to take the 2-week entrepreneurship training workshops. In addition, by making the services provided by INNET, the EMPRETEC Information Network, available for a fee to the broader business community in each country, the EMPRETEC Business Support offices could be expanded into national centres for export and investment information/opportunities, while providing a source of income to support the national programmes.

8.2 Government Procurement. The use of Government Purchasing Policy as an instrument for Technological and Industrial Development

An important development objective is to achieve a growing autonomy in the making of decisions that have to do with investment and production. This requires the acquisition of the capability to assess in an independent manner the problems of a country, and to identify and implement the appropriate solutions, using imported knowledge, technical services and equipment only as far as strictly needed, and trying to design solutions based on domestic efforts of research and engineering.

Government purchasing policy is a prime instrument to achieve this purpose, since it may be used to carry out actions through industrial decision centers that move large economic resources: public organizations and enterprises that make considerable purchases.

Basically, a purchase has the main purpose of supplying a good or service needed by the purchaser. But to this action of purchase, additional objectives may be added on, relating to the impact of the purchase on the economic and technological development of the purchaser, the seller and other national actors. The problematique of Government purchasing policy is precisely to identify desirable secondary objectives and to design criteria and procedures to achieve them, without harming the main objective we have mentioned.

Public sector purchases are very large in many developing countries. Its proper use may stimulate an expansion in the markets of national productive activities, and impel the technological development of suppliers, buyers and other economic units. As a result, a true *learning process* may take place, of great value to those activities.

The key to a successful Government purchasing policy lies in its *active* rather than passive character. The point is not simply that the public sector should buy locally what is already being produced with acceptable prices and quality. The public sector may also induce the production of new goods and services, which comply with more stringent specifications and employ a more complex technology, assuring a market for them and extending support to their producers. An active purchasing policy, through some additional costs in the short-run, may bring about significant benefits in the medium and long-run due to the positive impacts and externalities that the new purchases generate on the economy and on scientific and technological development.

For this purpose action should be taken on *current purchases* and on *investments*. In the former case standards and specifications should be adopted that allow the participation of local industry, gradually adjusting the specifications to push industry towards better technological levels.

As regards investments, it is necessary to assure an early participation in the design of investment projects, so as to allow their *disaggregation* and in this way create the possibility of participation of national suppliers of goods and services. In both cases the purchases to be made and their characteristics should be programmed well ahead of time, and there should be a concertation with local suppliers so that the latter may have opportunity to prepare offers and carry out purchase orders.

In general, the use of domestic consulting and engineering services may help to produce a set of positive impacts, going much further than the impacts that would take place on employing a foreign firm.

During the preparation of a project - the pre-investment stage - project characteristics are defined. The decisions adopted in this stage have strong implications on the specifications and the origin of the goods and services that will be needed in subsequent stages. These decisions may be more or less appropriate for local conditions, or be oriented to a higher or lower degree towards the utilization of local inputs, according to the approach and the biases of the organization carrying out the pre-investment work. Experience shows that when the pre-investment stage is handled by a domestic engineering organization it tends to result in a better technological choice and a higher local input content.

During the project execution stage a number of decisions must be taken on the supply of various inputs and elements. In many cases the technology and the basic engineering design embodying it are obtained from a foreign source; there is place, however, to disaggregate certain "peripheral" technologies from the "core" process, and carry out locally their engineering design. Sometimes it is necessary to carry out research and development work to adapt the process or the product to local conditions and it may be possible to do this locally.

During the stage of detailed engineering, in which basic engineering is transformed into a set of detailed drawing and instructions that will allow procurement and installation activities, it is necessary to take a number of decisions of a minor nature which when added up may mean significant differences regarding the characteristics of the components and inputs to be employed, and the source of these elements.

The participation of a local engineering organization is important to assure that domestic inputs are included whenever possible the stages of investment and production, thus allowing the full use of local supply potential. In this way positive effects may be generated for the investor organization, its suppliers and industry in general. One of the main effects here is the technological learning induced in these actors, beyond the increase in the demand of local engineering and local production.

Such potential benefits may be reduced to a certain degree by the costs deriving from inefficiencies and failures of local producers, the retaliation of

countries who see their exports going down, monopoly situations, etc. Such obstacles have frequently been magnified and often there has not been a realization of the benefits involved. Here there has been an influence of "safety first" attitudes and of little appreciation of local capabilities. Engineers and their organizations should combat these attitudes, showing the achievements of local engineering when complex responsibilities have been entrusted to it.

To use well its purchasing power, the country should build up a solid technical capability, with engineering groups able to design and implement projects in which there is a growing participation of domestic technology and industry. An autonomous technical capability of this nature should be especially sought in some vital sectors that are the "bridgeheads" of development, on account of their strategic importance, the size of their markets, their participation in exports, their use of natural resources, etc.

There are interesting examples of the application of Government purchasing power in several countries, among them the Indian policy of promotion of ancillary enterprises around large public firms, the Brazilian experience of a network of "nucleos de articulacao" in public enterprises linking them with local industry in order to induce an increased use of local inputs, and the nuclear energy programme of Argentina which through successive investment projects in nuclear power plants helped to develop domestic suppliers of complex equipment and engineering services.

8.3 Oriented Scientific Research. A National R&D Contestable Fund for Strategic Research: the example of the Public Good Science Fund in New Zealand

1. Introduction

This annex is based on a recent paper by the present author (A. Araoz, "Restructuring of science and technology and new modalities of industrial research in New Zealand", Cambridge, Mass., March 1993), which is to be published by IDRC.

New Zealand has undergone a series of changes and adjustments in recent years, as it became clear that the economic model previously followed by the country, with a largely protected economy relying on the export of agricultural commodities, did no longer generate enough wealth to mantain reasonably full employment and income growth.

The restructuring of science and technology in the public sector is one of the most interesting chapters of such changes. The functions of S&T policy-making, R&D funding and R&D execution were separated. A fund was created to support "public good" strategic, long term R&D, through a contestable process of project selection, and this has become the main vehicle for government funding of R&D. The four main science agencies were restructured; ten new Crown Research Institutes took their place. They are focused on sectors and problem areas rather than disciplines, and have been endowed with full

autonomy and commercial powers in the hopes of linking them closely to the productive sector

2. Science reform

New Zealand's science and technology sector is not large. In 1989 national expenditure on R&D represented 0.9% of GDP, about US$350 m, of which industry contributed 38 %. The personnel involved in R&D and related activities was 9350, of which about 40 per cent were in the four main government science agencies existing at that time.

Recent official documents in New Zealand have repeatedly recognized that research has a major impact on people's lives, though the limitation of resources in a small country like New Zealand makes it important to decide how much should be devoted to research, and to what areas of research these resources should be applied, assuring "value for money".

In line with this philosophy, the science regime in New Zealand has undergone radical change over the last few years, within the context of the major changes in the economy and the public sector.

In 1986 the government set up a Science and Technology Advisory Committee, which recommended in its 1988 report: (i) the separation of the three main functions of government in the S&T area: policy advice, allocation of funds, and performance of research, each to be performed by different institutions, (ii) the installation of a system of contestable funding based on considerations of scientific excellence, cost effectiveness and collaboration between researchers, and (iii) the establishment of national priorities in science and technology, based on wide consultations.

An important implication was that previous funding practices should be changed, away from supplying funds to institutions on an input basis, to purchasing science outputs from the "science provider" best able to produce that output in terms of quality and cost. This meant a complete break with past practices.

By the end of 1989 the two key agencies in the new regime, the Ministry of Research, Science and Technology and the Foundation for Research, Science and Technology were officially established. The government's funds for R&D were taken out of the budgets of the four government science departments and placed into the "Public Good Science Fund" for the funding of "output research", with an annual budget of about US$ 145 million for 1991/92, to be kept at an unchanged level (in New Zealand currency) for the following five years.

The next reform was the restructuring of the science departments, using their people and their assets to form ten new Crown-owned research institutes, which started their life on 1st July 1992. The CRIs specialize in one sector or problem-area, such as pastoral agriculture, crops, horticulture, forestry, industry, natural resources, social and economic issues, etc. They have been endowed with autonomy and flexibility, as well as full commercial powers to provide a much larger range of options for the transfer of technology. They

are expected to expand their income through R&D and services sold to clients in the private and public sectors, as well as overseas.

3. The new science regime

A central feature of the new regime is the separation of the government's involvement in research, science and technology into three areas of activity: policy, funding and operations. In the past these functions had been completely mixed together, leading to a confusion of roles.

The four key elements of the new science regime are: (i) a focus on outputs rather than inputs, (ii) a contestable funding system, (iii) an emphasis on partnership between private and public sectors to achieve the best results from research, and (iv) the development of a forward-looking and cohesive policy on research, science and technology, to bind the various components together.

These reforms have created a unique science regime in New Zealand. The government now buys its science and technology outputs from those sources best able to produce them in terms of quality and value, and maximizes the benefits from this investment through identifying the national priorities to be served. *The focus has shifted from funding institutions to meeting the government's science needs.*

4. Funding R&D by the Public Good Science Fund

By 1992 the total government-funded R&D was at an annual level of NZ$ 317 million (about US$ 180 million). The Public Good Science Fund had NZ$ 256m, of which $ 232m were to be allocated to R&D programmes by competitive bidding (the estimated distribution was 92% for CRIs and 8% for others) and $24m for CRIs as "non-specific output funding", i.e. a sum equivalent to about 10% of the PGSF given directly to the CRIs as grant money.

University research, funded by the state within the grant to tertiary education, was estimated at NZ$ 111m in 1991, of which research not related to teaching was less than 10%. From 1993 onwards universities will have access to PGSF contestable funds. R&D expenditure by the private sector (enterprises, Research Associations established by industrial branches, and a few non-profit autonomous research institutions) was estimated at NZ$ 241m in 1989/90, the most important research areas being manufacturing (33%), processing of primary products (33%) and infrastructure and services (21%). The ten Research Associations performed close to NZ$ 60m of R&D, of which $ 13m were in strategic research funded by the PGSF.

The Foundation for Research, Science and Technology (FRST) is responsible for allocating funds to "public good" science programmes on a competitive basis, from a yearly budget of NZ$ 232 million (US$ 145 million). It also provides about US$ 2.2 million for commercially oriented S&T through the Technology for Business Growth Scheme.

The Public Good Science Fund funds *strategic research* to support long-term national needs in any of 40 "output classes", as shown in the attached table. These areas, which were defined in 1989 after very extensive discussions with

ample participation, reflect the economic objectives that are felt to be important for New Zealand. Research projects, which need not be of immediate 'commercial' value, are funded with the expectation of achieving useful discoveries or knowledge that will underpin economic growth and sound environmental management.

The allocation of funds by the PGSF is made annually. It results from two distinct stages. In the first stage, the goverment decides on the total amount to be allocated by the PGSF and its distribution by output class. In the second stage, the Foundation allocates funds within each output class.

Let us look at the first stage. For the 1993/94 round of funding, a report was prepared by a Science and Technology Expert Panel, which conducted a nine-month exercise on priority setting, with comprehensive information-gathering and analysis, involving thousands of people across the whole spectrum of New Zealand society. The milestones in this process were a Science Priority Forum (which took place at the Parliament Building), the release of a public discussion paper, subsequent comments by many institutions, and the preparation of a final report with two alternatives, unchanged total funding or a slight increase (both in nominal terms). This report was submitted to the government, which chose the first alternative, and assured bipartisan support for the funding level and the priorities. The priorities thus defined will be followed by the Foundation to allocate PGSF funds in each output class through the coming round of contestable bidding.

In the second stage the Foundation invites the science providers to submit applications related to each of the 40 output classes. The applications are first subjected to peer review. The following step, merit review, is carried out by advisory committees, made up of widely experienced people from the scientific, academic and business communities, that assess the broader merits of applications. This is followed by grading by advisory committees, and final allocation by the Board of the Foundation. The projects selected are awarded research contracts. Through its purchasing, the Foundation can emphasize collaboration and coordination as well as competition between research organizations. It can also allocate funds for projects that take several years.

5. Some practical implications

The ten Crown Research Institutes, which are the main Government-owned research agencies, will obtain most of their income from the PGSF, through the funding of research projects submitted to the latter, as well as through "non-specific output funding" (a grant of about 10% of their budget).

This is in sharp contrast to the situation in the government R&D sector before 1988, when the four large official research bodies (the Department of Scientific and Industrial Research, the Technology Branch of the Ministry of Agfriculture and Fisheries, the Forest Research Institute and the Meteorological Service) enjoyed direct budgetary contributions and made their own decisions as to the activities they would undertake.

The ten CRIs that have replaced those four bodies have to submit research projects to the PGSF in order to compete for funds against each other and against other "science providers", and their assured income (from the non-

specific output funding) is a relatively small part of their budget. This makes life anything but easy for the researchers, who now have to develop fundable projects if they are to enjoy continued financing.

Furthermore, since the decision has been adopted to keep the size of the PGSF constant in current NZ dollars, at least during the next few years, funds from this source will progressively mean less as inflation continues. CRIs will need to develop their own sources of funds from sales of R&D and services, and it is expected that such commercial revenues will become increasingly important. For example, one of the CRIs, the Forest Research Institute, has already managed to cover 30% of its budget from such sources (the figure was less than 5% in 1986) and is trying hard to further increase its commercial operations.

Under these conditions the CRIs are expected to develop into lean, efficient organizations, carrying out work directly of interest to national requirements (strategic R&D) and to the needs of the productive sector (commercially oriented R&D and services).

8.4 Technological Information. Frequent Technologies For Africa

Experience in African industrial development has shown that a limited number of technologies are requested with great frequency. In the opinion of Mr Pierre Gyss, UNIDO expert, some 40 - 50 technologies would account for 90 per cent of requirements.

Mr Gyss has kindly allowed us to reproduce a listing he has prepared of such frequent technologies for West Africa. A more complete list could be developed for the whole of the continent, indicating where to concentrate present efforts of information systems, consultancy organizations and S&T institutions.

PROPOSITION DE FILIERES

Sous réserve d'inventaire, les unités de production suivantes figurent très fréquemment dans les demandes d'assistance et d'agrément en Afrique de l'Ouest:

N.B. Une analyse de cette liste mettra en évidence des possibilités de diversification d'un seul atelier sur plusieurs produits (par ex. les cintreuses et plieuses pour équipements de magasin de stockage et les remorques légères, l'assemblage des équipements informatiques et télécomunication, boissons aux fruits, compotes et confitures...) permettant de palier à l'étroitesse des marchés.

1. Produits Animaux.

1.1 Poisson et crustaces.

Fumage
Filettage et congelation
Conserverie (en rehabilitation surtout)

Fabrication de glace en écailles et barre

N.B. peu de demande en pisciculture et en fabrication de filets et autres equipements de pêche.

1.2 Viande et Volaille.

Elevage de poulets de chair sans ferme parentale,
Idem plus abattoir et congélation
Production d'oeufs comestibles et de poussins d'un jour,

Elevage Porcin
Abattoir/Charcuterie/Boucherie/Congélation
Ranch et Abattoir Bovin

N.B. peu de demande pour les parcs d'embouche

1.3 Laiterie.

Lait pasteurisé/caillé/aromatisé/Yaourt
à partir de lait frais
à partir de poudre et butterfat.
Cremes glacées

2. Produits végétaux.

2.1 Huilerie Savonnerie Cosmétiques.

Extraction d'huile d'arachide, de coton, de soja (palmistes)
Raffinage
Savon de ménage
Savon de toilette
Poudre à laver
Formulation et conditionnement de shampoings
Aliments composés pour vollailes et porcs

N.B. peu de demande pour la parfumerie et le conditionnement des cosmetiques à base de produits locaux.

2.2 Fruits et legumes.

Jus de fruit
Concentres
Boissons non alcolisées non gazeuses
Boissons non alcolisées gazeuses
Distillerie-Levurerie
Compotes et confitures
Fruits séchés

N.B. peu de demande pour la congélation et l'ionisation, ainsi que pour les essences et extraits (tels que citronnelle, bergamote).

Peu de demande pour la production et le conditionnement des fleurs et feuilles fraiches et sechées pour l'exportation.

2.3 Bulbes et céréales.

Séchage/égrenage/stockage du maïs
Grits
Amidon de maïs et de manioc
Dérivés de l'amidon
Boulangerie artisanale et industrielle
Biscuiterie
Confiserie
Chips de Manioc
Gari et Atiéké

Peu de demande pour les stations de nettoyage/conditionnement, le stockage sous gaz inerte et pour les activités liées à la riziculture; peu de demande pour les aliments infantiles et de sevrage.

3. Chimie et parachimie.

3.1 Pesticides Insecticides.

Remplissage de bombes à aérosol
Fabrication de spirales anti-moustiques

3.2 Détergents et germicides.

Dilution et conditionnement de l'eau de Javel
Formulation et conditionnement de détergents liquides et solides

3.3 Industrie de la santé.

Soluté injectable
Coton hydrophile
Pansements, serviettes et gaze
Fabrication de pillules et comprimés hors antibiotiques
Fabrication de sirops antitussifs et autres
Sechage et conditionnement de plantes médicinales
Extraction de principes médicamenteux

3.4 Divers.

Fabrication de colles
Fabrication d'encres d'imprimerie
Formulation et conditionnement de peintures et revêtments

4. Produits Minéraux.

Briques et tuiles cuites
Briques en terre stabilisée
Carreaux de ciment
Parpaings
Concassage pour agrégats et beton

5. Energie

5.1 Pétroliers.

Recyclage des huiles de vidange et reformulation en lubréfiant
Récuperation des huiles de vidange en combustible de chaudière
Fabrication et remplissage de bouteilles a gaz
Fabrication des réchauds et autres allant avec les bouteilles

5.2 Charbon de bois et assimilés.

Carbonisation en continu
Charbon actif
Torrefaction du bois
Extrusion des déchets et sciures
Réchauds et brûleurs appropriés

5.3 Renouvelable.

Assemblage de stations de pompage photovoltaïques
Assemblage de générateurs photovoltaïques pour l'éclairage Fabrication d'éoliennes et équipement annexe (pompes, générateurs)

6. Industrie manufacturière.

6.1 Bois et papier.

Traitement du bois par imprégnation
Séchage du bois de scierie
Atelier de menuiserie-ébénisterie
Fabrication d'éléments de second oeuvre (blocs porte, portes isoplanes, huisseries normalisées)
Lames de parquet, planchers et plinthes

Recyclage du papier
Fabrication de cahiers et registres
Imprimerie offset

6.2 Textiles.

Atelier de confection industrielle

6.3 Elastomères/Plastomères.

Moulage par injection pour petits articles
Articles en polyester renforce (sanitaires, citernes, plaques de toiture, barques de pêche)
Soufflage et impression
Moulage de poudres de récupération et poudrettes (articles chaussants)
Surmoulage (filerie électrique et composants électriques).

N.B. peu de demande por le rechappage et l'industrie des elastomères.

6.4 Divers.

Fabrication de craie scolaire
Fabrication de crayons à partir de plaquettes
Fabrication de plaquettes pour crayons
Fabrication de bougies

7. Industrie Mécanique.

Fonderie et fabrication de pièces de rechange simples
Atelier de reconditionnement de moteurs à explosion
Assemblage de cycles, motocycles et remorques légères
Mobilier métallique et équipements pour magasins de stockage
Utensiles émaillés

8. Industrie Electromécanique.

Atelier de reconditionnement/rebobinage de moteurs électriques
Fabrication de boitiers et assemblage de tableaux électriques
Assemblage d'appareils électroménagers

9. Electronique.

Assemblage et SAV d'équipements pour l'informatique
Assemblage et SAV équipement radio, TV, équipements de télécommunication

8.5 Organized Technological and Business Information. Intelligence Activities And Products

1. Introduction

The intelligence activity is concerned with gathering, digesting and consolidating information in a variety of relevant areas to facilitate the decision-making process in enterprises, R+D institutions, Government organs

and other actors. This refers to both short-term adjustments and long-term strategies, both of which call for specific information, forecasts and expert opinion in the interest of making timely and correct choices.

The right knowledge at the right time with the correct interpretation is an essential ingredient of competitiveness and good management. To this end, many enterprises in industrialized countries have developed elaborate and dedicated intelligence systems that survey and scan their technological and economic environment in order to detect potential environmental threats and opportunities and formulate appropriate strategic responses. Such activities include monitoring the trends in technology development and assessing their impact on future competitiveness; analyzing consequences of ongoing R&D; evaluating the actions and capabilities of other firms, be they competitors or potential partners; forecasting market trends and potential; and monitoring economic trends. Policy makers and decision-makers in industry are in constant need of up-to-date information which has to be processed and analyzed so as to allow identification and rational selection of alternatives.

We are living in an increasingly transparent world where "more than 95% of the information needed is readily available". In Eastern Europe and the developing countries this transparency has not yet been fully exploited, whereas in the industrialized countries the tools of intelligence have been developed and honed to "find the information you need that is out there" and draw correct inferences. Competitive intelligence (as defined by the US Society of Competitive Intelligence Professionals) is "the process of ethically collecting, analyzing and disseminating accurate, relevant, specific, timely, foresighted and actionable intelligence regarding the implications of the business environment, the competitors and the firm itself."

Intelligence is a refined product; it entails interpretating information to meet specific needs and drawing conclusions to facilitate decisions and planning. It is not a panacea, but one of the tools essential to the achievement of management objectives.

An intelligence unit produces a number of intelligence products as required by its clients. These products are highly elaborated in terms of possessing considerably greater informative value than the original data extracted from information sources. The focusing can be on a particular decision situation or a family of similar decision situations. In the first case, the intelligence product is tailor-made for a certain client and normally has a confidental or reserved character; only occasionally can it be utilized by other decision makers of the same organization or of a different organization. In the second case, the family of similar decision situations, multi-client intelligence products of a more general character are involved that are not confidential and can thus be shared by many decision-makers. However, they require further processing in order to be adapted to the particular situation that each decision-maker must face.

Intelligence products covering the external environment of the organization are of particular interest. Here we find intelligence on the suppliers of the inputs required by the organization to fulfil its mission and satisfy its customers. Each supplier may be examined from different angles, such as expected changes in production technology, specialization of human resources, competitors, legislation regulating product markets. An

intelligence report may deal, for example, with an assessment of future scenarios concerning raw materials supplies, prices, restrictions, etc.

Another INTELL product is intelligence on the market for the organization's products - for each family of goods and services, customers, channels of distribution, associated financial markets, competitors and legislation regulating the market.

Furthermore, intelligence on technological developments which could affect the competitivity of the firm is essential for proper strategic planning.

Another important area is the organization's internal environment. In this context, intelligence products focus on the strengths and weaknesses in such areas as human resources, organizational climate, financial situation, production (technology, equipment, etc.), stocks and sales force.

An intelligence - INTELL - unit serving an industrial branch would supply both multi-client and single-client INTELL products. Table 1 shows a list of possibilities suggested by Gargiulo (1991).

2. The production of intelligence products

For the production of INTELL products, the unit will need the following elements (Cubillo, 1990):

(a) *Information capturing*
This means identifying and accessing an information source, which may be direct, via objects and events, or indirect, via data bases and key informants. This may require a complex and expensive data gathering effort which, in order to be meaningful, should be closely related to the various stages of the decision-making process. The technologies for capturing the information include intellectual technologies (procedures, methods) and information technologies (specialized equipment and mechanisms); a wide variety of specialized human resources are needed.

(b) *Information selection*
This entails collating, cross-checking and evaluating the information gathered so that only the most reliable and relevant information is entered into the system. The sources of this information are the information gathered by the capturing component and information already stored in internal databases. The work involves comparing data, cross checking information and judging the quality and relevance of the information: a task that calls for highly specialized and experienced human resources.

(c) *Information processing and storage*
This entails creating internal information resources on magnetic/optical media data bases, or on paper data bases (archives, document collection, microforms), drawing on the information flow that has been filtered during the selection stage. This calls for cataloguing, indexing, abstracting, integrating, consolidating and formating information, using both information technologies (computer and telematic) and reprographic technologies (scanners, photocopying and micrographics).

Table 1

Products of an intelligence unit

- Reports:
  - On-request research into one or more of the following subjects:
    competitors, industry segments, technology (state of the art), technical and regulatory standards, economy, trade, policy, country situation, customers, etc.;
  - Multi-client reports broken by subject: branch activity, investment opportunities, etc.;
  - Reserved or restricted newsletter containing: alerts, industry insights, firm evaluation, foreign competition evaluation;
  - Subscriptions for the general public.*

- Inquiry services:
  - Data published or to be obtained from on-line searches;*
  - Information developed for specific requests that may include analysis and evaluation, and sometimes a multidisciplinary approach;
  - Critical reviews, compilations, correlations, etc.

- Assessment and support:
  - Meetings: background papers, conduct and organization;*
  - Negotiation support;
  - Studies and information validation.

- Training:
  - Managers on the effective use of intelligence;
  - On the art of negotiations;
  - On the methodology of intelligence;
  - Strategic planning and modern business practices.*

- Other services:
  - Translation;*
  - Document acquisitions;*
  - Bibliographies and references;*
  - Consulting services (short-term)*
  - Publishing proceedings of meetings, workshops and seminars;*
  - Preparation of directories;*

  - Preparation of charts, graphics and the like;*
  - Preparation of lists for selective dissemination or information.

Note: None of the products listed contain 100% intelligence. Those marked with (*) have a high proportion.

Source: G. Gargiulo (1991)

(d) *Report preparation and delivery*
This entails conceiving the intelligence product required in a specific decision-making situation, assembling the information available as internal data-bases and gathering new information prior to synthetizing both information sources and generating and delivering the intelligence product. Basically these tasks demand intellectual activities (comparing, synthesizing, consolidating, drawing of conclusions, etc.) but some new physical technologies are being developed, such as hyper-media and windows environment, that show good potential in terms of facilitating the preparation of requests.

The same author also points to several kinds of operations that transform existing information products into intelligence products with higher value-added:

Table 2

Operations involved in making INTELL products

Consolidation:	aggregation and comparison of information;
Integration:	bundling of information of different types (numeric, textual, referral) or of the same type, by sources;
Projection:	estimation of future states of indicators on properties of a given object;
Contextualization:	association of complementary information with an information set on a given objct or event, so the relative position of properties or states can be better ascertained;
Formating:	Enhancement of the physical presentation of the resulting information product for readability and clarity.

Source: J. Cubillo (1990)

3. INTELL support system

While the phase of intelligence report design and preparation will probably be reserved for the INTELL unit, other operations may be obtained more cheaply from external suppliers, through which access may be gained to public databases, information technologies infrastructures, intelligence expertise infrastructures, and particularly inter-personal networks - persons with the required know-how in certain fields who are willing to make such know-how available.

This last source is essential for the quality of INTELL products. In many areas information is not available in databases or documents, the only source being personal contacts. When the information is accesible in databases, it is still necessary to evaluate and cross-check it with the help of experts.

It may be cost-effective to buy the services of existing databases rather than building own databases, an exercise normally laborious and time-consuming.

An externality for an INTELL unit is access to a fully fledged telecommunications infrastructure capable of maintaining good contact with various locations within the country and abroad. The spectrum of telecommunications services is equally important. Telephone, fax and electronic mail are critical components.

Industrial countries have an information and knowledge environment favourable to INTELL activities - they have excellent public library and documentation systems, a large database industry, optimal telecommunications facilities, and strong institutions in the financial, commercial and R&D fields. In some cases, like the USA and Sweden, there are university courses in the field of corporate intelligence, as well as professional associations of intelligence experts. This situation is in sharp contrast to that of most developing countries.

4. INTELL organizational options

The simplest way to have access to a capacity for generating INTELL products is to hire the services of an outside intelligence agency or specialist. Sometimes these units or specialists are known as "information brokers". However, intelligence expertise requires more than just information brokerage.

This solution has the disadvantage that the organization will not be able to accumulate INTELL experience, and there may also be a risk of disclosure of confidential material to competitors. Hence it will be used mainly by small industrial firms operating in a stable and protected environment, which only occasionally need intelligence products.

More innovative firms, operating in turbulent environments, may wish to create their own intelligence capabilities. There are many alternatives here, ranging from a fully fledged department located high up in the organizational ladder to the hiring of an individual for undertaking intelligence work on his own. In some large multinational firms (like ICI/Petrochemicals and Motorola), large and complex units have been set up, requiring a heavy investment and substantial operational costs.

A third option is to set up co-operative intelligence capabilities, in which several firms and organizations share the costs of an intelligence capability. A group of firms with similar interests that operate in a competitive and innovative environment can agree to fund an independent unit or private intelligence specialist to serve their intelligence requirements for decision making. This will cover the areas and kinds of information that the

organizations are willing to share among themselves, a sort of "pre-competitive INTELL"; core information will in general not be handled by the co-operative unit.

Finally, a number of organizations may set up co-operative intelligence support systems, thus developing the necessary substantive personal networks, data bases, documentation systems and informatics infrastructure, as well as building up the necessary links with public resources in industrial countries like patent databases and large libraries.

5. Activities of UNIDO

UNIDO has recently carried out activities towards the development of INTELL mechanisms in certain sectors of developing countries. Exploratory work has been done on the subject of techno-economic intelligence in general, and its application in countries of Latin America, in areas such as dairy products, shrimps, fruits and vegetables, apparel and machine tools, through "INTELL demonstration units" in those subsectors, where general, multi-user, "pre-competitive" INTELL may be of great value to a number of enterprises.

8.6 Consulting and Engineering. Development of Consulting and Engineering Capabilities

1. Introduction

Modern industrial development, which requires complex investments and the introduction of new technologies, has brought about the appearance of consulting and engineering as specialized activities that organize and apply knowledge for the purposes of investment and production.

Consulting and engineering organizations are institutions of great potential value, which serve in a variety of ways the needs of enterprises, investors, financial institutions and other actors in the industrial scene of a country. It is of particular interest to examine the nature and activities of consulting and engineering organizations in developing countries, and the way they may be developed and brought to maturity . The experience of countries like Brazil, India and the Republic of Korea in the 1970s may be useful in the case of African countries, which present similar developmental problems (see A. Araoz, *Consulting and Engineering Design Organizations,* IDRC, Ottawa, 1981).

2. Characteristics

Consulting and engineering (C&E) are activities of an intellectual nature, characterized by certain methods of work and by a multidisciplinary approach. The services produced by C&E organizations can serve a wide variety of clients in production, research, Government and finance. They cover an ample range of applications and include different aspects - technical, economic, environmental, marketing, organizational, financial, legal and training. They aim at the formulation and execution of investment projects, the efficient operation of productive installations, the purchase and

introduction of external technology, the sale of technology, the improvement of management practices, the restructuring of companies and other organizations, market analysis, and the establishment of partnerships and joint ventures with other local or foreign firms.

Consultancy firms abound in the industrialized countries, from small companies specializing in one or a few of the above activities to those offering a complete range of services, including architect-engineering, to industry and Government. Some "newly industrializing countries" (NIEs) have acquired C&E organizations of high calibre which have been instrumental for their industrial development.

A C&E unit should master the technology of consulting and engineering and acquire a reasonable degree of competence in the technology of the area or areas it covers. To that end, it needs qualified and experienced personnel, good management procedures, appropriate organizational know-how and other characteristics favourable to its efficiency. The best consulting and engineering organizations are distinguished by their emphasis on professionalism and multidisciplinarity.

3. Importance of counting with a domestic C&E capability

When C&E activities are carried out by competent domestic units with knowledge of local conditions, significant benefits may accrue to the local actors as well as to the economy as a whole. These benefits include more adequate technological solutions, clearly defined investment packages, efficient absorption of foreign technology and foreign consultancy inputs, and better business agreements. There may be an increase in the bargaining power vis-a-vis foreign corporations, investors and technology suppliers. Knowledge may be spread more effectively among local firms. New skills, attitudes and capabilities are bound to be introduced throughout the industrial spectrum as widespread learning takes place. In the best of cases C&E functions as an effective link between the R&D activity and the productive sector.

As with all infant industries, there are costs in developing C&E capabilities and accepting some relative inefficiency for some time. But if a country lacks the capacity to carry out C&E activities by itself and has to rely on outsiders to give advice or design and execute projects, there will be less local power of decision, and the solutions put in place may not be in the best interests of the country. Optimal investment and business decisions, and self-reliance in technological matters, depend crucially on acquiring and using effectively domestic C&E capabilities in productive firms and as specialized C&E units.

The use of foreign C&E organizations is often regarded as convenient on grounds of speed, efficiency, and reliability. While sometimes this use cannot be avoided, an undue reliance on outside C&E may involve serious drawbacks, however, particularly in the long run. In order to minimize those drawbacks, and to increase the positive effects of employing C&E services from developed countries, certain criteria should be applied. The purpose should be to employ foreign C&E as a complement to local C&E, rather than as a substitute for it, and to seek mechanisms of co-operation between both to favour the maximum utilization of local resources and make full use of the foreign consulting

capacity as a vehicle for technology transfer and the training of national consulting personnel.

4. Organization and management

Management of a C&E unit is not simple. Difficulties arise on account of the wide variety of services produced, which are tailor-made for each client, and from the nature of the principal inputs employed: high-level human resources, sophisticated organizational skills, specialized technical know-how, and information of many kinds.

In general such units count with a moderately sized team of permanent professional staff, which will notably include project managers capable of analyzing a client's requirements, designing a programme of work to satisfy those requirements, putting together a team of professionals and managing the work. The C&E unit will normally employ outside expertise in different fields as required by the task on hand.

To ensure proper utilization, C&E services must reach users at the appropriate time in a form that responds to their needs. In the highly industrialized countries, clients are able to state their needs for C&E services very precisely; they also possess technical structures able to absorb the services consultants give them, while the market mechanism transmits the impact of such services to the rest of the economy. By contrast, in a developing country the clients may not be able to specify the type of C&E services they need. Furthermore they will not be able to absorb the C&E services effectively for want of a techno-economic capability of their own, and the potential external benefits (i.e. positive impacts on the economy) may not materialize because other actors are not aware of opportunities or are not capable of seizing them. To avoid such an outcome, the C&E unit needs a good "delivery system" based on strong links with clients and other actors where the impact could be favourable. Efforts should be devoted to overcoming barriers such as negative client attitudes, the absence of a common language and the lack of economic incentives for clients to contract local inputs.

5. Development process

The growth and development of a C&E unit should pay attention to a number of aspects relating to its internal functioning and to its relations with clients and other actors. We may mention in this regard the choice of the areas in which it intends to work, the acquisition of know-how and expertise, and the education of clients to help them acquire sufficient capabilities in the preparation of terms of reference, drafting of tenders, evaluation of bids and monitoring of progress. Also important is the development of a network of national and international contacts, so that the unit enjoys rapid access to information, experts, technology, laboratories, enterprises, and financial agencies.

The key to the development of a C&E unit lies in the acquisition of know-how and expertise. The unit needs to build up a good professional team, acquire technological knowledge and develop its management capabilities. These tasks are interrelated; the development of professional resources cannot be separated from the acquisition of know-how, and in particular the

development of management capabilities requires the unit to absorb key technical knowledge.

The development of human resources should be in step with demand, or possibly somewhat ahead of it, if those resources are to be prepared for the tasks they are to carry out. Recruits may be fresh graduates, persons with 3 or 4 years' experience in technical work, or experienced professionals. In regard to training, two important elements are academic training at home or overseas, and on-the-job training while assignments are carried out, particularly when this is done in association with a more experienced C&E unit.

The efficient operation of a C&E unit calls for the use of modern management techniques and the acquisition of expertise in handling complex tasks that are carried out by persons with different backgrounds. The acquisition of technology and expertise implies a lengthy learning process, in the technology of the sector to which services will be rendered and in the technology of consulting and engineering. Mastery of the latter requires that attention be given to techniques such as demand analysis, project evaluation, mathematical model-making, electronic data processing, scheduling, marketing, legal aspects, financial engineering and report preparation. The knowledge acquired should not only be in the minds of the staff, but should also be incorporated in the organization itself, through specialized routines, computer programmes, technical files and lists of technology and equipment suppliers. This "firm-embodied" know-how or institutional memory reinforces the aggregate knowledge of the staff and allows a departing staff member to be replaced by a new recruit with minimum disruption.

Technology acquisition and learning are facilitated by recruitment of experienced personnel, the repetitive work carried out for successive clients, the establishment of feedback from clients once assignments are completed (possibly through follow-up visits and meetings), the close interaction with R&D institutions, technology owners, and equipment makers, the further training of staff members through special programmes, and the formation of special groups to master certain technologies.

An important way of achieving this is through association with an experienced foreign C&E organization, either on a long-term basis or for certain projects, using the partnership to train personnel and gain access to crucial data, manuals, operating instructions and other documents that collect and summarize years of experience. The C&E unit should negotiate access to such information, which is vital if there is to be an effective transfer of corporate knowledge.

There is no one single model for the development of a C&E organization. The way an organization develops depends on circumstances. Paths and strategies are dictated by the concrete objectives to be achieved, but the process is gradual and relies on the acquisition of expertise and credibility in succesive stages.

6. Policy

Developing countries need to build up national C&E capacity within large industrial firms as well as in specialized units, and put this capacity to good use, if they are to have control of decisions governing their development. This is not likely to happen spontaneously. Promotional efforts are required to support the formation and development of C&E units until they become commercially viable. Since benefits to the country as a whole are bound to be significant over and above those accruing to the users of C&E services, the costs of developing C&E should ideally be shared by the country through appropriate government action. Support measures may include profitable large contracts, strong backing vis-a-vis foreign C&E enterprises, risk-taking on the part of clients, ample credit and other facilities.

The development of a C&E organization to maturity is bound to be gradual until it attains a reasonable level of social efficiency, its actions being guided by long-term objectives. During the development stage the unit's actions are governed principally by concrete, short-term objectives, the main purpose being to reach the mature stage. As we have already indicated, support measures will be required throughout this process. The time needed to complete the process and reach maturity will vary, depending very much on the support received and on the characteristics of the environment.

9. REGIONAL COOPERATION IN INDUSTRIAL TECHNOLOGY: SOME SIGNIFICANT ELEMENTS

9.1 Cooperation Networks in Science and Technology. An African Network of Industrial and Technological Research Institutes

There are numerous advantages in creating a cooperation network among a number of scientific or technological institutions of similar characteristics established in different countries of Africa, such as development economics research centres, biotechnology groups and industrial technology research institutes (ITRIs), to mention only three possibilities.

As an example, we examine how such an institutional network could be organized for the many ITRIs in Africa, with the purpose of linking them up and facilitate their cooperation.

The network would allow the member institutes to profit from each other's experience, exchange scientific personnel, carry out joint research and other activities, and negotiate jointly with international organizations and foreign research institutions. It would help them to collaborate in a number of applied scientific and technological fields, and to participate in a joint learning effort, at a time when a single ITRI of small to moderate size (as is usually the case in Africa) finds it increasingly difficult to keep up to date and to develop and maintain an expertise on its own in the fields of work it has chosen, particularly those involving new technologies.

The main elements in the network would be the following (A. Araoz, "Nuevas modalidades de cooperacion tecnica en America Latina", *Comercio Exterior*, Mexico, Sep. 1981):

(1) The **nodes**, i.e. the institutes that would make up the network. They may assume different characteristics, but in general would have a strong component of R&D and technological services aimed at industry.

An operational definition of what constitutes an eligible ITRI should be established beforehand, and the candidate members should comply with it. For instance, the network may or may not include "captive" R&D labs within industrial companies, or university labs even though oriented to industry.

A survey should be carried out to identify the likely candidates before attempting to constitute the network. The number of members from different countries would vary according to the country's size and the stage of its industrial development; a large country like Nigeria has more ITRIs that are potential members than a small one like Senegal.

(2) The **nucleus**, or central unit of the network, in charge of coordinating the activities carried out within the network. This could be organized as a Secretariat which would be independent of the nodes but would report to a Board made up of the latter's representatives.

The Secretariat should be small, with very few professionals under fixed-term contracts (to avoid creating a bureaucracy). Whenever necessary it would employ consultants to develop projects, carry out joint activities, etc. It should operate flexibly, but at the same time enjoy a good measure of institutional stability. This may be obtained by attaching it to a regional institution such as the African Regional Centre for Technology, ARCT, or to a regional project sponsored by UNIDO. In this way it could count with a a chief officer (or Secretary) and supporting staff, hired for several years, and budgetary resources covering structural costs during that period.

The Secretariat would actively organize and promote various types of flows between the nodes, and joint activities among them. It should be prepared to help institutes in their development and improvement, for instance by organizing technical and training programmes for them, particularly as part of revitalization efforts. It would also engage in activities relating to information, training, the holding of symposia and meetings, consultations on different aspects of industrial technology, relations with institutions outside the region, and so on.

(3) The **links** between the nodes, or channels through which flows would take place. A smooth circulation of flows depends on stable and reliable links. The establishment of such links is one of the more important tasks the nucleus should undertake at the time the network is created.

Traditional links include postal and telephone exchanges, periodic newsletters and bulletins, periodic meetings, formal consultation mechanisms, and (very importantly) informal personal contacts of different types.

More modern methods would include fax, electronic mail, teleconferencing, computer-based libraries, and other such means. A distant possibility would be

some type of satellite linkage as was proposed some years ago by the WAITRO Secretariat.

(4) The **flows** circulating through the network, between the nucleus and the nodes, and between the nodes themselves. Such flows may include the following types of "knowledge resources": (a) *knowledge*, comprising in the first place substantive (scientific and technological) knowledge on the different hard and soft fields covered by the ITRIs in the network; a second category of knowledge would be policy and management knowledge relating to the organization, development and operation of an ITRI; (b) *technology*, usually in the form of "packages" of readily applicable solutions rather than just a research finding or "basic" engineering knowhow ; (c) *technical and scientific services*, such as analyses, documentation, engineering, training syllabuses and materials, advice on various problems, formulation of programmes and projects, etc.; and (d) *information and intelligence*, on knowledge resources, social and economic subjects, specific experiences, etc.

Many of these flows will originate within the network, often as a result of joint activities. There may be significant flows coming from the outside, for instance those captured through technology monitoring and assessment in different fields, which would ideally be circulated throughout the network.

Particular issues may come up in the case of flows of technology where propietary rights or commercial considerations may impede free transmission to other nodes.

(5) The **joint activities** undertaken by two or more members of the network, such as: research and development projects; technology monitoring; technology assessment; training courses; the establishment of common standards, specifications, procedures, norms and codes; the formulation of common policies, for instance for joint action at the international level, etc.

These activities may be set up and carried out as projects, which should be carefully prepared by the participating nodes with assistance from the Secretariat. Joint projects should be adequately funded, from sources other than the regular budget of the network. A joint project will constitute a temporary cooperation network around a single topic, and will generate intense flows between the participanting nodes.

R&D projects would be of two types. In the first place, they may refer to substantive questions in a particular scientific or technical field. Secondly, they may deal with policy issues which need "policy research" of a multidisciplinary nature, possibly with the participation of economists, social scientists, lawyers, etc.

(6) The **objectives** pursued by the network members through the functioning of the network. A set of long term objectives should be carefully spelled out when designing the network and should gain the agreement of the founding members. It should be possible to modify them when other institutions join the network or when circumstances change. Short term tactical objectives to guide activities in the network should be adopted at the periodic meetings (annual or biennal) of the Board, and would normally be expressed in a work programme for the coming period. This may be drafted by the Secretariat on the basis of suggestions by the nodes.

(7) The funding of the Secretariat and of the activities to be carried out within the network. The importance of this element should not be minimized, since the smooth and efficient functioning of the network depends on it. Pluriannual budgets should be prepared and financial resources gathered; projects and joint activities should not be started if specific funding is not assured. The main sources of funding would be the participating institutes themselves, which should contribute a membership fee, and cover part (sometimes all) of their own expenses in activities in which they participate. Other sources would be international cooperation, preferably through UNIDO; bilateral cooperation; various foundations, etc.

* * *

The network should ultimately become a true cooperation system. This requires that several conditions be met: clearly defined long term objectives that are shared by the member institutes; firm and stable links among the latter; an intense circulation of flows so that systemic relationships are established through them; the sharing of flows (mainly information, knowledge and technology) originating in outside institutions; joint activities carried out with sufficient continuity; . If these conditions are obtained, and the network acquires systemic characteristics, there will be a much higher probability that the efforts and resources assigned to cooperation in the African Network of Industrial Technology Institutes will produce high returns, through a significant improvement of the efficiency and efficacy of the member institutions.

A feasibility study should be prepared before constituting the network. This study, which could presumably be funded by UNIDO, should indicate whether the network is viable from the technical, political and financial points of view, and should provide an initial design as well as a preliminary budget for at least three years of operation. If the findings are positive, a meeting could take place with the participation of the most important candidate members, in order to discuss such findings and, if all goes well, to launch the network.

9.2 Higher Education in Science and Engineering. Creation of an African Institute of Technology

1. Introduction

This is the outline of a proposal for a collaborative Programme between an Institute of Technology in an industrial country (IT) and the scientific community in Africa.

The Programme, which would be of a regional scope, would be beneficial to the development and growth of the science, technology and management infrastructure in Africa, and would mean the creation of a high-level educational and research institution which could be called the African Institute of Technology.

The following essential factors in development and maintenance of scientific capabilities could be provided for by the Programme:

- An improved quality of education and research;
- Solid research traditions that are fully integrated into regional and national needs;
- Creation of an environment conducive to original research, and attractive to young and ambitious scientists and engineers;
- A more favorable environment for the development of a rich reciprocity between science, industry, and governments that will maintain a high quality of work.

The following sections describe briefly the scope of the collaboration.

2. General framework of the Programme

A suitable Institution, such as a first rate technical University, would be selected in Africa for the purpose of the collaborative program with IT, and would be the platform on which the African Institute of Technology would develop.

It is suggested that the Programme, and later the Institute, should actively recruit nationals of all African countries passing a rigorous selection process. The appointment of a selected candidate would be regardless of the candidate's financial capabilities and a Scholarship Fund would provide for those that are unable to meet the tuition, living and travel costs.

The size of the Programme would depend on the resources available, but the aim should be to produce a minimum of 250 B.Sc's, 75 M.Sc's and 20 Ph.D's yearly.

The main features of such a programme would be:

(a) Breadth

In order for an advanced science and technology community to become effective in terms of its contributions to development, a broad research and educational base must be developed. The proper place for this to occur is within an established research and educational institution with active science and engineering programs. To expedite this transformation, major emphasis has to be placed on research and graduate programmes in several fields of science, technology and management, as well as related fields in the social sciences. The impact must extend to participants at all levels: senior administrative officials; senior and junior faculty and research staff; and graduate students. Attention will also be given to the upgrading of under graduate education in those fields.

(b) Scale

The collaboration, in turn, must have a critical size which will involve disciplines of interest to personnel at the participating African institution.

Experience in collaborative programmes of this nature is such that a minimum critical size of involvement of senior faculty and staff is of prime importance. The proper environment for exchange of techniques, faculty and other personnel only occurs when the critical size is present. The long-term planning must recognize this synergistic effect, and should allow for growth of the Programme in a systematic fashion. At the same time, all activities must be carefully monitored and coordinated in order to insure that available resources are utilized to the greatest advantage.

(c) General Scope of Activities

The development of advanced research and educational programmes in science and technology requires an appropriate balance between classroom instruction, development of computer, library and laboratory facilities, an active program of applied and theoretical research, and educational activities which supplement those of the classroom. All of the above are required to attract high caliber faculty, senior research staff, and students, and provide the basis for fruitful collaboration with outside institutions.

Such a balance has been carefully maintained at collaboration projects of some ITs with foreign universities and research institutions. However, for the purposes of the programme in Africa, it is believed that the strongest potential contribution, given the available resources, would be in the areas of collaborative research and supplementary educational activities such as workshops, personnel exchanges, short courses and fellowships. These, therefore, would form the major part of the Programme's scope of activities.

(d) Timing

The Programme would be divided into three phases, to extend over a six year period:

(i) Mobilization Phase (One Year). A small number of collaborations will be organized and methodologies for future efforts will be developed and evaluated. Existing research and academic programs in science, technology and management at the selected African Institution will be reviewed and areas for concentration of Program effort will be established. Appropriate departments, faculty and senior staff participants, and topics for research will be chosen. Towards the end of this phase, a detailed list of activities will be developed for the following phase of the Program in terms of scope of activities, numbers and types of participants, and target areas for further institutional development at the African Institution.

(ii) Steady State Phase (Four Years). The maximum number of collaborations will be reached and major Programme objectives will be fulfilled. Educational activities as well as research efforts will be fully developed. The Programme will have achieved sufficient results for dissemination and discussion with other prominent organizations in Africa. At some moment during this phase the African Institute of Technology would be formally created, either as a part of the mother African Institution or as a separate institution.

(iii) Concluding Phase (One Year). The scale and extent of IT's involvement will be gradually reduced. A final assessment of the Programme's efforts and results will be conducted at this time. Recommendations will be developed for continued pursuit of the Programme's objectives in Africa on an independent basis, within the framework of the new African Institute of Technology.

3. Collaborative Activities

Within the first year, an initial set of Programme activities will be selected from initial discussions between the African Institution and IT, with the participation of other organizations in the African science and technology infrastructure who may be involved. Criteria for this selection would include the contribution to building up stronger science and technology capabilities, relevance to development, intellectual character of the issues for investigation, demonstration effects and potential for follow-up activities.

The activities will focus on three general analytic approaches:

- Engineering analysis and technical evaluation, including field and laboratory studies, design, and prototype development.

- Economic analysis, focusing on project, sector, and national planning issues.

- Social science analysis of management and manpower development issues, socioeconomic change, and technology transfer strategies.

The economic and social science analyses will complement the scientific and technological studies, and place them in their proper development context.

Collaborative research will be the primary vehicle for achieving the objectives of the Programme, and will provide a framework for organizing and implementing the other Programme activities.

(a) Collaborative Research Projects

Experience shows collaborative research projects to be the most effective mechanism in promoting institutional change and in the development of individual faculty and students. Through these projects, resources at academic institutions are mobilized and strengthened, and productive linkages are established with other institutions concerned with science, technology, management and development.

The research will focus on areas of science and technology in which a certain level of expertise has already been developed at the collaborating African Institution. Some areas of particular interest to Africa which appear to offer the most potential for collaborative projects are: energy, agroindustry, chemicals, biotechnology, electronics and automation, public works, and marine resources.

Discussions will be held on the scope and methodology of the research to be undertaken, and technical proposals will be prepared and submitted to the Executive Committees in IT and in the African Institution, stating the objectives and scope of work, describing the methodology of work, identifying tasks and individual responsibilities, describing needed facilities, setting down a work schedule, proposing a budget, and describing seminars, workshops and short courses that may be conducted in connection with the research. Biographical data on the project personnel would be attached.

Projects would be selected and the principal investigators would be given responsibility to select project team members, assign specific tasks, perform the work, organize workshops and seminars, etc. All projects would be required to report on a semi-annual basis.

(b) Other Programme Activities

Within the context of the research projects, several other activities will be organized. These activities will not only benefit the participants in the research teams, but many of them will be open to others at the selected African Institution. The activities will include personnel exchange, workshops and short courses, seminars and conferences, publications, science and technology support systems development.

The presence of these activities is essential in developing the intellectual environment at advanced institutions of science and technology, and in helping to upgrade teaching at the undergraduate and graduate levels.

(i) Personnel exchange

It is expected that faculty, senior staff, and students from the African Institution will be selected to make long-term researches or short-term visits to IT, working with counterparts on research projects, pursuing formal courses in relevant academic disciplines or participating in individual programmes designed to develop a specific expertise. The four basic types of exchange will be the following:

Long-Term Personnel Exchange (up to one year): a few junior research staff or faculty members may be selected to receive postgraduate fellowships at IT.

Short-Term Personnel Exchange (up to one academic term, duration of five months or less), individually designed to fit the participant's interests as well as the overall objectives of the Programme.

On the other hand it is expected that IT faculty will visit Africa periodically to discuss research plans and results, and to present informal seminars on their research or lectures in academic courses.

Students: Special Programmes. In this category, students will be accepted as special students by IT departments, or enroll in special programmes for international visitors. They will attend courses with academic

content relevant to their interests, and in most cases will do significant research towards their theses.

Students: Academic Degree Candidates. These students will first gain admittance to regular degree programs at IT. Research assistantships may be provided to these students, who will then work with an IT research project team in the student's area of interest.

(ii) Workshops and Short Courses

These are defined as short-term courses of instruction and/or series of discussions, which focus on areas of specific concern to a research project (or set of projects). A "workshop" is usually conducted on a informal basis for a period of a week or less. A "short course" generally lasts more than a week, is more precisely structured, and has a more formal academic content.

Faculty members from the research projects will organize the courses, and arrange for appropriate lectures or discussion leaders. Although course content will be primarily aimed at the interests of the research project staff the participation of other faculty and students will be encouraged whenever possible, to extend the effects of this collaboration to a broader segment of the African community.

(iii) Seminars and Conferences

It is expected that several seminars and one or more conferences - a large meeting to discuss a broad subject area -will be held during each year of the Programme. These activities will serve not only to promote an awareness of the specific research projects, but also of the Programme as a whole.

(iv) Publications

A system for the publication and dissemination of technical reports associated with research programmes will be installed at the African Institution, and will provide another important mechanism for faculty members to communicate their findings and obtain recognition for their research accomplishments.

(v) Science and Technology Support Systems Development

Some of the resources of the Programme would be devoted to the development of computer, laboratory, and library facilities. This may range from the evaluation of alternative proposals to actual system design and hardware/software procurement, for example, in computers in education.

4. Budget items.

a) Current expenses of the Programme (6 years)

- Collaborative Research

1. Long-Term Projects
2. Short-Term Projects

- Educational Programs and Exchanges
  1. Personnel Exchange
  2. Short Courses and Workshops
  3. Conferences & Seminars

- Administration, Logistic Support, Travel

b) **Scholarship Fund (6 years)**

c) **Initial investments**

1. Physical Infrastructure (buildings, labs, computers, etc.)
2. Library & subscriptions
3. Systems and other items

9.3 Consulting and Engineering. Creation of a full scale African Consulting and Engineering Organization

1. Introduction

The need for African countries to build up their capabilities in consulting and engineering has been indicated in Annex 6 above. When a country cannot carry out C&E activities by itself and has to rely on outsiders, the investment and operating decisions may not be in the best interests of the country. We have suggested that foreign C&E should be used as a complement to local C&E, rather than as a substitute for it, and that mechanisms of co-operation should be sought between both. When C&E activities are performed locally, the resulting benefits may include an increase in bargaining power vis-a-vis foreign actors, the choice of more adequate technological solutions, the efficient absorption of foreign technology, and the acquisition of new skills and capabilities.

To obtain such favourable results a country should count with capable, mature C&E organizations. This may only be possible in some of the larger African countries, with a good stock of high level human resources and a potentially important market for C&E services. On the other hand, the effort, cost and time required to set up a full scale C&E firm may be beyond the possibilities of most African countries at this time when their economic strength is not at its best. Cooperation among them may be a good solution towards developing C&E capabilities.

We propose that a number of African countries join efforts in creating and developing a full scale C&E organization of a regional character that will serve them efficiently, and which would subsequently help in developing national consulting and engineering capacities.

AFRICONSULT, as we will call it, would be based in one country and extend its services to the other countries owning shares in it, and eventually to the whole of Africa. It would be a private sector firm, commercially oriented, and

should acquire full economic viability once the initial formation period is over, which may take several years. It could accept capital from African governments and Banks, and from foreign firms and organizations; but the majority (or possibly the voting majority) should be in the hands of private sector African firms and individuals.

AFRICONSULT would originally concentrate on a limited number of technical fields that are of special relevance to the countries where it would be working, for example, civil infrastructure, agroindustry and energy. These fields could be enlarged as time goes on.

Ideally the services provided by AFRICONSULT would contribute to open up new horizons for old and new activities, prepare and implement high quality, efficient investment projects, and assist local companies to undergo a learning process in technical areas and particularly in management matters. In fact, training in management could become an important part of the organization's activities.

The clientele would include local and foreign industrial firms; African government agencies, industrial associations, Banks and technical institutions, and regional and international agencies and Banks, particularly including the African Development Bank and the World Bank.

2. Services

AFRICONSULT would supply its African industrial clients with a wide variety of services in two main areas. The first area would cover internal needs: market analysis, investment projects, training, production planning and control, procurement and sales procedures, costs, accounting and auditing, and other management activities. The second area would be aimed at external aspects: relations with other actors in the country (suppliers, clients, R&D organizations, Government) and particularly with foreign actors (companies, banks, consultancy and R&D organizations). The services provided would be directed towards purchases and sales, alliances and joint ventures, as well as technology imports and exports.

The organization should also be prepared to render services to foreign clients in relation to commercial and investment opportunities in African countries, and to advise them on such aspects as local conditions, the conduct of negotiations and the drafting of agreements. Finally, it should attend the consulting and engineering needs of regional and international Banks and agencies.

A checklist of the services that may be rendered by AFRICONSULT is shown in Table 1. Though we are not proposing that the firm should supply such a complete range of activities, it is to be hoped that a large proportion of them would eventually be covered.

3. Staff

AFRICONSULT should aim at a size that would allow it to be reasonably efficient,

with a stable central staff of not less than 25 to 30 professionals. This core staff would be supplemented as necessary for specific assignments by temporarily hiring outside experts and by subcontracting various technical and consultancy organizations, foreign and African (here ARCT, ARCEDEM and several universities come to mind).

The core staff could comprise some 10 to 15 engineers and technologists, 10 economists and management specialists, and a few professionals in legal, administrative and central services. These numbers would hopefully grow as business expands.

A feasibility study would be required prior to the creation of AFRICONSULT. It should analyze the markets for C&E services and suggest how the firm should be structured, how it could develop into a mature, self-supporting organization, and what explicit support policies would be needed throughout the growing stage.

4. Development

The development of an organization of this nature would take a number of years until maturity and self-sustaining operation are achieved . Experience shows that the crucial aspect is the development of the firm's human resources. Certain major constraints are to be faced in Africa at the present moment, principally the scarcity of experienced professionals.

This could be remedied to a certain point by initially recruiting Africans that are already working in industrial countries and have accumulated a sufficient degree of relevant experience, such as professionals of large C&E organizations and business firms, university professors and researchers, and international civil servants. There is bound to be a large pool of such trained, experienced people from which to select prospective staff members for AFRICONSULT. To ensure that the best candidates are brought in, the conditions of employment should be comparable to what is habitual internationally. This, however, may be resisted by staff recruited locally.

Outside cooperation would seem essential to the development of a C&E organization at this early stage in the industrial development process of the African countries. This cooperation could take place at two levels.

First, at the planning level, there could be assistance in designing the C&E organization in view of its markets, the services it could offer, the technical fields to be covered,etc., to analyze its economic viability, and to map the stages of its development. This assistance could eventually be covered by a technical co-operation programme with an international organization such as UNIDO.

Second, at the operative level, external agencies could assist AFRICONSULT to acquire the necessary know-how and skills. As we have mentioned, an important way of achieving this is through association with one or more experienced foreign consulting firms, either on a long-term basis or for specific assignments, using the foreign partner to secure the training of personnel and the access to know-how and "know why".

TABLE 1

Services that could be offered by AFRICONSULT: a checklist

1. Services to African clients on internal aspects

1.1. Investment area. Services for the whole investment cycle. In the preinvestment stage: planning and feasibility studies, selection and negotiation of basic technology. In the implementation stage: supervision of detailed engineering, procurement, civil works, erection and installation, commissioning and training. In some cases, full responsibility under a turnkey contract.

1.2. Technical area. Services relating to R&D, product development and product design, process engineering, application of new technologies, energy saving, waste treatment and environmental matters.

1.3. Production area. Services relating to processes and methods, quality control and quality assurance, plant engineering, maintenance, production planning and control.

1.4. Sales area. Services relating to sales procedures, organization of marketing activities and after-sales services.

1.5. Procurement area. Services relating to procurement procedures, acquisition of plant, equipment and services, subcontracting of components and other inputs.

1.6. Central management area. Services relating to company diagnosis/audit (which may cover analysis of capabilities, management and organization, personnel policies, skill profiles, marketing, product mix, production processes, environmental impact, energy efficiency, productivity, costs, economic and financial performance), introduction of new management systems such as cost accounting, introduction of new organizational structures in different areas, preparation and supervision of projects for reorganizing and upgrading activities (including better utilization of existing capacity and installation of new plant), mobilization of financial resources for investment and for working capital, and provision of a range of professional services such as auditing, accounting and legal advice.

1.7. Training area. Services relating to the assessment of needs for training on all the above areas, particularly management, and assistance in designing and implementing training programmes (in the classroom, on-the-job, or abroad).

2. Services to African clients on external aspects

2.1. Advice on relations with other local actors (suppliers, clients, R&D, Government); networking with other productive units through subcontracting and other means.

2.2. Advice on relations with foreign actors (companies, banks, consultancy organizations, R&D institutions).

2.3. Identification of business partners, local and foreign.

2.4. Local and foreign purchases (materials, components, equipment, know-how): analysis of options, assistance in negotiations.

2.5. Local and foreign sales (products, know-how): market studies, identification of "niches" and clients; assistance in negotiations.

2.6. Advice on partnerships with foreign companies through joint ventures, strategic alliances and other means.

2.7 Identification of sources of finance, local and foreign; negotiations, financial engineering of projects.

3. Services to foreign clients
   3.1. Survey and analysis of commercial opportunities.
   3.2. Survey and analysis of investment opportunities.
   3.3. Reports on local conditions.
   3.4. Assistance in the conduct of negotiations.
   3.5. Assistance in the drafting of agreements.

4. Services to regional and international Banks and agencies
   4.1. Studies on different economic, technological and business areas
   4.2. Preparation of plans and programmes
   4.3. Preinvestment services, including feasibility studies
   4.4. Project implementation services
   4.5. Evaluations, audits, etc.

9.4 Technology Acquisition. Creation of an African Organization for Technology Transfer and Diffusion through Demonstration Enterprises: the Example of the Chile Foundation

1. Introduction

This Annex is based on a paper by J. Cordua, "Estudio de caso de Fundación Chile", Fundación Chile, Santiago, February 1993.

The main activity of the Chile Foundation is not research and development, but rather bringing into the country proven knowhow in areas of commercial importance and carrying out an active task of technology transfer and diffusion to local users. This is done through traditional methods and, increasingly, through a novel method of setting up demonstration enterprises that apply commercially the technology and show its viability. Such enterprises are sold to the private sector once the demonstration effect has been achieved. Thirty one demonstration enterprises have been set up since 1982, and six have already been sold.

The Foundation was created in 1976 by agreement between the goverment of Chile and the ITT Corporation, as part of a broad settlement for the expropriation some years before of ITT property in that country. Each partner agreed to contribute US $25 million over a period of ten years for the creation of a private non-profit corporation with the aim of "scientific and technological research, its development and the application of its results to the economy". During the first ten years of its life the Foundation was administered by, and received technical advice from, ISEC, a subsidiary of ITT. It is now run by nationals of Chile.

The Foundation's full-time staff currently numbers 180, of which 75% are professionals. It uses an even larger number of short-term consultants and experts from Chile and abroad. The annual cost of its operations is in the order of US $10 million. Since 1986, costs have been fully covered by the income from the sale of services, the results of the enterprises created and the interest on financial investments. The Foundation's assets are currently $56 million, higher than the sum of the original contributions.

2. Early development

The Foundation was created at a time when the country was starting to apply a new development model, by opening up the economy, providing incentives to export activities and to national and foreign investment, and searching for a higher economic stability. The country's economy has steadily grown and diversified, and has achieved a successful insertion into the world markets. Products attended by the Foundation have grown in importance: wood products now represent 10% of exports, agro products 9.5%, marine products 8.8%. The good results obtained by the Foundation are largely explained by this favourable policy environment, particularly its export bias.

In 1978 the Foundation started to provide testing and certification services to the food industry, using its new laboratories. During the following years it carried out many activities related to agroindustry such as: freezing of berries

and of horticultural products; development of a Swiss-style yogurt; study of varieties of peaches and apricots for the fruit canning industry; introduction of new varieties of green asparagus; sanitary improvements in the dairy industry. In marine resources, feasibility studies were made on the culture of salmon, trout and other species. Work on forest products began somewhat later, in 1983. Activities in electronics and communications that had started early were gradually phased out because of the lack of a sufficiently large market in the country; they were replaced by work on the industrial application of microprocessors. More recently the Foundation has started activities related to software production.

As we can see, the orientation has principally been towards the dynamic export sectors. The Foundation has adopted a practical approach to ensure that sufficient revenue is generated from its activities, principally the official certification of quality of export fruits and vegetables,

The Foundation's structure comprises four technical Departments, Agroindustry, Forestry, Marine Resources, and Development and Marketing, and three modern Laboratories in the chemical, chromatography and microbiology areas, which offer a wide variety of tests and analyses mainly related to the needs of the export industries, including quality certification. There is, additionally, a Department of Finance and Administration.

The Foundation has specialized in economic sectors chosen on the basis of the country's and the institution's comparative and competitive advantages. Within those sectors it has oriented its efforts mainly by market signals, which was a novel concept when first used since at that time other institutions followed orientations derived from the concept of "strategic needs" of national development. The Foundation now contributes technology and services to four of the most dynamic sectors of the economy: agroindustry, forestry, marine resources and informatics. It has achieved prestige and comparative advantages in them.

3. Technology transfer activities

To transfer technologies to the country's enterprises, the Foundation employs both traditional methods and its own method, the creation of demonstration enterprises.

The main traditional instruments in technology transfer employed by the Foundation are diffusion (seminars and publications), training, technical assistance (principally for the development and commercialization of new products and services), and quality control and certification.

In 1982 the Foundation started to apply a model of creation of enterprises for the demonstration of new technologies, as a tool for the efficient transfer of technology. The Foundation studies and develops a project, converting it into a functioning private enterprise that demonstrates the validity of the technology incorporated. To do so it looks for the best know-how existing abroad and uses it in the new enterprise. The wide diffusion of the initiative and its achievements motivate other entrepreneurs, by imitation, to invest in the new activity. The Foundation is ready to supply consultancy services to the new initiatives, if requested. A diffusion chain is created in this way, and is regarded as complete when the new economic activity is consolidated. At that

time the demonstration enterprise is sold, recuperating at least the invested capital. Thus take place the transfer of technology and the creation of a new productive activity.

4. The creation of "demonstration enterprises"

One of the characteristics of the Foundation's model of technology transfer is the creation of "demonstration enterprises". Their purpose is to show in the country the technical and economic potential of a technology, already proven overseas, which can generate new production opportunities based on a technological innovation in Chile.

The Foundation prefers to create the new firm by itself, but may do so through a partnership with private entrepreneurs, when a certain experience is particularly needed, or when the investment is too large.

The transfer and diffusion cycle is closed by selling the firm (or the Foundation's share) once it has achieved the purpose of demonstrating practically the technical and economic advantages of the new technology. The Foundation's experience shows that the cycle has an average length of four to seven years.

The phases of the cycle are:

(a) Identify an opportunity for a new productive activity, preferably with export possibilities, for which there is a proven technology abroad which has not yet been used in the country.

(b) Introduce the new technology through a demonstration enterprise.

(c) Assist the new enterprise in different areas, particularly marketing, quality control and troubleshooting.

(d) Diffuse the new technology in the country.

(e) Sell the Foundation's share in the demonstration enterprise, once it has stabilized and started to show profits.

(f) Search for a new opportunity to restart the cycle.

The success of this approach depends to a large degree on having ample financing and a stable, autonomous and flexible operation.

This mechanism of technology transfer and diffusion presents a number of advantages, principally the active participation of a technical institution in the investment and operation of the project, which in turn gives confidence to prospective investors, and the fact that for an industrialist the best argument in favour of a new technology is the commercial success enjoyed by whoever has applied it.

There are also problems, such as a potential conflict between the institution's aim of technical assistance to producers and the fact that it is at the same time a producer in the same branch. Additionally, the management of a number of

enterprises demands a high managerial capability which normally is not available in a technological institution.

In spite of such problems, the Foundation has obtained very positive results. A total of 31 enterprises were created in the following sectors: agroindustry (13), aquaculture (11), wood (5), and informatics (2). Six of them have finished the cycle and have been sold with good profits. One was closed down, and a few show problems. The remaining, about 18, are doing fine (see the attached table).

The most interesting consequence has been the spate of followers in many of the cases. Salmones Antártica S.A., the first demonstration company, founded in 1983, promoted a rapid development of the salmon industry, which did not exist previously. During the first six years after its creation, more than 60 salmon producing firms were established, and salmon production went from 94 metric tons in 1983 to 35,000 in 1992. Chile is today the second world producer of salmon in captivity, with exports of US $200 million a year.

5. Characteristics of the institution

As a private corporation, the Foundation enjoys a great degree of autonomy, and it has extended this characteristic internally. Departments enjoy great independence in their operations, and define the strategies, tactics and actions needed to implement the policies laid down by the Board, including marketing, budgeting and operational aspects. On creating a demonstration enterprise, the department in charge carries out the initial phases until the enterprise starts and is turned over to a manager.

The salient characteristics of the Foundation's institutional model are: orientation towards the market; pragmatism; autonomy; specialization in a limited number of productive areas (agroindustry, forestry, marine resources and informatics); professional management; own model for technology transfer (creation of demonstration enterprises).

The Foundation has been able to attract a distinguished group of professionals, and this has allowed it to achieve high productivity levels and carry out a large volume of activities with a relatively small professional staff. The frequent use of outside consultants, both national and foreign, significantly amplifies the capabilities of the permanent staff. Managers have a commercial, profit-seeking spirit, which has made for good economic results.

The concept that the professional excellence of its personnel is the main factor for the success of the institution is reflected in the personnel training and updating policies of the Foundation. The staff is encouraged to participate in international courses and meetings, in order to update their knowledge and establish personal contacts. The wide use of consultants is also a rich source of knowledge and experience for the Foundation's staff.

The Foundation charges for all of its services and thus has to adapt to client demand its programmes and the services it produces. The enterprises created by the Foundation are an important source of contacts, leading to new clients wanting to duplicate the experience and needing the Foundation's support for this.

The Foundation's main comparative advantage is its excellent image, based on a great credibility and prestige. The credibility comes from a first rate track record on providing effective technical assistance and an effective transfer of technology. The institution's prestige brings frequent invitations to its managers and professionals for participation in technical meetings, both national and international. The Foundation enjoys a high coverage of its activities and achievement by the media, and its three periodical publications are also important promotional instruments.

In sum. The Chile Foundation offers a very interesting contrast to the usual industrial technology research institution in a developing country. It is self-sustaining, shows a strong commercial outlook, concentrates on introducing the best available technologies (rather than carrying out research) to attend local needs, and has had a strong impact on the productive activities of the country in key export sectors.

ANNEX 1

TECHNOLOGY AND ENTERPRISE DEVELOPMENT: GHANA UNDER STRUCTURAL ADJUSTMENT

A study by S. Lall, G.B. Navaretti, S. Teitel and G. Wignaraja, The World Bank Regional Programme on Enterprise Development, Washington, DC, 1993 (summary)

This study surveyed more than 200 Ghanaian enterprises, 32 of which in depth, in four industries: textiles and garments, food processing, woodworking and metalworking. The purpose was to analyze in those firms the process of acquiring technological capabilities, the technological strengths and weaknesses, and the influences on firms' acquisition of technological capability. A number of policy conclusions have been drawn from this work. Before reviewing these conclusions we will refer to the conceptual background and to the characteristics of industry in Ghana.

(a) Some conceptual aspects

Technological capabilities were categorized under three headings: investment capabilities, needed to prepare and implement investment projects; production capabilities, including process engineering, product engineering and industrial engineering, and linkage capabilities, needed to link up with other local and outside firms and institutions. Table 1.1 gives a detail of these elements.

Industrial technology development is taken to depend on three groups of factors: (i) the incentive framework governing the demand side, comprising the external environment (notably domestic and foreign competition) and government policies (such as carefully designed interventions to promote the growth of infant industries); (ii) supply factors, comprising skills (basic literacy, technical skills, highly qualified human resources), information from a variety of sources including the industrial technology infrastructure (providing extension services, standards, research and development, etc.), and finance; and (iii) institutions such as those in education and training, science and technology, and SME support.

Technology related activities take place in most industrial firms. Large firms may become more competent in areas where there is a size threshold for efficient technological activity, but small firms may be efficient in certain activities. Much of recent technical progress has come through organizational innovations, particularly those required for flexible manufacturing systems.

(b) Ghana's industrial sector and its performance

Ghana has some large modern firms, in food, aluminium and some heavy industries, principally owned by foreign capital and the state, and little connected with the domestic economy. They are highly dependent on foreign technology, inputs and skills, but few are likely to be internationally competitive. A second stratum is made up of small scale firms, which are largely African owned, and have low skills and low demand for technical

TABLE 1.1 TECHNOLOGICAL CAPABILITIES

(Adapted by the present author)

Technological capabilities are the information and skills - technical, managerial and institutional - that allow productive enterprises to utilize equipment and technology efficiently.

They include (1) *investment capabilities*, for conceiving and implementing investment projects; (ii) *production capabilities*, for operating efficiently and improving a plant; (iii) *linkage capabilities*, to establish production and technological links with other firms and institutions. For each category we list below *simple* or experience-based TCs, *intermediate* or adaptive-duplicative, search based TCs, and *advanced* or innovative, risky, research based TCs.

1. Investment capabilities

1.1 *Preinvestment*
S: Prefeasibility and feasibility studies, site selection, scheduling of investment
I: Search for technology source, negotiation of contracts, inform. systems

1.2 *Project execution*
S: Civil construction, equipment erection, commissioning
I: Equipment procurement, detailed eng, training, recruitment of skilled pers.
A: Basic process design, equipment design and supply

2. Production capabilities

2.1 *Process engineering*
S: Debugging, balancing, quality control, preventive maintenance, assimilation of process technology
I: Equipment stretching, process adaptation and cost swaving, licensing new technology
A: In-house process innovation, basic research

2.2 *Product engineering*
S: Assimilation of product design, minor adaptation to market needs
I: Product quality improvement, licensing and assimilating new imported product technology
A: In-house product innovation, basic research

2.3 *Industrial engineering*
S: Work flow, scheduling, time and motion studies, inventory control
I: Monitoring productivity, improved coordination

3. Linkage capabilities
S: Local procurement of goods and serv., information exchange with suppliers
I: Technology transfer to local suppliers, coordinated design, S&T links
A: Turnkey capability, cooperative R&D, licensing own technology to others

services. There is finally the informal sector which meets localized demands, using little equipment and few skills demanding formal training.

Ghana's industrial performance has been poor, and in fact there was"de-industrialization" from 1977 to the mid-80s, when industrial output overall dropped to 39 percent of the 1977 value. There was a partial recovery after 1984 as cocoa prices increased and foreign aid came in, but further growth depends on adding new capacity and especially by improving technological efficiency as trade barriers have come down after the start of structural reforms in 1986. The performance of individual industrial branches has varied; those more affected have been textiles, garment, leather, iron and steel products, and electrical and transport equipment.

Manufacturing exports grew in 1986-91 but little of it came from new exports beyond natural resource processing. The report points out that structural adjustment has not made allowances for the "costs, difficulties and market failures involved in enterprises becomig efficient" and that "an understanding of the technological capability building process would have led to the expectation that local enterprise in Ghana would find it very difficult to develop the technological and other capabilities that are needed for world class competitiveness... a considerable period of learning and relearning would be involved... with (the) need of considerable assistance from external intitutions before prices did their work".

The reasons for poor performance reside first in the incentive framework, particularly trade policies giving strong protection until 1986 which was not used to develop adequate industrial capabilities and infrastructure, followed by a relatively open trade regime which has exposed industry to international competition, while foreign investment flows have been weak. Secondly, there are shortcomings in skills, which are sufficient to allow some progress but not enough for a sustained expansion into sophisticated industrial activities, and in technological effort in enterprises, in industry-related R&D which is small and largely unrelated to industry's needs, and in technological services sector where activities relating to standards and product certification have little value.

(c) Findings

(i) The industrial firms surveyed have developed only limited technological capabilities in simple technologies, and showed little dynamism in this respect. *Investment capabilities* were weak; there is a lack of consultancy support for investors, except for MNC affiliates which can draw upon the parent companies. *Production capabilities* in process technology varied in different branches and tended to be poor with the possible exception of MNCs and some local firms in food processing and a limited number of firms in metalworking; product technology capabilities were relatively poor, with no efforts to build them up and no effective institutional assistance. Finally, the sample showed very low levels of *linkage capabilities*, both with other firms (in subcontracting or local procurement of manufactured inputs and spares) and with institutions that provide training, research and services. In sum, relatively few firms have been able to face import competition, but there are significant differences and some are clearly more competent and may eventually develop the technological capabilities needed to grow.

(ii) A group of 15 "technologically competent" firms in the sample were separately analyzed. These firms were found to be under different types of ownership. They were larger than other firms, had carried out efforts to develop their technological competence, paid better wages, had better educated entrepreneurs and production managers, and counted with a higher proportion of scientists, engineers and technicians.

(iii) The study looked into the relations between human capital and technology development. Regarding entrepreneurs, there was no shortage of entrepreneurial spirit but the issue is whether entrepreneurs have sufficient education and experience to face technological challenges; only a small proportion do. Production managers are better educated in the competent firms, and they sometimes function as "technological catalysts" whose knowledge and efforts are critical to upgrade technology. The level of skills of employees depended on the nature of the technology (highest in food processing, lowest in garments). The numbers of technical staff were low, and this was unrelated to size. On the job training varied in effectiveness, the best being in foreign affiliates; some firms got their training from equipment suppliers, others developed their own systems. There was little external training in institutions or in firms overseas.

(iv) The analysis of technical effort in the firms was hampered by the lack of data on the time spent by professionals and technicians in enhancing productivity (though it was found that none of the firms carried out R&D). The study therefore looked into other related aspects: (i) technology licensing and technical assistance; very few firms were trying to improve their process technology by getting knowhow from abroad, and there was little constant search for foreign technological knowhow; (ii) manpower in quality control, maintenance and other specific technical activities: the numbers were very low in QC and there were more people attending these tasks in the larger enterprises; (iii) relations with technology institutes: as we have previously mentioned, linkages with the science and technology infrastructure were very low. Firms lack information on a variety of tasks needed for technical efficiency (see Table 1.2) and they are not able in general to define their technological needs ("they have to be taught to learn"); even if they could there are few local institutions that could effectively help them. Firms with a systematic technological activity use internal sources of information (the entrepreneur or the "technological catalyst") for simple matters and, for more complex ones, overseas sources such as the MNC parent, foreign licensing, and occasionally joint ventures. This lack of domestic institutional support may be an important cause of weak technological performance.

(v) The incentive structure is the most important indirect influence on the investment in technological capabilities. Before liberalization industry was protected unselectively, with no offsetting pressure to invest in technology capabilities; this, plus the very large deficiencies in skills, industrial experience and supporting institutions, prevented industry to exploit ooportunities for learning. Immediately after liberalization there were more incentives to improve operational capabilities, with the easier access to foreign technology, equipment and inputs. Somewhat later however foreign competition came in strongly and a good number of local firms could not withstand it and had to close down, particularly in labour intensive activities using simple technologies, like the textile industry which found its market

TABLE 1.2 TASKS NEEDED FOR TECHNICAL EFFICIENCY

(Adapted by the present author)

This is a list of the main technological tasks that manufacturers have to perform to become technically efficient (there are many others related to management and marketing).

– What technologies are appropriate to survive, grow and (in the longer term) export in the new competitive environment

– What equipment to buy, how to evaluate its capabilities, where to buy it and what prices to pay.

– Where and how to negotiate the best technology transfer deal.

– How to participate in project engineering, and to persuade foreign technology suppliers to impart elements of process technology to local engineers.

– How to train workers to the necessary skill levels. initially and on a continuous basis, with in-house and external inputs.

– How to establish suitable quality control procedures, standardize products and get them certified. so that they can have market acceptability.

– How to optimize production processes, adapt them to local scales of operation, materials. components, and market conditions, by in-house engineering effort and troubleshooting, or by getting technical assistance and consultancy.

– How to establish industrial engineering procedures, schedule production, control inventory, keep track of productivity, set up procurement procedures, and so on.

– How to reduce costs over time and adapt to changing factor conditions, by conducting (or contracting) research into processes and keeping a watch on international technological developments.

– How to improve products and diversify the product range, again by conducting or contracting design, research and development.

– How to source materials and components locally, by establishing linkages with potential suppliers and subcontractors, and rendering them technical assistance.

– How to establish supply or sales contracts with overseas companies.

flooded with imports of cheap Asian textiles and second-hand garments. The report suggests that "the new incentive structure, while giving strong signals for investing in improved technological capabilities, failed to give the breathing space or provide the sort of supply side measures that were needed for a strong supply and investment response... Improved incentives provide a necessary but not sufficient condition for technological capabilities development to happen... The speed of liberalization and its lack of coordination with capability building measures has imposed costs on Ghanaian enterprises, including those in activities in which the country may be expected to have a comparative advantage".

(d) Policy implications

The report concludes that in order to promote industrial technology and competitiveness there is a need for policy support and new initiatives, beyond the reforms brought by liberalization into the incentive regime. Infant industry protection would be needed to encourage new activities that require lengthy learning, but this protection should be designed and put in place carefully to minimize negative effects on the development of technological capabilities.

An important point is that protection will not work in the face of large deficiencies of technical knowhow, skills and support services, which should be remedied while at the same time informing and educating enterprises to use these assets.

The report mentions the "need to build up a variety of educational, training, technology and infrastructural institutions to carry out the tasks that the government has to perform". The institutions now existing have limited effectiveness, and this should improve; the government is attempting to do it.

Finally, there is the need to put together "a clear and comprehensive vision of the components of a proper strategy, and how to integrate its incentive measures with policies on the development of capabilities". In this way Ghana may achieve an integrated strategy for industrial development.

ANNEX 2

SCIENCE AND TECHNOLOGY FOR LEAST DEVELOPED COUNTRIES AND OTHER SMALL DEVELOPING COUNTRIES

A Report of the UN Advisory Committee on Science and Technology for Development, United Nations, New York, 1991 (summary)

This report starts from the proposition that, in order to be active participants in the world economy, countries need to develop their own S&T capabilities. An effort is made to assess "the specific characteristics and problems of the least developed countries (LDCs) and what these imply for their S&T capabilities and the potential role of S&T for their development".

LDCs have long been faced with major problems - poverty, low growth rates, high population growth, weak manufacturing sector, heavy dependence on foreign aid to maintain imports and introduce technology, declining role in world exports, heavy external debt, vulnerability to outside shocks. These problems of old date are now compounded with others that originate in the changing global context, with the accelerated introduction of science-based, technology-intensive technology, heightened competition, the shift in the industrial paradigm towards a more flexible specialization and economies of scope, globalization of production and investment, and the requirements of sustainable development.

The thinking regarding technology is changing. Technology, in addition to hardware, includes a "soft" dimension relating to knowhow, skills, management, marketing, etc.; it is increasingly knowledge intensive; it "can no longer be regarded as a cost of modernization but as an investment towards long term growth and competitiveness". There is a need to revise the supply-push approach to technology; the type of technology that is required needs to be derived from the demands of the marketplace and the needs of society. It is suggested that LDCs should reassess their policies in technology and science and consider ways to optimize the benefits of S&T.

The report identifies *major problem-areas in S&T in LDCs* : vulnerability, weakness in demand for technology, and limited capabilities for technology supply. Several aspects of weakness in science and technology are explored:
(i) Weakness in domestic research capabilities, which are small and are not directed towards strengthening technological capabilities and supporting production.
(ii) Weakness in the ability to search for and acquire outside technologies; one aspect of this is a weak capability of "technological intelligence".
(iii) Poor technology management, to a good extent because of focusing on hardware to the detriment of the increasingly important "soft" aspects of technology.
(iv) Relative neglect of the private sector, which has not been addressed by the S&T system. The latter should become more client-oriented, and its performance should be increasingly defined in market terms. SMEs should be promoted and helped through various mechanisms, among them tax incentives, financial schemes, infrastructural support, export promotion, incubators, venture funds and business support systems. A dynamic and growing private sector can be a strong source of demand for S&T.

(v) Weak institutions to foster domestic technological capabilities, including the financial, educational and S&T institutions. This would require the strengthening of necessary institutions, and new innovative institutional and organizational arrangements to cope with the issues stemming from the new global context.
(vi) Little participation of relevant stakeholders in the policy making process.

The report then lists some *key issues to be examined* in order to develop practical measures to improve the contribution of science and technology to the economic growth in LDCs:
(i) Strengthening of endogenous capabilities in S&T, defined as "the extent of local capability to exercise independent, informed judgment and actions regarding the acquisition, deployment and generation of technologies for economic and social development". It is suggested that they may be acquired through a sequential process. Table 2.1 shows the UN Advisory Committee's view of the different elements that make up an endogenous capability.
(ii) The complex issue of a "critical mass" in S&T, a combination of qualitative and quantitative components. This will vary for countries with different needs and for different sectors and disciplines. In some cases critical mas could be developed at a subregional or regional level.
(iii) Critical technologies in which LDCs should focus efforts, not necessarily for technology creation but for developing local capabilites to make the best use of those technologies whatever their origin. It is suggested that a set of criteria be developed for the identification of critical technologies.
(iv) Strengthening of intermediation mechanisms that help technology move from the R&D stage to production. Many institutions can play a role here - government agencies, R&D institutions, universities, manufacturers' associations, banks, consulting firms, etc.
(v) Environment and technology. Industrial wastes, as well as population pressures, desertification and urbanization, put growing strains on the environment. To integrate environmental sustainability with technological development brings up specific problems, principally the applicability of standards used elsewhere and the costs of acquiring and introducing clean technologies, which may clash with production objectives, particularly in the short run. The report suggests that LDCs should define by themselves what environmentally sustainable development means in their context and what standards should be adopted.
(vi) The donor community contributes an important share of new investment and influences technology choice, which frequently is not suitable for the recipient LDC's resources and conditions. The report suggests that there should a better choice of technology, involving the stakeholders in this process, that aid should be less tied, that greater emphasis should be placed on the soft aspects of technology, and that aid programmes should explicitly seek to promote local S&T capabilities. Such types of measures would increase the effectiveness of aid programmes.
(vii) Local resources, both physical and human, should be fully taken into account in the choice of technology, tending to their higher utilization. The report suggests actions in the popularization of science, a more appropriate science education, focusing on local conditions and needs, a heightened training effort, better incentives for students to go into S&T-related fields, etc.

TABLE 2.1 THE ESSENTIAL ELEMENTS OF ENDOGENOUS SCIENTIFIC AND TECHNOLOGICAL CAPABILITY

(Adapted by the present author)

These elements, each of which requires education and training at the appropriate levels, are shown under an increasing order of endogenous capacity.

1. Capability for informed judgment or decision
   - information
   - S&T focal point
   - linkages among S&T expertise, government and users

2. Selection and utilization of technologies
   - management and organization of S&T
   - technical skills
   - technology assessment and transfer mechanism

3. Adaptation and accretion of technologies
   - R&D capability
   - R&D funding mechanism
   - engineering capability
   - financial institutions
   - marketing capability

4. Creation of new technologies
   - a strong science base
   - innovation management capability

Attention should be given to the brain-drain problem, as well as the tapping of expatriate nationals through TOKTEN and other mechanisms.
(viii) Regarding the role of science, the report feels that the emphasis on basic research is to be questioned. Emphasis should be placed on the use of the vast reservoir of existing knowledge, seeking new combinations and applications through "science-based technology research", and making incremental improvements in existing technology. There should also be an effort to use the pool of traditional, informal knowledge, and to "blend" traditional technologies with new technologies
(ix) Policies in trade and in technology should be coordinated to avoid adverse side effects of one on the other, deriving from intellectual property rights, local content laws, import restrictions, restrictive trade agreements, adoption of international standards, pressures to acquire cleaner technologies, etc.
(x) The economies of LDCs are to a large extent rural, with a preponderance of informal activities, mostly employing traditional methods of production. S&T should be used to improve their productivity, working through the social and cultural context. (Note: there has been a good deal of UNIDO activity in this respect, for instance in gari production and in the mechanization of certain activities).
(xi) There should be an emphasis on the soft side of technology, which is important in the absorption and diffusion of newly acquired technologies. The list of soft assets includes "the scientific knowledge base, the technical

intelligence and knowhow, the, organization around the technology, the technical and extension services, the marketability of the technology, the, management of the technolgy, and its backward and forward linkages". Imported technologies "sometimes require an entire restructuring of organizational arangements".
(xii) Alliances should be encouraged with foreign firms to exchange information and technology, as in a barter agreement. This is a flexible and useful mechanism for the transfer of technical know-how, and may give a firm greater technical and market possibilities.
(xiii) Cooperation with African and other developing countries may help endogenous capacity building, by allowing to share knowledge, pool resources and complement capabilities. Access to a network such as the Third World Academy of Sciences helps to prevent the isolation of scientists, and to orient problem-solving efforts.

The report reaches the conclusion that "the changing global context and the new definition of science and technology requires a new approach to S&T policy in the LDCs". Four main areas for initiatives are outlined:

(i) *A greater emphasis is need on the soft side of technology,* the elements of which have been listed above. Countries should aim at developing technology assessment capabilities, assisting firms in technology sourcing, intall extension services that may carry out trouble-shooting and in "learning" a technology, and promote stronger links between science and production.

(ii) *The activities of S&T development and technology transfer should be more responsive to demand.* This will require better liaison mechanisms, professional and financial incentives for R&D institutions to respond to the demands of the productive sector, encouraging scientists to take up field activities, using new and emerging technologies to upgrade traditional technologies, and developing better statistcs and indicators related to S&T.

(iii) *Generation of demand for S&T* may be sought by increasing mass awareness by popularizing S&T through different means, and by giving support to potential users for increasing their demand for S&T. The report mentions a number of actions for this last purpose: reduction of bureaucratic prcedures, facilitating access to market information, export promotion, supply of basic infrastructure, promotion of SMEs, tax incentives, credit availability, assistance in finding finance, training in management and marketing, technnology incubators, technology venture funds, business support systems.

(iv) *Building of endogenous capabilities is required* and may be carried out through several means: getting young people started in science education at an early age, higher mobility of scientific personnel, collaborative R&D projects, better technical education, incentives to enter science related professions, bringing home qualified expatriates, promoting local innovation, promoting learning in the production process and training at the firm level, improving the institutional context, identifying critical technologies, tapping into traditional technology systems, participating in the design of donor-aided projects and assuring their contribution to the building of local capabilities. At a subregional and regional level, governments should collaborate to develop jointly critical areas and to establish scientific networks.

The report finally suggest that "no specific strategy for building S&T capacity and international competitiveness can be recommended for LDCs as a whole. This must be approached in a case by case basis, taking into account both special needs and advantages of the country in question".

ANNEX 3

ROUND-TABLE OF AFRICAN INVESTMENT PROMOTION CENTRES

(Summary of Report by UNIDO)

The Round-Table of African Investment Promotion Centres (IPC's) was organized by UNIDO in cooperation with the Organization for African Unity, OAU, and the African Development Bank, ADB, in Bulawayo, Zimbabwe, from 7 to 9 September 1992. It was attended by 71 participants, including representatives of 20 African IPC's, 5 UNIDO-IPSO's, African regional and sub-regional organizations and multi-lateral organizations.

The purpose was to bring together representatives of African IPC's and UNIDO Investment Promotion Service Offices (IPSO's) to establish an investment promotion network in order to increase the mobilization of resources for investment into Africa, among other things by adopting the UNIDO investment promotion methodology and tools. There was also a discussion of 27 investment projects that were scheduled for promotion through UNIDO and the IPSO's.

The main recommendations of the Round-Table were:

1. African governments should take active steps to create a good image of their respective countries as investment locations, especially where new open-market policies have been introduced, in an effort to reverse the declining flow of direct foreing investment (DFI) to Africa.

2. African governments should create an inviting environment to DFI by providing protection of investments, possibilities for full and free repatriation of capital and profits, streamlined administration procedures for the establishment of enterprises, adequate physical and industrial infrastructure, satisfactory expatriate quotas and supportive monetary and fiscal policies.

3. To the extent possible, local and foreign investors should be treated alike and have equal access to industrial incentives.

4. Industrial incentives should fit in and complement Structural Adjustment Programmes. In principle, they should be intended to achieve specific policy objectives such as geographical dispersal of industry, development of a priority subsector, use of local materials etc.

5. To the extent possible, and subject to conditions in individual countries, investment promotion centres should preferably be autonomous institutions under the direction of a Board of Directors with wide private sector representation, and operate as a one-stop shop. IPC's should work to improve their own investment environment and structures in their role as advisors to their governments on investment promotion matters. IPC's should endeavour to generate income to the extent possible. IPC's should be more promotion oriented rather than regulatory.

6. In order to facilitate the promotion of investment projects, African IPC's should adopt a uniform system for the formulation and screening of projects, namely the UNIDO methodology and tools in the form of the standard

investment project profile form, the user-friendly software for the pre-appraisal of projects (PROPSPIN), the Manual for the Preparation of Feasibility Studies, the software for feasibility analysis and reporting (COMFAR) and the data-base for investment promotion programmes (DIPP).

7. Ways and means should be found for the substantial expansion of UNIDO's "Delegates Programme" to enable many more African Delegates to be attached to UNIDO IPSO's.

8. African governments and IPC's should address the issue of foreign exchange risk on external loans to enable many more entrepreneurs to make use of external lines of credit which exist in national development, regional and subregional banks.

9. An investment promotion network should be established composed of African IPC's, UNIDO's worldwide network (IID and IPSO's) and other relevant organizations including OAU, ADB and finance institutions. The network should be institutionalized. UNIDO IID should act as a clearing-house for general information of interest to the members. African IPC's should promote investment projects directly with UNIDO IPSO's keeping UNIDO IID informed. The network should start operating immediately on an informal basis until the ground-rules of the network are established in successive Round-Tables of African IPC'S.

10. UNIDO should review and publish an up-to-date version of its Manual on Investment Promotion Centres.

11. UNIDO should prepare for distribution a directory of African IPC's and IPSO's, giving their objectives, functions and services provided.

12. UNIDO should continue with its work of preparing an Executive Summary of Investors' Guides to African Countries, with the cooperation of African IPC's. These Guides should be up-dated periodically.

13. Ways and means should be found for UNIDO to provide technical assistance for the strengthening of the capabilities and capacities of African IPC's in project identification, formulation, screening, promotion and follow-up.

14. The Round-Table of African IPC's should meet regularly, with the next meeting preferably in about one year's time.

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