OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

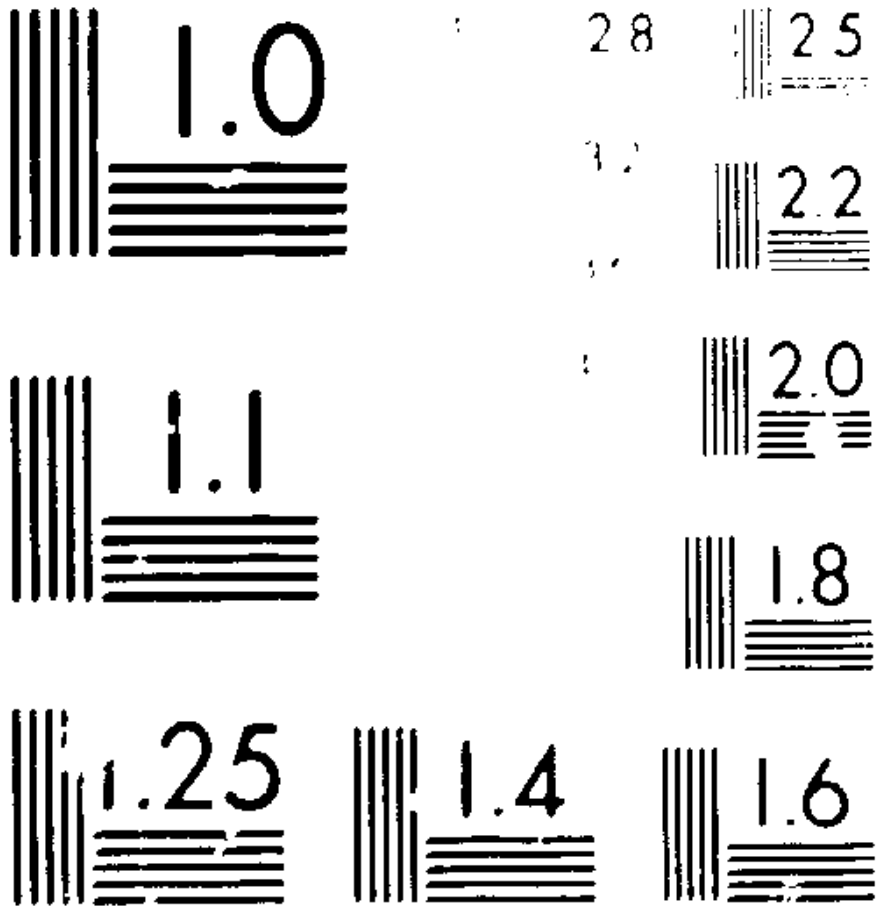
FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org


1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

09478

A

UNITED NATIONS

United Nations Conference on Science and Technology for Development

Vienna, Austria, August 1979

A/CONF.81/BP/UNIDO
Vienna, July 1979

AVAILABLE IN: English
French
Russian
Spanish

BACKGROUND DOCUMENTS RECEIVED FROM SPECIALIZED AGENCIES AND OTHER ORGANIZATIONS OF THE UNITED NATIONS SYSTEM

(Decision 4 (II) of the Preparatory Committee, sect. 1C)

United Nations Industrial Development Organization

STRENGTHENING OF TECHNOLOGICAL CAPABILITIES OF DEVELOPING COUNTRIES: A FRAMEWORK FOR NATIONAL ACTION*

* This document has been reproduced without formal editing.

id.79-5509

CONTENTS

I. INTRODUCTION

1. General Assembly resolution 2152 (XXI) which established UNIDO calls upon UNIDO to undertake operational activities, action-oriented studies and research programmes to promote the industrialization of the developing countries. In view of the fact that industrial technology is an integral part of industrial development, the resolution underlines UNIDO's role, inter alia, in "building and strengthening of institutions and administration in the developing countries in the matter of industrial technology ..." [paragraph 2(a) (iii)] and "dissemination of information on technological innovations origirating in various countries and, for the developing countries, assistance in the implementation of practical measures for the application of such information, the adaptation of existing technology and the development of new technology especially suited to the particular physical, social and economic conditions of developing countries through the establishment and improvement, inter alia, of technological research centres in these countries' [paragraph 2(a) (iv)].

2. The Lima Declaration and Plan of Action has also been instrumental in initiating several mandates and activities for UNIDO in the field of industrial technology. Following a proposal contained in the Lima Declaration and Plan of Action, General Assembly resolution 3507 (XXX) called upon UNIDO to establish an industrial technological information bank. The same resolution called upon the Executive Director of UNIDO and the Secretary General of UNCTAD to continue their efforts in their respective fields, to assist in the establishment, in developing countries, of centres for the transfer and development of technology at the national, sub-regional and regional levels.

3. Endorsing the Lima Declaration and Plan of Action, General Assembly resolution 3362 (S-VII), asked UNIDO to establish a system of consultations between developed and developing countries and among developing countries themselves, in order to facilitate the achievement of the goals set forth in the field of industrialization, including the redeployment of certain productive capacities existing in developed countries and the creation of new industrial facilities in developing countries. Such consultations include the associated technological aspects.

4. Resolution 47(XI), which was based on a draft resolution introduced during the Second General Conference of UNIDO, represents a consolidation and restatement of certain UNIDO activities and mandates in the field of development and transfer of technology. The increased transfer of industrial technology and the strengthening of national technological capabilities, highlighted in the above resolution, are interrelated, whereby national technological capabilities form the basic prerequisites for the selection, acquisition, adaptation and absorption of technology - whether imported or indigenous - and for the development of appropriate technologies. The complex issues which arise in this connexion span the whole range of choice and transfer of technology, the development and promotion of appropriate technologies, and the national policies, institutional infrastructure and manpower development needed for these purposes. In identifying the areas in which UNIDO may assist developing countries, resolution 47(XI) spells out many relevant instruments in section III, paragraph 2, subsections (a) to (j).

5. The Constitution of UNIDO as a Specialized Agency in articles (h) and (j) states as follows:

> (h) Serve as a clearing-house for industrial information and accordingly collect and monitor on a selective basis, analyse and generate for the purpose of dissemination information on all aspects of industrial development on global, regional and national, as well as on sectoral levels including the exchange of experience and technological achievements of the industrially developed and the developed countries with different social and economic systems;
>
> (j) Promote, encourage and assist in the development, selection, adaptation, transfer and use of industrial technology, with due regard for the socio-economic conditions and the specific requirements of the industry concerned, with special reference to the transfer of technology from the industrialized to the developing countries as well as among the developing countries themselves.

6. UNIDO's work in the area of development and transfer of industrial technology has been substantial.[1/] More than three quarters of UNIDO's

---

1/ See Development and Transfer of Technology Series No. 2: UNIDO Abstracts on Technology Transfer; Studies and Reports on the Development and Transfer of Technology (1970-1976) and the Annual Reports of the Executive Director to the Industrial Development Board.

work is directly related to technology. This is only natural and logical since it is only within the framework of such basic considerations that industrial technology can be applied realistically and effectively. To promote such application of technology, three major elements have been identified for purposes of national action. First, the linkage of technology to industrial development, and through industrial development to overall development goals, will be successful only in the context of the formulation of relevant policy measures by the national governments; technology policy and planning therefore become important elements. Second, the development of technological capabilities in each country is a pre-requisite for the selection, acquisition, adaptation, absorption or development of technology, and this involves, among other things, the building up of institutions and the training of manpower. The third element is the appropriate choice of technology, since inappropriate choice will be not only expensive but will distort the pattern of development.

7. In connexion with the third element mentioned above, UNIDO organized the International Forum on Appropriate Industrial Technology in New Delhi and Anand (India) on 20-30 November 1978. This Forum was also intended as a contribution to UNCSTD itself. The Ministerial-Level Meeting and the Technical/Official-Level Meeting preceeding it was not only concerned with the conceptual and policy framework of appropriate industrial technology, but also with the programmes of action which provide a basis for effective international co-operation in developing and promoting specific technologies in the fields of pharmaceuticals, pulp and paper, cement and construction materials, textiles, basic industries, energy for rural requirements etc. This report draws the attention of the UNCSTD to the report of the Ministerial-Level Meeting which represents a consensus on the vital subject of appropriate choice of industrial technology. The report itself is contained in the annex to this document. The documents reviewed by the respective technical working groups as well as specific proposals for action are contained in the monographs on each of the sectors and are being issued separately.2/

2/ Copies of the Monographs on Appropriate Industrial Technology are being made available during UNCSTD.

8. This paper specifically refers to the second element mentioned above, namely strengthening of technological capacities of developing countries which is also the central issue before the Conference. While the Conference agenda deals with science and technology, this paper deals with more technology questions. It is considered necessary to make a distinction between science and technology since the former is universal and the latter is proprietary. The actions to strengthen capacities also take different forms in terms of policies, institutions, programmes and skills. The distinction between the two has also been stated by the UNESCO background paper which is before the Conference.3/

9. In regard to technology, the UNESCO paper states as follows:

"There is a uniqueness about technology, which is still evident in the institutionalization, structures and methods, organization of work and systematic and innovative approach characteristic of it today. It has its own roots, which do not necessarily lie in science (historically, its practices sometimes preceded their scientific explanation). Technology has its own momentum, which over the last two centuries has grown to the extent of thrusting it into the centre of economic development and, in doing so, sometimes dragging science with it."

10. With regard to science, the same paper states that:

"Science is generally defined as ordered, or systematic, knowledge, the development of which proceeds by accepted criteria. From a more philosophical point of view, the object of science is the search for basic truths concerning the universe. In practice, it is the systematization of observed facts and the strength of its predictive function which make science a pre-eminently useable form of knowledge in the service of man and his advancement ..." "Technology, on the other hand is not so easy to define or grasp as science. It implies more than sheer knowledge, and know-how is one of its essential and intrinsic ingredients (as it is also in the work of the scientific researcher)... "As in the past, the basic advances of science may

---

3/ See UNESCO background paper A/CONF.81/BP/UNESCO, pp. 18-19

still often derive from the creation of a more advanced technology which puts new and powerful tools at the disposal of science for a deeper exploration of reality."

II. THE NEED FOR TECHNOLOGICAL CAPABILITIES

11. Perhaps the most significant feature of the current scene on the application of industrial technology for development is that almost the whole spectrum of applied industrial technology in the developing countries is transferred from the developed countries with the developing countries being the unequal partners in this transfer. Broadly speaking, the developed countries not only possess technologies that the developing countries do not, but their technological advantage is sustained on the one hand by their research and development effort and their access to financial and managerial resources and on the other by undefined rules for the transfer of technology and the working of the international patent system. Against this, the developing countries as a class suffer from an inherently weak bargaining position compounded of an inadequate knowledge and skill to select, acquire, adapt and absorb technologies or to develop technologies of their own. The situation has developed into a vicious circle where technological dependence breeds further technological dependence. The continued application of inappropriate technologies that ensue leads to distortions in the industrialization process, which in turn result in the benefits not flowing to the masses of population in the developing countries. The degree of industrial growth warranted by the Lima target is bound to aggravate the dimensions of this vicious circle unless corrective action is taken.

12. The starting point for breaking the vicious circle is undoubtedly the development of indigenous technological capabilities. It will not only enable the development of technologies suitable to local conditions, and thereby obviate external technology payments and the application of inappropriate technologies. The development of new technologies by developing countries is on current evidence, significantly slower than their industrialization. Hence, at least for sometime to come, their reliance on imported technologies is bound to continue. Such imports cannot take place meaningfully

in the absence of an indigenous capability to select, acquire, adapt and absorb technologies. Besides, the transfer of technology within a country, particularly to decentralized sectors and rural areas and the upgrading of existing technologies are truly indigenous tasks which external agencies cannot perform for long or with any significant degree of success. Hence indigenous technological capabilities are a key element in ensuring that the benefits of technology flow to as large a section of a country's population as possible. Thus indigenous technological capabilities are an imperative prerequisite for industrialization and the two have a cause and effect relationship. The essence of the strategy of industrialization of developing countries may well be to discover and exploit this relationship.

13. The development of indigenous technological capabilities is sometimes regarded as a slow evolutionary process. This view overlooks the fact that certain capabilities can and should be developed in the short run; equally, the possibility that co-ordinated policy action can secure the optimal use of available capabilities, speed up the development of further capabilities and also obviate the inadequacies and imbalances that may otherwise manifest themselves in the long run.

14. The objective of the development of technological capabilities should be to promote technological self-reliance, make available the benefits of modern science and technology to the masses of the people and secure the development of specific sectors of economic activity, such as industry and agriculture, transport, energy etc.

III. THE DIMENSIONS OF TECHNOLOGICAL CAPABILITIES

A. The variety

15. The capabilities required for indigenous technological development are inter-related but separate and distinct. They consist essentially of skills, services and functions acting by themselves or through institutional means. Their variety can be better understood if the process of development and transfer of technology is viewed as involving certain distinct stages. It will be convenient to view the process as involving the selection, acquisition, adaptation and absorption of technology on the one hand, and

development of technology on the other. A particular skill, service or function may be required for more than one of these stages just as each of these stages will require more than one skill, service or function. Even so a discussion on this basis will enable the clear identification of gaps and the kind of policy and institutional measures that may be necessary, generally, or for speficic sectors of industry. The capabilities again may be general or industry specific. They may be capabilities to facilitate decision making or to operate machines and construct and erect factories, or carry out activities such as research, design, engineering and commercialization of processes.

B. The indices

16. Several indices of technological capabilities could be suggested. They will only be briefly mentioned here since each index has its limitations and data of this type are not easy to come by.

17. The proportion of expenditure on research and development to Gross National Product could be an index.4/ Apart from the fact that it does not cover the whole span of technological capabilities the expenditure may not contribute fully to such capabilities to the extent that the research is in basic rather than applied fields or remains uncommercialized.

18. Similar limitations apply when the number of scientists and engineers is taken into account. In most developing countries they are about 307 per million of economically active population as compared to 3,800 in developed countries. When the number of such personnel engaged in industrial research and development or production is taken into consideration, the position is even worse.

19. The proportion of industrial units in each sector which have imported technology would indicate the extent of technological dependence and inversely the extent of indigenous technological capabilities. The proportion of the

---

4/ See table I, Diana Crane, "An Inter-Organizational Approach to the Development of Indigenous Technological Capabilities: Some Reflections on the Literature." (OECD Development Centre, Occasional Paper No. 3, CD/TI 174731, December 1974). Also see UNESCO's Worldwide R and D Survey. According to preliminary data for 1978, R and D expenditures in developing countries accounted for only 0.35 per cent of DNP as compared to 2.29 per cent in developed countries.

value of production based on foreign technology in each sector could be a better index. However, data of this type are very limited. The type of services imported, ranging from turn-key projects to mere outright purchase of technical information, would also be relevant.

20. Other indices for technological capability would include the number and value of production of local technologies commercialized, the indigenous content in assembly or formulation industries, the number of consultancy and design engineering firms, the extent of growth of the capital goods industry, etc. There is thus a constellation of factors that could reflect the growth of indigenous technological capabilities.

IV. PRESENT STATUS OF DEVELOPMENT OF TECHNOLOGICAL CAPABILITIES

21. A brief survey of the present status of national efforts to develop technological capabilities in developing countries is necessary to identify the gaps and the steps needed to optimise and accelerate such efforts. However since developing countries are at different stages of technological development only broad statements are possible. At one end are countries such as Brazil, India, Mexico, Pakistan and the Republic of Korea which have a measure of basic scientific and technological infrastructure; at the other end of the scale are several least developed countries where technological development may have barely started.

A. Selection of technology

22. Selection of technology requires both information and evaluation.[5/] Enterprises in developing countries, with the exception of a very small percentage of large enterprises, do not possess technological information and more important, they often do not know where to get it from. As a result industrial and technological decisions are taken on inadequate information. Where information does become available, the ability to evaluate such information for purposes of decision making is often lacking.

23. Information centres have been established in many developing countries, in several cases with the assistance of UNIDO[6/] or UNESCO. These information

---

5/ UNIDO has initiated efforts to fill this gap through the Industrial and Technological Information Bank (INTIB) see also UNIDO's DTTS series Nos. 8, 9 and 10.

6/ e.g. UNIDO has established over 40 such centres in developing countries.

centres are either independent institutions or part of research institutes of other institutions. They are sometimes part of sectoral industry centres. The extent to which information available to all such institutions is fed into the decision making processes varies significantly from country to country. They also vary in their organization and structure from a library or a mere collection of books to institutions with extension and consultancy facilities. The technological information component is often a relatively undeveloped component of their activities. Processed technological information of practical value in decision making requires trained personnel with access to information from all over the world. They will often have to be not only information scientists, but persons with techno-economic backgrounds.

24. In developing countries the evaluation of a project from an economic and technological point of view suffers not only from want of information but also from lack of capabilities and adoption of relevant criteria to be applied. 1/ Entrepreneurs make private cost-benefit analyses of their own. The banks and financial institutions also make such analyses from the point of view of a project's economic viability. Several developing countries have attempted to upgrade their capabilities through institutions where evaluation is a major function. In some countries UNIDO has assisted in establishing industrial studies or development centres or investment production centres which facilitate the building up of evaluation capabilities. Such evaluation however does not necessarily grapple directly with the choice between alternative technologies. Technology is often taken as a constant and not as a variable. Many developing countries do not appear to have made a systematic examination in their own context of the implications of the choice of technology and the criteria to be applied in such a choice.

B. Acquisition of technology

25. In the actual acquisition of technology, the capabilities required are in the adequate specification of the technological services required and in the negotiation of the terms and conditions. Entrepreneurs have not, with notable exceptions in the more advanced of the developing countries particularly,

---

1/ See UNIDO, Guidelines for Project Evaluation (E.72.II.B) and Guide to Practical Project Appraisal (E.78.II.B.3).

significantly built up such capabilities. This compounds their weak bargaining position. Guidelines for negotiation, model contracts, and investment promotion institutions serve to assist the entrepreneurs in this regard.[8/] In addition, government regulations on the import of technology has been found to help not only the governmental objectives but also enterprises.

26. Governmental regulation of imports of technology which constitute an institutional base for building up such capabilities exist however in only about a dozen developing countries.[9/] In other words, such regulation does not exist in the majority of developing countries. The reasons for this are many. Some countries have not been aware of the value of regulation and others have perhaps made a conscious decision not to have such regulation at present. Among the latter category are countries which regard themselves as not having yet reached a stage of development when such regulation can be considered necessary. Yet others are faced with financial and managerial resource constraints, and they believe the climate for foreign investment would be upset by the regulation of technology imports. Financial and manpower constraints thus induce technological constraints as well. Some countries perhaps consider that in their own context, setting up industries is more important at a given point of time than building up technological capabilities. In the process they may run the risk of charting a wrong course of technological development and thereby industrial development as well. Moreover, as already stated, even for importing technology and absorbing it, a measure of local technological capability is required and has to be built up.

27. Even where the capability for acquisition is built up through regulatory institutions, the direction of such regulations vary considerably. With the exception of India and the Republic of Korea, governmental regulation has been generally introduced only in the 1970's. Such regulation has however generally concerned itself with limiting the size of payments and avoiding restrictive clauses. They have also helped to build up indigenous technological capabilities by not allowing restrictive clauses which may have an adverse effect on such capabilities and more importantly, by not allowing the import

---

8/ See UNIDO's Guidelines for Evaluation of Technology Transfer Agreements (forthcoming as UNIDO's DTTS No. 12). Also model contracts have been prepared and discussed in consultation meetings organised by UNIDO.

9/ The countries include: Andean Group countries, Argentina, India, Malaysia, Mexico, Philippines, Portugal and the Republic of Korea. The nature and extent of regulations vary from country to country.

of technology when technology is indigenously available. However, monitoring and follow-up of imported technology have not yet become the strong points of the regulatory agencies. Nor do they appear to have contributed significantly to disaggregating the technology packages offered for import, or developing sector-wise technology policies based on an assessment of the state of the art in the respective industrial sectors.

28. The regulatory agencies could contribute in several ways to the development of indigenous capabilities.[10/] India and the Republic of Korea, for example, require the association of indigenous consultants whenever consultants are required in the process of importation and absorption of technology. In India, it is also required of technology importers that they should set up R and D facilities within a stipulated period. Provisions for sub-licensing and central purchasing of technology are also conducive to the growth of indigenous capabilities.

29. The technological implications of foreign investment policies perhaps require greater attention than hitherto. Several countries have adopted policies for inducing investment, in some cases alongside imported technology regulations. In cases where the foreign investor decides the volume and build-up of production, the manufacture of components or the use of local raw materials and other facilities, the number of expatriates and the nature and extent of training of local personnel, care has to be taken that such decisions are conducive to the growth of indigenous technological capabilities.

C. Adaptation of technology

30. The adaptation of technology to local conditions, raw materials and markets would also require the availability of skilled manpower and their actual experience in production for at least a few years. This stage has apparently not been reached except in the more advanced of the developing countries. More importantly, adaptation of technology could be done by

(a) engineers and technicians within an enterprise when it finds it necessary to adapt the technology it uses on account of economic incentives or compulsions;

10/ See UNIDO, The Role and Functions of Technology Regulatory Agencies in Technical Development, ID/WG.275/7.

(b) industrial research institutes; and

(c) consulting engineers.

Developing countries as a class do not appear to have initiated policies involving incentives or compulsions for adaptation. On the other hand, the environment of a protected market is of little help to adaptation.

31. Only in a few developing countries such as Brazil, India, the Republic of Korea, Yugoslavia, etc. have consultancy engineering capabilities been created in any significant measure. In several other countries consultancy engineering firms have come into being but their experience and versatility are limited, often confined to civil consultants of equipment suppliers or other consultants from abroad.

32. In general, most developing countries are found to lack in technological service capabilities. Such services range from macro-level industrial planning to micro-level project identification, feasibility studies, plant specifications, detailed engineering designs, civil construction and machinery installation, and the commissioning, start-up and operation of plants. The most significant gap even in fairly industrialized developing countries, is in detailed engineering and designing and in sectoral consultancy services through nationally owned units. This makes the disaggregation of imported technology packages extremely difficult and creates a critical lack of infra-structure, resulting in an undue dependence on foreign design and engineering services with their consequential impact on the pattern of investment for particular projects and on the requirements of capital goods and equipment as well as on subsequent plant operations and management. In other developing countries, the gaps in consultancy services are even more marked and extend to almost the entire range of services indicated above.[11/]

D. Absorption of technology

33. The question of absorption of technology involves in a narrow sense the conditions necessary for the absorption of a particular technology, whether imported or indigenous. Here the technical qualifications and experience of the manpower are undoubtedly important. Often the transfer of an alien technology to a totally different sociological environment creates problems in absorption and requires special efforts on the part of transferors as well as

---

11/ UNIDO, The Role and Functions of Technology Regulatory Agencies in Technological Development (ID/WG.272/7), p.11

transferees of technology. The absorption will be considerably facilitated if the technology contracts specify in detail the number of persons to be trained and the nature of training to be provided by the transferor of technology. The actual number of persons trained as part of technology contracts has been found to vary not only with the nature of technology and the type of technology contract (including whether foreign investment is associated or not), but also with the countries of origin of the technology suppliers.

34. In a broader sense however, the question of absorption of technology raises the basic problem of human resource development in developing countries. The base for absorption as indeed of technological development is provided by qualified engineers and scientists, middle level technicians and skilled labour. As regards engineers and scientists, the situation in most developing countries is marked by both paucity in numbers and less than full utilisation of their capabilities. Educational facilities for this purpose are relatively lacking and the university traditions and curricula are not such as to promote their capabilities in, or association with, applied research and production activities. Several relatively small developing countries also lack the necessary scale of requirements to have fully fledged technical institutions of various types. Another phenomenon in certain developing countries is that of "brain drain" involving the export of much needed technological manpower. Generally speaking, requisite educational policies and manpower plans for projected requirements are still at an initial stage in developing countries.

35. As regards middle level technicians and skilled workers, training facilities have been created in some developing countries for a variety of basic industrial skills such as fitting, turning, welding, etc. Such capabilities can however only thrive in an environment where they find opportunities for gainful application in production. Besides, horizontal mobility of such skills within the country could substantially promote the absorption of technologies. No systematic data are available to indicate that such mobility is a prominent feature in developing countries.

E. Development of technology

36. Development of technologies is regarded as a major desideratum by developing countries. However only in a few developing countries do industrial establishments have research and development units of their own and even these

have a limited research and development record and with very little horizontal transfer. In general, whatever research takes place in developing countries is by and large government funded through industrial research institutes or universities. This expenditure, which does not exceed 0.4 per cent of the Gross National Product of the developing countries, is often spent on basic rather than applied research on schemes not necessarily drawn up as a result of clearly defined industry related priorities. In some developing countries voluntary agencies and institutions are attempting to promote appropriate technology in one or more specific sectors. But they tend to be small, lacking in government support and away from the mainstream of industrial activities. They have thus not been able to make any significant impact on the technological development of the countries concerned. The number of developing countries which have activities for invention promotion or patent registration is also small, thus hardly providing any impetus to the innovative capabilities of the local population.

37. The approach to industrial research is itself generally more Western-based than inward looking, contributing very little to the technological advancement of locally used technologies and solving the problems of the rural areas. Thus several developing countries may find that the starting point of their efforts to develop technologies may itself have to be changed so that their technological development does not take on an enclave character.

38. The capabilities for innovation and development of technologies are not only subject to financial and manpower constraints but reduced in their effectiveness by the circumstances mentioned above. The commercialization of research findings requires a much larger degree of technological manpower and financial resources for services such as product and process development, pilot plant, plant design and installation, process adjustment, advice on manufacturing operations, quality control, product and process improvement, etc. With a few exceptions, such skills and services are lacking in developing countries.

39. While most developing countries have placed heavy reliance on industrial research institutes for their technological development, it can be safely stated that the mere presence of the institutes has been no guarantee for much development. The number of processes commercialized by them have not been significant. Except for the least developed countries, most developing countries have one, and often more, research institutes. Some countries even appear to have too many research institutes to function in an effective and

co-ordinated manner. The research institutes established have been of various types but by and large, with a handful of exceptions, they belong to the categories of government controlled, autonomous state-aided or quasi-governmental institutes. There are both single purpose and multi-purpose institutes and single sector and multi-sector ones. At one end of the spectrum are institutes providing quality control and testing services in a single sector of industry and at the other end are multi-sector ones with services extending to applied research, pilot plants and extension and consultancy.

40. The constraints of the institutes functioning in developing countries have been well documented[12/] and need to be only briefly referred to here. Such constraints may be classified as internal and external.

41. The internal constraints include:

(a) mistakes most frequently made at the initiation such as:

(i) too ambitious a structure and choice of director and key personnel with inappropriate training and experience; and

(ii) failure to assess the applied research and development needs of the nation and industry before building and staffing the laboratory.

(b) Operational short-comings such as:

(i) inept management;

(ii) lack of business orientation;

(iii) wrong type of staff;

(iv) inadequate remuneration of staff;

(v) lack of mobility of staff;

(vi) lack of priority based research;

(vii) lack of commercialization efforts;

(viii) lack of a package of services to industry;

(ix) lack of guarantees for technology developed; and

(x) lack of compulsions to do contract research.

42. Among the external constraints are poor contacts and co-ordination with industry and government, lack of adequate funding and indiscriminate importation of technology.

12/ See, for example, "Guidelines for Development of Industrial Technology in Asia and the Pacific", Ch. IV and V. (ESCAP, 1976).

43. Even if these constraints are removed, one major problem of technological development will remain, which is how to transmit the impulses of technological development to the rural areas and to the vast majority of the population in order that the general level of technological awareness and capability of the population as a whole (as distinct from the number of scientists and engineers) can be improved. This is a problem which has not been adequately considered by either the developing countries or international thinking.

V. MAJOR CONSIDERATIONS IN AN INTEGRATED STRATEGY

44. The foregoing survey, necessarily general, shows that while developing countries are aware of the challenge of developing technological capabilities, their response has varied. The elements that go towards constituting such capabilities and the factors that influence them are so numerous and varied that policies and actions have generally been compartmental and unco-ordinated. The important task is that the national efforts combine to produce a synergistic rather than a mutually cancelling effect. An integrated strategy is obviously indicated. It will no doubt have many facets and may require action over a wide area of governmental and public activity. The strategy should be to not only create specialized and skilled manpower resources within the country but also to ensure that such resources are deployed in the desired directions. In doing so the basic issues of indigenous technological development should not be ignored.

A. Development goals

45. It is increasingly recognised that wrong choice and application of technology can distort the pattern of industrial and economic growth and that many developing countries have found that the fruits of their growth have not spread to the population masses. Consequently technology policy has to be viewed as a derivative of the industrial development strategy which itself has to be derived from the overall development goals of the country.[13/] Thus it is the overall development goals that will provide the raison d'être and basic shape to any strategy for developing technological capabilities.

13/ This is a major theme of UNIDO's International Forum on Appropriate Industrial Technology (New Delhi and Anand, India) which was specially organized as an input to the UNCSTD. See Reports of the Ministerial-Level Meeting and Technical/Official-Level Meeting ID/WG.282/123 and 124. See, for example, Conceptual and Policy Framework for Appropriate Industrial Technology in Developing Countries, Discussion Paper (ID/WG.232/112).

46. Indeed a fundamental question which each developing country has to ask itself is whether the development of its technological capabilities is going to take on the same enclave character as that imparted by foreign technology imports or whether such capabilities will be more widely spread in the sense that the general technological level of the population as a whole is enhanced and consequently its efficiency, productivity and prosperity can be increased. The foundation for the latter type of technological development will have to be much deeper and stronger than for the former. If technology is an instrument of oppression between "have" and "have-not" countries, it can equally become so between the "haves" and "have-nots" within a country. Consequently, developing the capabilities for the relatively less sophisticated activities of the rural areas should be an essential part of any strategy. Hence internal transfer and indigenous adaptation and development of technology are far more important than is commonly realized. This is a truly indigenous task which no foreign country, least of all a developed country, can perform.

B. Human resource development

47. This is a major task to be viewed far beyond the confines of conventional manpower planning. First of all, the phrase "technological manpower" has to be viewed in a broad context encompassing the technological improvement of a wide variety of occupations and not simply as a set of specialized technical services. Secondly, in a social context, technological capability has to be viewed and planned not merely as a matching input in a productive process (as it would be in a private context), but as an infrastructure or 'external economy' to be provided ahead of demand and in an all pervasive way.

48. In this sense, development of technological capabilities should be considered synonymous with human resource development. All too often, the people of the developing countries are looked upon as beneficiaries of technology rather than as generators and users of technology. A large population can be a source of strength rather than a handicap if they possess the capabilities for improving their economic well-being. Most developing countries have come to recognise that opportunities for education should be provided to as large a selection of the population as possible. Such opportunities should predominantly include the opportunities for acquiring technological capabilities.

49. Human resource development will require a series of practical steps, often unspectacular but fundamental. Such steps will include the large-scale

training of artisans, the improvement of traditional technologies and occupations, the promotion of self-employment, a vocational orientation to school curricula, a rural orientation to engineering and diploma courses, problem-oriented approach of research institutions to traditional technologies and rural areas, etc.

C. Growth points

50. Growth points for technological capabilities reside in certain sectors which may need special attention.[14] The modernization of agriculture not only upgrades the agricultural techniques and increases the incomes of the farmers but also brings to their field several new implements, and more importantly brings home to them the benefits of the application of modern science and technology. Transport development not only opens up the hinterland but can encourage repair and maintenance capabilities. Widely spread and small-scale agro processing industries (such as rice and oil mills) also carry with them the seeds of diffusion of technology and the improvement of local processing methods.

51. An engineering industry is the generator and transmitter of technological capabilities par excellence.[15] Casting, forging, welding, fabricating, etc. not only promote the respective skills but mark the beginning of machine building capabilities, promote design consciousness and provide the first insights for the disaggregation of an equipment or technology package. The engineering industry "establishes the very essential skill base for technical progress. It permits the indigenous development of appropriate technologies and their innovative developments. It helps to eliminate the critical shortage of spare parts experienced by many developing countries, - learning to tinker with things is the first stage towards the discovery of appropriate technology and there is nothing better than mechanical, electrical and electronic workshops to give this necessary on-the-job training.[16]

14/ See UNIDO Development Policy to Strengthen Technological Co-operation by D. Ernst (ID/WG.301/1).

15/ UNIDO, Development of Infrastructure for Engineering Industry in Developing Countries by S.M. Patil (ID/WG.301/5).

16/ UNIDO, Industrial Development Strategies and Choice of Appropriate Technology in Developing Countries, Background Paper (ID/WG.282/113), p.11.

52. Since electric power is an indispensable part of the development of all developing countries, capabilities for operating and running power generation and transmission systems and later, on the manufacture of at least the simpler electrical items such as distribution transformers and transmission towers, are too important to be ignored.

53. Mobility of technical manpower and skills is an important agent for the diffusion and growth of technological skills. This mobility has to be promoted by each country within its own context.

D. Technology Plan

54. The identification and activation of growth points, leading sectors and key result areas is too important to be left to chance or piecemeal action but should logically form part of a Technology Plan. The phrase "Technology Plan" may invoke degrees of sophistication and detail that could appear forbidding to some developing countries who are grappling with the more immediate problems of industrialization. What is important is the concept and approach symbolized by the Technology Plan, viz. that a comprehensive framework for national action which is consistent in its effects and time sequence should be created. Such a framework is proposed here. Each developing country may choose its own starting point within the framework depending on how much ground it has covered already and what its needs are. It may also adopt its own time-frame and take up those elements of action which are suitable in its context. Common to all developing countries in any national action should be the awareness of technology as a resource, clarity about the ends of its generation and use and consistency in the means adopted to achieve the ends.

VI. FRAMEWORK FOR NATIONAL ACTION

55. The framework for national action proposed here consists of four self-evident steps which will be discussed in detail:

(a) A broad consensus on the desired mix of appropriate technology and the pattern of national technological capabilities;

(b) An assessment of the present status of technological capabilities and identification of gaps and shortcomings;

(c) Strategy formulation in terms of policies, programmes and institutions, together with the financial and manpower resources needed for its implementation;

(d) A re-assessment of the coherence of ends and means as well as arrangements for co-ordination and monitoring.

56. The framework is designed to avoid piecemeal action or the incorrect understanding that once action has been taken in one or two directions the rest will take care of itself.[17] It is based essentially on the three pillars of policies, programmes and institutions. Policies by themselves can only act like valves which channel or shut off the flow of national resources and energies. The creation of such resources and energies has to be effected through specific programmes of action, with emphasis from policies giving the lead. Institutions are instruments of implementation and can only be as effective as the policies and programmes that back them, although over a period they can themselves help generate policies and programmes. What needs to be avoided is an excessive reliance on any one of these three factors at the expense of the other two.

A. National consensus on technology mix

57. The first step requires the achievement of a broad consensus on the desired mix of appropriate technology and from there the pattern of national technological capabilities. Though in a general sense technological capabilities will be required whatever the technology mix, clarity is essential for the generation of particular types of capabilities. The latter will in turn be derived from the development objectives. If the benefits of technology should spread throughout the population, then its application and the capabilities required should cover a very wide field of national activity.[18] Hence it can be said for all developing countries that the basic common skills should be generated abundantly and existing technological skills should be upgraded rather than uprooted. Subject to this, the technology mix and therefore the desired pattern of technological capabilities may vary for each country. In a labour surplus economy the emphasis may be on labour intensive industries while in developing countries with a shortage of manpower, labour-saving technologies and skills to operate sophisticated machines may require special attention. In the cases of export-led growth the technological capabilities of the export

---

17/ See UNIDO, Integrating Technology and Development by I.H. Abdel-Rahman (ID/WG.301/6)

18/ See op. cit. Report of the Ministerial-Level Meeting, Anand, November 1978.

industry sector would receive priority. Wherever possible the desired levels of particular technological skills should be quantified. Broad norms should be adopted bearing in mind that technological skills should be created as an infrastructure ahead of demand rather than as an ad hoc response to demands as they emerged at a particular point in time.

58. The choice of the appropriate technology mix will have considerable economic and social implications. Besides, interaction between generators and the uses of technological skills should be brought about at the outset. Policy makers and planners in developing countries should therefore seek to achieve a broad consensus in this respect among the concerned government departments, universities and academic institutions and industry.[19/] The national dialogues that have taken place as part of the preparatory steps for the United Nations Conference on Science and Technology for Development are relevant in this respect. Reviews of such a broad consensus will be required periodically. The government of each developing country will have to identify or establish a mechanism which will have the responsibility for organising such a review.

B. Assessment of present status

59. An assessment of the present status of technological capabilities and identification of gaps and shortcomings has not been systematically carried out in many developing countries. It is however a prerequisite for the proper formulation of a strategy. In order to ensure maximum objectivity persons and agencies not belonging to the particular sectors assessed will have to be associated. The assessment may include the following activities.

Technological manpower

60. The strength of the existing technical and scientific manpower has to be assessed as should its current deployment and pattern of utilisation. The likely growth of the manpower based on current trends has to be estimated. The extent of "brain drain", if any, has to be assessed. The whole exercise has to be done keeping reallicative possibilities in mind, since additions to manpower may require a gestation of three to five years, short of reversing "brain drain" or bringing in expatriate manpower. The categories of manpower to be assessed

---

19/ See UNIDO, Science and Technology for Development by Y. Nayudamma (ID/WG.301/3)

would include scientists, science graduates, research and development personnel, teachers, engineers (civil, mechanical, electrical, chemical, metallurgical, electronic, etc.) engaged in production, teaching, consultancy, design and other occupations; middle level technicians of various types; trained artisans; traditional artisans, etc.

Indigenous technologies

61. Many developing countries do not have a clear picture of the traditional technologies available to them.[20] Such technologies, which are appropriate to their conditions and are particularly relevant to rural areas and to activities like agro processing and building materials and construction, have to be systematically assessed with an eye to their improvement by the application of modern science and technology. This would mean that existing traditional skills will be upgraded and the general pool of technological capabilities enlarged. It is necessary that research institutes of developing countries are actively associated in such an assessment.

Sectoral developments

62. A survey and assessment of the status of technological advance and of technolgical manpower in specific sectors should be made. The sectors would include not only individual industry sectors but technological service capability areas such as consultancy, design, construction, etc. Industrial sectors of priority would include agro-processing and engineering industries as well as those considered as being priority sectors in each country. The survey should cover not only large-scale industrial units and technologies, but small-scale and traditional ones as well.

Impact of policies

63. It is important to examine the role of policies in order to see whether they promote or affect indigenous technological development and growth of technological capabilities. Here both promotional and regulatory policies have to be examined.[21] Apart from explicit technology policies, industrial,

---

20/ See UNIDO, Technologies from Developing Countries. DTT Series No. 7 and ID/WG.282/65. UNIDO has initiated (as a part of INTIB) efforts enabling developing countries to compile their own technologies.

21/ UNIDO and UNDP are examining proposals to undertake detailed case and country studies.

trade, financial and fiscal policies have to be examined since they indirectly affect the technology mix, and often do so more powerfully than technology policies themselves. For example, industrial policies may permit the establishment of units which are too large where smaller units could do as well, thereby making a draft on specialized technological capabilities not readily available within the country. Similarly trade policies may permit the import of sophisticated and large capacity equipment whereas skills and capabilities may already be available within the country that could produce somewhat less sophisticated equipment. Examples can be multiplied. An important test to be applied is whether the various policies produce a synergistic or a mutually cancelling effect.

Internal diffusion of technology

64. The state of diffusion of technology within the country and the existence of conditions to promote such diffusion should be assessed. Internal mobility of technical personnel promotes transfer and diffusion of technology within the country and enables the training and transfer of skills to a much larger number of persons than would otherwise be possible. The economic relationship between the urban and rural areas have to be examined to see how the strengthening of such relationships could contribute to the growth of technological skills in the rural areas. The facilities available for the encouragement of innovation have also to be examined.

Technological institutions

65. A survey and assessment of the technological institutions available, the functions performed by them and the potentialities of their development is essential. Technological institutions should not be construed in the narrow sense of industrial research institutions alone.[22/] The survey should cover information centres, project formulation and evaluation centres, investment promotion agencies, investment boards, technology regulating agencies, productivity councils, design institutions, consultancy and other technological service agencies, extension centres for small industries, institutions for technological education, research institutes, etc. The reason for this is that their activities will impinge in some way or other on technological development. The institutions may be promotional, regulatory or service institutions.

22/ See in this connection, UNIDO, Utilization of National Technological Institutions in the Developing Countries for Industrialization, Report of an Expert Group Meeting (ID/WG.246/6).

In this sense it may be better to think in terms of functions or services rather than institutions per se, since ultimately what is required is not the institutions themselves but the functions or services to be performed. The functions and services and the institutions should then be correlated. Voluntary agencies concerned with appropriate technology should also be covered. In assessing the institutions one should not only go by their numbers, the number of technical personnel employed and the expenditure incurred, but by their output. The possibilities of strengthening the institutions, extending the scope of their activities to include more functions and services, avoiding duplication in their work and ensuring co-ordination should be identified. The place of the respective institutions in the governmental set up, their involvement in decision making for industrial and technological development and the contacts they have with industry and the public are critical factors in assessing their effectiveness. In regard to research institutes, their role in essential technolgical functions such as extension, pilot plant and commercialization of technologies should also be assessed.

C. Strategy formulation

66. The practical formulation of the strategy in terms of policies, programmes and institutions, will vary for each country in accordance with its conditions, requirements and priorities. While specific actions are suggested illustratively in what follows, the emphasis is on providing a framework for action.

Policies

67. The broad consensus referred to earlier will itself bring out the broad policy goals to be adopted. But they have to be incorporated in specific policy instruments which may be regulatory or promotional or of a short- or long-term nature. While some of these instruments have to be actually embodied in industrial, trade, fiscal and financial policies, there is a need for formulating a policy for technological development, drawing upon the consensus. If possible, a "Technology Policy Reclamation" or Resolution could be adopted by the government.

68. In further discussing the policy instruments it is convenient to revert to the classification of technological capabilities for selection, acquisition, adaptation, absorption and development of technology. Such capabilities can be fostered only if conditions are created in which these processes are facilitated. The policy measures to be taken should answer to this requirement also. Such

measures could be general or selective for particular industries or services, as required. The cluster of policy instruments outlined in this paper have to be interpreted and applied according to the varying needs of the countries.

69. Policies to promote the selection of appropriate technology could include, for example:[23]

(a) Differential direct and indirect taxation (e.g. tax exemption or lower taxation for products/enterprises in the small-scale sector or utilizing newly developed or indigenous technologies; taxes on imported equipment or technologies);

(b) Differential financial and credit policies (e.g., lower rates of interest and liberal credit for products/enterprises in the small-scale sector or utilising newly developed or indigenous technologies);

(c) Industrial policies concerning size of units and criteria for expansion (e.g. certain products could be reserved for manufacture in the small-scale sector; policies discouraging more assembly industries based on imported components);

(d) Trade policies on import of capital goods or raw materials (e.g. import control; not permitting import of equipment of too large a capacity; phased programmes for the reduction of import content of raw materials and components);

(e) Policies on foreign investment and import of technology (e.g. discouraging turnkey contracts; not allowing foreign investment or import of technology in specified areas; associating local consultants or research and development institutions in selection).

All these will involve on the one hand an "infant industry" protection to indigenous technologies and technological capabilities and on the other, a compulsion to use them in preference to imported ones.

70. Developing countries may like to adopt, as about a dozen of them already have done, a policy for acquisition of foreign technology.[24] This policy should not only cover technology per se, but equipment (which embodies technology) and foreign investment (which is a vehicle of technology and invariably predetermines it). Such a policy will obviate distortions in the pattern of industrial growth, besides avoiding an undue outflow of foreign exchange. It should have both regulatory and promotional aspects. It should protect indigenous technologies and technological capabilities where they are available

---

23/ See UNIDO, Report of the Second Consultative Group on Appropriate Industrial Technology (ID/WG.279/12) and also Reports of the International Forum on Appropriate Industrial Technology.

24/ See UNIDO, National Approaches to Acquisition of Technology, DIT Series No.1 (ID/18[illegible].

and satisfy national requirements. It should encourage inflows where there are gaps in production, technologies or technological capabilities. Technologies which need to be protected and those which need to be encouraged to grow could be specified as a matter of policy. A mechanism for screening technology contracts will also be necessary. Such screening could ensure that the technological services required are clearly specified; technology packages are unpackaged wherever possible to admit contributions from indigenous technological capabilities; adequate provision should be made for the training of local technicians; there should be no unwarranted restrictions on the further dissemination of the technologies and the technological capabilities involved. Although each developing country may have its own approach towards the extent of promotion or regulation of foreign technology, the establishment of a screening mechanism will enable the continuous and systematic monitoring of foreign technology inflows which does not exist in many developing countries at present.

71. Policies could also promote adaptation. For example, adaptation to the satisfaction of a technical authority could be imposed as a condition in contracts for acquisition of foreign technology. Costs of adaptation could receive preferential treatment in taxation. Adaptation to local raw materials and components could be secured through a policy of phased programme of reduction of imported raw materials and components.

72. Absorption of technology in a narrow sense could be facilitated by policies which insist that foreign technology/investment inflows be accompanied by adequate training of local personnel both in terms of the number of persons trained and the extent of their training. The passing of a National Apprenticeship Act whereby each industrial unit is required to take a certain number of apprentices for training would also enlarge the pool of trained personnel. Free horizontal occupational mobility has also to be ensured. There are no known direct policy instruments for this purpose. However, general policies which do not unduly restrict the setting up of new units in the same industry may help incidentally. Policies for attracting the country's technical personnel resident abroad either for permanent settlement or for short-term guidance should also be formulated and implemented, as is already being attempted by a few developing countries.

73. Long-term policies for the absorption of technology should concentrate on human resource development so that the general level of technological capability may well be required in traditional societies. Policies that promote a greater involvement of scientists and technicians in the development problems of the country will be needed including the restructuring of their salaries and responsibilities wherever necessary.

74. Developing countries will have to make serious reappraisals of their educational policies particularly in the following respects:

(a) introduction of a vocational content in the school educational curricula and making such courses available to as large a number of students as possible;

(b) re-orienting the technical courses at the university level so that the awareness of the students to the technological problems in the country, particularly with reference to rural areas is enhanced; and

(c) educational curricula should include association with industry and practical training.

75. It will be useful at this stage to consider policies for the enhancement of technological service capabilities. To strengthen civil construction capabilities, it may be necessary to stipulate that civil works in industrial plants be done by local civil engineering organizations and where the work necessarily has to be done by foreign organizations, this should be done with the association of the local organizations. In setting up large steel plants, fertilizer plants, etc. it may be useful to ensure that local units for detailed engineering designs and drawings are set up as a matter of policy. The orderly growth of engineering design and consultancy organizations can be promoted by suitable policies for their regulation and development. The Republic of Korea has legislation on this subject. In India, it is a condition of industrial approvals that if foreign consultants are employed on a project, an Indian consultant should be the prime consultant. Financial institutions and research institutes should also be asked to increasingly take on consultancy assistance as part of their functions.

76. Policy measures thus have a key role in the development of technologies and in the creation of technological capabilities. For the promotion of research and development, access could be levied on industry (e.g. in the Philippines for the textile industry) and the proceeds utilised for research and development purposes. A tax rebate could be allowed on the research and development expenditure of companies to encourage them to set up such facilities. In India it is part of the condition of approval for the import of technologies, that the importing unit should set up research and development facilities within the period of the contract so that the need for continuing the import beyond that period may be obviated.

77. To preserve traditional technologies and capabilities, protection could be given to them by way of reservation of lines of manufacture, policies of government purchases, etc. The adoption of technologies developed locally (e.g. by research institutes or industrial enterprises) could be encouraged by tax interest concessions or by liberal conditions of industrial approvals.

78. For widespread dissemination of technology and for encouraging innovative capabilities, the promotion of self-employment and techno-entrepreneurs should be encouraged as a matter of policy. Concessional financial assistance through financial institutions will particularly help in this respect. Policies for worker participation in production and technology decisions will be of help. Patent laws and financial encouragement for innovations and their application are necessary. Special incentive schemes to universities and academic institutions for promotion of innovative activities may have to be devised.

Programmes

79. Programmes for the development of technological capabilities should be drawn up and implemented whether as part of a technology plan or otherwise. The preceding discussion itself indicates a number of areas in which concrete action programmes have to be initiated. The following would appear to constitute a minimum programme in this respect.

80. Programmes of technical education for various scientific and engineering courses have to be implemented. Systematic training of skilled workers has to be imparted in respect of a number of skills through the establishment of industrial training institutes. Detailed manpower planning will have to be carried out for this purpose. With regard to university and other advanced courses, the requirements of manpower may not justify the immediate establishment of institutions and courses in the case of some developing countries. In these cases, regular arrangements for technical education have to be made, preferably in other developing countries.

81. Short-term training programmes have to be organized on a systematic basis for acquiring technological capabilities of different kinds. These will include for example, training of information scientists and engineers for obtaining and processing technological information; training of managers, entrepreneurs and government officials in the evaluation, negotiation and acquisition of technology and training of research and development personnel in the management of research and development, evaluation of research and development projects,

commercialization, extension work, liaison with industry and other related matters. Training programmes and sensitizing courses are necessary for policy makers in project and technology evaluation and the implications of choice of technology. Special courses may be necessary for technical personnel in such aspects as design, production engineering and productivity. In-plant training programmes for engineers and skilled workers are essential. While some of the programmes referred to could be organized within a country itself with the help of outside experts wherever necessary, there are others in respect of which the training may have to be imparted in developed or other developing countries.

82. As already stated, programmes of development of certain "technology-lead sectors or a few priority sectors" have to be drawn up since they will provide the growth points for technological capabilities. While each country could identify such sectors with reference to its own conditions, priority sectors in general would be agro-processing industries, engineering and metal-working industries and electricity generation and distribution and the like.

Institutions

83. While policies and programmes require institutions or agencies to implement them, the role of institutions should not be overestimated as if they were a panacea by themselves. The value of institutions lies in that they provide a measure of continuity and collective interaction of experience and in due course become repositories of technological capabilities. At the same time they can be only as good as the policies and programmes they help to implement. Institution-building can be quite expensive and can also raise a host of co-ordination problems. On the other hand, the problems of developing technological capabilities are too numerous for a single institution to tackle, save by way of monitoring.

84. Developing countries have in fact a wide variety of institutional examples to choose from. They include ministries of science and technology, technology transfer centres, sectoral industry development centres, research institutions of various types, information centres, technology regulation agencies, etc. each performing one or more technological functions. A balanced approach to institution building will have to start from the functions, capabilities and services required and see how they can be provided effectively to entrepreneurs

on the one hand and government officials and policy makers on the other.[25/] Apart from institutions for technical education and training, at least three basic types of institutional functions may be required. One type relates to technology policy formulation and monitoring at the macro-level as well as technology screening and evaluation at the micro-level. These functions have to reside in a government department or agency, suitably located in the governmental set up to influence decision making. Another type of institutional function relates to technological information, evaluation and consultancy assistance to entrepreneurs. These may have to be performed by an agency, governmental or quasi-governmental, which is enabled to have effective relations with government, financial institutions and industry. The third type of function relates to technology development, adaptation and commercialization with facilities for consultancy and extension work. Such functions have to be exercised by research institutions or technology development centres, which may be single or multi-sectoral, depending on requirements.

85. Several of these functions have also to be injected into ostensibly non-technological institutions such as ministries of industry, planning, trade and finance, financial and banking institutions, etc. Sectoral industry centres have to function as technology adaptation and development centres as well. Technological diffusion, particularly in the rural areas, may require institutional innovations such as those adopted in India, viz. small industries centres, district industries centres and polytechnology clinics (i.e. extension and consultancy outposts of research institutes).

86. The practical steps which a developing country should take in institution building will then be as follows:

(a) to examine whether adequate institutional arrangements exist for the technological functions described in the immediately preceding paragraphs;

(b) to create new institutions and strengthen existing ones as necessary;

(c) to ensure adequate linkages and co-ordination between the institutions, government and industry;

(d) to provide the institutions with adequate manpower, material and financial resources;

25/ Undoubtedly there is a need for redefinition of objectives and goals of existing R and D institutions to closely associate with the needs of the industrial enterprises and technology requirements of the rural sector.

(e) to create or strengthen institutions for technical education and training;

(f) to reorient the programmes of the institutions towards the major problems of the country, particularly to those of the rural areas;

(g) to incorporate technological elements into all relevant non-technological institutions;

(h) to ensure a nexus between the institutions and decision making for development; and

(i) to provide appropriate encouragement to voluntary agencies and university departments in this field.

Manpower and financial resources

87. The strategy should obviously take note of the manpower and financial resources needed for its implementation. It will first of all require an initial stock of technological capabilities to formulate policies, implement programmes and establish institutions. This would call for better deployment of existing technological manpower and reversing of "brain drain" to the best possible extent in the short run. To the extent that critical shortages of manpower exist, expatriates and experts from international organizations will have to play a supplementary role. Local counterparts should however be associated at every stage since the task is ultimately a national one.

88. No less formidable a problem will be posed in respect of the financial resources needed for the ide-ranging strategy proposed. Instead of the commonly suggested one per cent of their Gross National Products for research and development alone, developing countries may have to devote something like three per cent of their Gross National Products for development of technological capabilities.[26/] Practically the whole of the resources may have to come from the government budget in the initial period of 10 years or so. This may mean some shift in the pattern of public expenditure which is possible only as a matter of declared policy. This shift is more likely to be brought about by allocating a larger proportion of incremental increases in public expenditure for this purpose than by changing the existing distribution of public expenditure. In any event, given the scarcity of resources, priorities in implementing the different elements of the strategy will have to be drawn up.

26/ cf., UNIDO, Industrial Development Strategies and Choice of Appropriate Technology in Developing Countries (ID/WG.282/113), p.17.

D. Consistency, co-ordination and monitoring

89. An overall assessment of the strategy formulated is necessary at the policy level in terms of the consistency between its various components and its coherence to produce a synergistic effect. Co-ordination and monitoring arrangements will also need to be made. For this purpose, a technology wing in the Ministry of Industry or a separate Department or Ministry of Science and Technology may have to be created. Some developing countries have already created such agencies. It is important that the co-ordinating and monitoring agency should be in the mainstream of policy and decision making and planning, with sufficient authority to be effectively heard instead of being merely representing inter-departmental consultations. It should have a budget of its own from which it should be in a position to allocate funds to different agencies and institutions for the implementation of programmes. It should make periodical reviews of the status of development of technological capabilities and relate it to the development goals to be reached. It should be so structured that it does not become another "department" lost in routine and administrative tasks.

90. Even though each developing country may choose policies and actions to match its own requirements, it should, at the very least, re-examine and evaluate its efforts in the light of its development objectives and ensure that they are adequate, consistent and co-ordinated and take place within a clear framework for national action. The potential of such a framework will be fully realized, if the problem of development of technological capabilities is treated not as a mechanical exercise in manpower projections but as a derivative of development objectives and synonymous with human resource development. The basic rationale for the development of indigenous technological capabilities is after all that rather than give a man a fish it is far better to teach him fishing.

ANNEX

REPORT OF THE MINISTERIAL-LEVEL MEETING (EXTRACT)

The text that follows was agreed upon at the Ministerial-Level Meeting held at Anand, India, from 28-30 November 1978 as the second part of the International Forum on Appropriate Industrial Technology. It is reproduced verbatim:

I. CONCEPTUAL AND POLICY FRAMEWORK FOR APPROPRIATE INDUSTRIAL TECHNOLOGY

Appropriate technology and industrial development strategy

The meeting considered that there may be need for reorientation in industrial strategy in several developing countries in order that, while overall growth was sustained, the benefits of industrialization were extended to all sections of the population. The degree of reorientation and the choice of industries would vary with specific country situations, factor endowments and development objectives. The use of appropriate industrial technologies was considered an essential element in any reorientation of industrial strategies and programmes.

The concept of appropriate technology was viewed as being the technology mix contributing most to economic, social and environmental objectives, in relation to resource endowments and conditions of application in each country. Appropriate technology was stressed as being a dynamic and flexible concept, which must be responsive to varying conditions and changing situations in different countries.

It was considered that, with widely divergent conditions in developing countries, no single pattern of technology or technologies could be considered as being appropriate, and that a broad spectrum of technologies should be examined and applied. An important overall objective of appropriate technological choice would be the achievement of greater technological self-reliance and increased domestic technological capability, together with fulfilment of other developmental goals. It was noted that, in most developing countries, a major development objective was to provide adequate employment opportunities and fulfilment of basic socio-economic needs of the poorer communities, mostly resident in rural areas. At the same time,

some developing countries were faced with considerable shortage of manpower resources; in some other cases, greater emphasis was essential in areas of urban concentration. The appropriate pattern of technological choice and application would need to be determined in the context of socio-economic objectives and a given set of circumstances. The selection and application of appropriate technology would, therefore, imply the use of both large-scale technologies and low-cost small-scale technologies dependent on objectives in a given set of circumstances.

The Meeting stressed that the formulation of objectives and the determination of appropriate national development strategies was the responsibility of Governments. Consequent on determination of such strategy and the priorities to be accorded to various production sectors, appropriate industrial technologies should be selected and applied in the context of each country situtation. For this purpose the capacity of institutions might need to be strengthened in developing countries in order that appropriate choices were made on an informed basis. Such choice would involve taking several factors into account, such as the size of the potential market; the optimal utilization of natural resources and the exercise of national sovereignty in such utilization; role of the public and private sectors; appropriate scale of production; the desirability of geographic dispersal; capital- and labour-intensity of various techniques and processes; use of appropriate sources of energy; technical efficiency; availability of trained manpower; and the impact on the environment. Technological choice should not be confined to the production techniques only but should include management methods and other aspects of industrial operations. "Simple" technologies, to the extent that they tended to serve a specific objective, might be utilized, provided, however, that their application was conducive to techno-economic growth and did not result in

a stagnation in industrial skills and income of workers. Neither should the use of such technologies have the effect of continuing or worsening the technological backwardness of the developing countries.

The Meeting considered that, for developing countries having considerable surplus labour and requiring significant increase in employment opportunities, greater industrial dispersal to semi-urban and rural areas might constitute an important developmental objective. It was felt that inadequate emphasis had hitherto been given in most developing countries to the selection and application of low-capital and labour-intensive technologies, which would be of direct benefit to poorer sections in these countries. This needed to be corrected. The scope and potential of such dispersal in respect of several production sectors directly relevant to the fulfilment of basic socio-economic needs had been, inter alia, elaborated in the reports of the sectoral Working Groups in the Technical/Official-Level Meeting held at New Delhi on 20-24 November 1978. The reports not only highlighted various technological alternatives available in different sectors such as food processing, agricultural implements, building materials, paper products, textiles, light industries, oils and fats, drugs and pharmaceuticals and the like, but had also dealt with essential infrastructure needs of rural areas, viz, energy and transportation.

The Meeting, while recognizing that modern and capital-intensive technologies were essential in some sectors and in certain country-specific situations, emphasized that such technologies should be related to the particular factor conditions and circumstances of each country. This would require that foreign technology when acquired should not only be obtained on suitable terms and conditions but should also be rapidly absorbed and adapted to domestic conditions. Transfer of technology from developed to developing countries should be carried out on the

basis of equality and justice, without detriment to the national sovereignty of developing countries.

The Meeting stressed, in the above context, the need for close interlinkage between large- and medium-scale industries using capital-intensive technologies and small-scale and rural industries using relatively simple and labour-intensive techniques. The example of dairy development around Anand, India, as visited by participants, which effectively combined the use of highly capital-intensive techniques at the processing stage with improved traditional systems of milking and collection and organized on a village co-operative basis with the necessary government assistance, was considered to be very appropriate. It was felt that scope and potential for similar interlinkages should also be established in other production sectors in the context of resource endowments and factor conditions in each economy.

It was considered that the selection and application of an appropriate spectrum of industrial technologies could significantly accelerate the pace of industrialization in developing countries towards the achievements of the quantitative target of 25 per cent of global industrial production by the year 2000 and greater fulfilment of the qualitative objectives set by the Lima Declaration and Plan of Action. This would, however, require appropriate measures at the national and international levels. Noting the role of foreign aid in determining technological choice, the Meeting felt that Governments concerned should ensure that such aid did not result in distortions in appropriate technology use in developing countries. The application of appropriate technology also required the right international climate conducive to the establishment of a new international economic order.

Governmental policies and measures in developing countries

The Ministerial-Level Meeting was of the view that the role of Governments in developing countries was of vital significance in determining the appropriate technology spectrum and in promoting the growth of technological capability in each country. A wide range of policies and measures should be considered, including a comprehensive programme for technological development and the creation of a suitable technological environment and capability for choice and application of appropriate processes and techniques.

While foreign technology inflow and exchange would continue to be necessary, greater attention should be paid to the selection of such technologies and the terms and conditions under which these were acquired. While user enterprises should generally select the technology they considered most suitable, Governments might prescribe guidelines in this regard and also increase the bargaining capacity of such enterprises through screening of foreign technology proposals. Policy and institutional measures should also be formulated to encourage the rapid absorption and adaptation of such technologies to local conditions.

The Meeting was of the view that, since in most developing countries greater emphasis was necessary on industrial dispersal and rural industrialization together with the use of technologies appropriate to such dispersed industries, a comprehensive set of policies should be formulated for this purpose by the Governments concerned. It was felt that existing policies in developing countries had tended to favour the growth of large-scale and medium-scale industries in the organized urban sector. Policies and other measures required for effective growth of small-scale and rural industry would comprise the provision of necessary infrastructure, financial assistance and incentives, provision of technological information in suitable forms,

technological support and guidance, common service and extension facilities, extensive training programmes, adequate access to machinery and equipment, scarce raw materials and the like, together with fiscal and other measures designed to foster the rapid development of such industries. The extent to which national policies and programmes should be oriented in this direction would necessarily have to be related to specific country situations.

National technology plans

The Ministerial-Level Meeting considered that each developing country would need to formulate a programme for the growth of national technological capability and the effective utilization and development of industrial technologies suitable to their respective industrial sectors. This might require a national technology plan. Such a technology plan should facilitate the evaluation and upgrading of traditional technologies, the effective acquisition, absorption and adaptation of foreign-owned technology and the development of innovative processes and techniques. The upgrading of human technological capability should be an essential part of such a plan and should be incorporated in education and training programmes.

The essential ingredients of a technology plan or programme for each developing country could comprise (a) the identification of technological needs in critical and priority sectors in each economy; (b) the development of an effective technology information and dissemination system for identification and evaluation of technology alternatives and diffusion of innovations and adaptations; (c) the development of national technological service capacity, including design and engineering, prototype testing, quality certification, and metrology; (d) the creation of suitable mechanisms for regulation, screening, monitoring and adaptation of foreign technology

inflow; (e) industrial R and D activities of institutional and enterprise levels, and the strengthening of functional linkages between research centres and educational institutions on the one hand and production distribution and service sectors on the other; and (f) technology assessment to take account of the impact of technologies, including environmental impact and working conditions. In this connection attention was drawn to the fact that poverty in itself constituted an environmental degradation, and its removal contributed to the improvement of the human situation.

It was considered that screening of foreign technology, which had already been undertaken in several developing countries, might comprise (a) provision of guidelines for selection of technology and know-how in relation to national policies and local factor resources; (b) determination of suitable terms and conditions under which foreign technology was acquired in different production sectors; (c) disaggregation of the technology set, so that national capability for technological services and supplies of various inputs could be adequately utilized. It was felt that Governments of developing countries should provide guidelines in respect of the acquisition of technology. The screening of foreign technology proposals should also take account of alternative indigenous techniques and processes and those which had been acquired and subsequently adapted to local factor conditions.

National institutional mechanism

The Ministerial-Level Meeting considered that suitable institutional arrangements should be set up at the national level in developing countries to co-ordinate the development and application of appropriate industrial technology in various production sectors, within the framework of development objectives and factor situations in each country. The functions of such an

institutional mechanism would comprise inter alia: (a) identification of technological alternatives in various sectors; (b) co-ordination of R and D programmes relating to appropriate industrial technology in various domestic institutions and enterprises; (c) recommendations as to policy and other measures to promote the application and development of more appropriate techniques in particular production sectors.

Measures for international co-operation

The Ministerial-Level Meeting considered that greater technological co-operation among the developing countries was essential. The specific measures recommended for increased co-operation among developing countries were: (a) collection and dissemination of information regarding the experience and availability of alternative technologies; (b) greater inflow of such techniques and processes between R and D institutions and production enterprises in developing countries, including joint ventures and the like; (c) greater utilization of technological services, including consultancy engineering, from other developing countries; and (d) joint programmes for research in specific sectors, exchange of experience between expert personnel, training and the like. The Meeting endorsed the recommendations made in this regard by the United Nations Conference on Technical Co-operation among Developing Countries (TCDC) held at Buenos Aires from 30 August to 12 September 1978.

Greater co-operation between developed and developing countries was also considered essential in the context of exchange and inflow of more appropriate technologies. Technological development programmes should have necessary support of Governments of both developing and developed countries. It was stressed that greater technological exchange should take place between medium- and small-scale enterprises in developed and developing countries and that appropriate measures to encourage such inflow

should be taken by Governments concerned and by international agencies. It was also felt that R and D activities in respect of appropriate processes and techniques should be further expanded by institutions in developed countries in collaboration with counterpart institutions in developing countries. It was also considered that transnational corporations should be encouraged, where appropriate, to adopt and engage in research on more appropriate technologies for and in their industrial establishments in developing countries.

The question of an institutional international mechanism for appropriate technology was also discussed. The general view of participants was that, at this stage, greater priority should be attached to the establishment, development and strengthening of national institutional mechanisms for the development and absorption of appropriate technologies. Where found necessary, regional or subregional mechanisms could also be considered. At the international level, the Meeting considered it necessary to strengthen substantially the programme of UNIDO and other United Nations agencies in respect of development and appropriate technologies, including international instruments for this purpose. It was felt that UNIDO in particular should perform a catalytic role, especially in respect of diffusion of information on available technologies in various industrial sectors of special interest to developing countries and provision of assistance to institutions in developing countries engaged in R and D on appropriate industrial technology. The resources of UNIDO for this purpose needed to be augmented.

II. PROGRAMME OF ACTION

The Meeting appreciated the work of the 12 sectoral working groups on appropriate industrial technology and commended the programmes of action recommended in each sector for national and international action. It was

observed that, in preparing the sectoral reports, experts from developing and developed countries had collaborated with each other in formulating their overall approach to appropriate industrial technology. The Meeting recommended that joint technical work of this kind should be continued, updated and extended to new sectors.

It was noted that the working groups addressed themselves mainly to the identification and assessment of alternative technologies in the respective sectors and the policy requirements and the actions to be taken for their adoption. While it was for the individual countries to determine their industrial sectors of primary importance, the sectors covered by the experts in a sense reflected those production branches which cater specifically to the socio-economic needs of the poorer sections; those sectors which contribute to the better utilization of natural resources, and those which provide a stimulus for upgrading skills and the manufacture of such basic inputs as metals, fertilizers and chemicals. It was further noted that the detailed examination of these sectors was related not only to the consideration of employment potential both direct and indirect, but also industrial dispersal to non-metropolitan and rural areas, and provision of adequate impetus for the growth of a broad-based industrial structure.

It was noted that the possibilities of dispersal of industries and for application of relatively small-scale economically and technically feasible technologies in the sectors examined by the Working Groups were much greater than generally thought of. Accordingly, Governments in their industrial development plans and programmes might wish to place greater emphasis on R and D and other support mechanisms for small-scale industry. The exploration of such possibilities needed to be undertaken by developing countries in a systematic manner through appropriate policy and institutional

mechanisms. Attention had been drawn to a number of policy aspects such as the need for incentives both in the form of direct financial assistance and through tax exemption or differentiation; credit policy for assistance to small producers; encouragement of dispersal by methods such as licensing, adoption of standards and production designs and price and labour practices. Particular emphasis would need to be given to strengthening technological capabilities in developing countries and the development of a wide range of technological services for consultancy, design and engineering etc. The role of pilot plants, of testing centres and the facilities for demonstration was recognized as well as the need for collection of technological information and its dissemination through manuals, technological journals, films, inter-country visits, mobile exhibitions etc.

While stressing that the determination of the technology spectrum and the choice of appropriate technologies was a national prerogative, the Meeting urged developing countries to examine the policy recommendations as well as the programmes of action recommended by the Working Groups in the light of their requirements and to ensure suitable follow-up. The Governments of developing countries needed to draw up their own implementation plans and review or establish institutional infrastructure and undertake training in specialized skills to develop the capacity for choice of technology in various sectors.

The Meeting welcomed the number of offers made during the meeting of the Working Groups for raw material testing; for examination and evaluation of processes suitable for small-scale plants; for pilot plant operations and commercialization as well as the offer of bulk drugs at cost to be formulated and distributed on a non-profit basis. These and other offers of assistance would need to be followed up through bilateral assistance programmes and

through international organizations such as UNIDO, as appropriate. The Meeting also noted that the Working Groups had identified a number of techniques and processes which seemed to hold great potential for the developing countries if they were technologically further updated and brought to commercial levels of production. Theseincluded the small vacuum pan sugar mills, mini cement plants, small pharmaceutical formulation units to cater for the health care of the majority of the rural population, establishment of rural workshops, biogas units, windmills, solar driers etc. These and other valuable elements of programmes of action arising out of the sectoral Working Groups needed to be followed up in a systematic way. This would involve contacts with Governments both of developed and developing countries, discussions with technological institutions, promotion of research and development projects and providing focal points for these and other elements of the programmes of action, including their financing.

The significant role to be played by UNIDO was emphasized by the Meeting. UNIDO was requested to initiate the implementation of programmes of action through advisory and consultancy services undertaken as part of its technical assistance programmes, financing a certain number of projects through its Industrial Development Fund and accelerating the flow of information on technological alternatives through its Industrial and Technological Information Bank (INTIB). UNIDO was also requested to accelerate its programmes of co-operation among developing countries in the field of appropriate technology and facilitate inter-country exchange of experience through country visits, information exchange and other suitable means, utilizing in this connection regional and subregional mechanisms.

The Meeting emphasized the need for specialized training in regard to choice of technology, evaluation of technology alternatives, and screening of acquisition of technology in accordance with the policies of the country

concerned. UNIDO, in co-operation with other United Nations agencies, was requested to accelerate its training acitivities in this field.

It was also considered necessary that UNIDO should promote research on critical technological problems and provide guidelines for evaluation of technologies and negotiation of technology contracts and, more particularly, assist developing countries in the preparation of technology plans at the request of the Governments. UNIDO was further more requested to publish as soon as possible the documentation submitted to the Meeting as well as the valuable material submitted to each of the 13 Working Groups suitably selected and edited. An offer of financial assistance was made by Sweden to facilitate the task.

The Meeting requested UNIDO, under its existing mandate, to monitor and review the implementation of the programme of action, including any new initiatives in the field of appropriate industrial technology. The Meeting invited UNIDO to monitor progress on the implementation of the programmes of action and to inform member countries in a manner it deemed to be appropriate.