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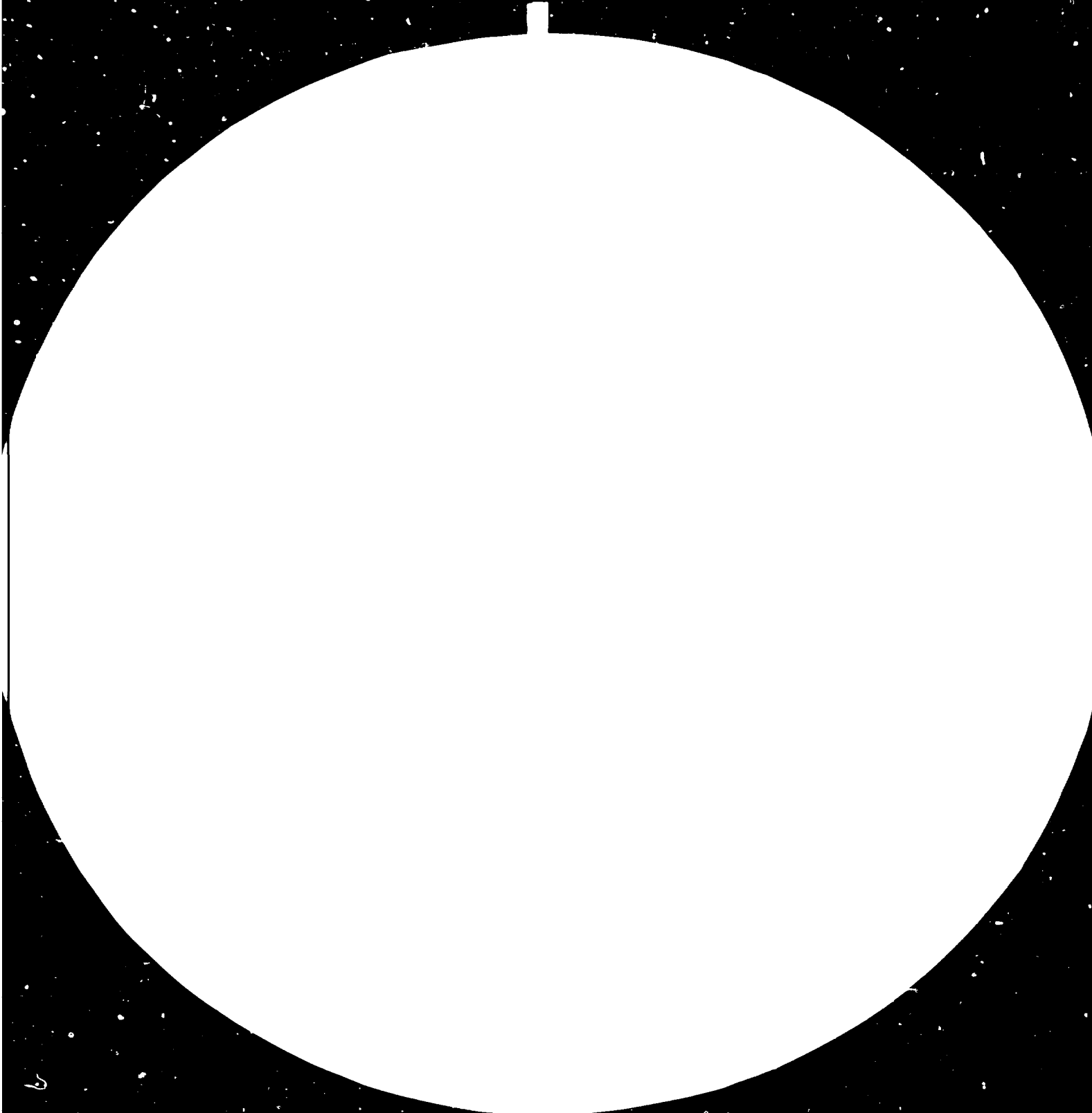

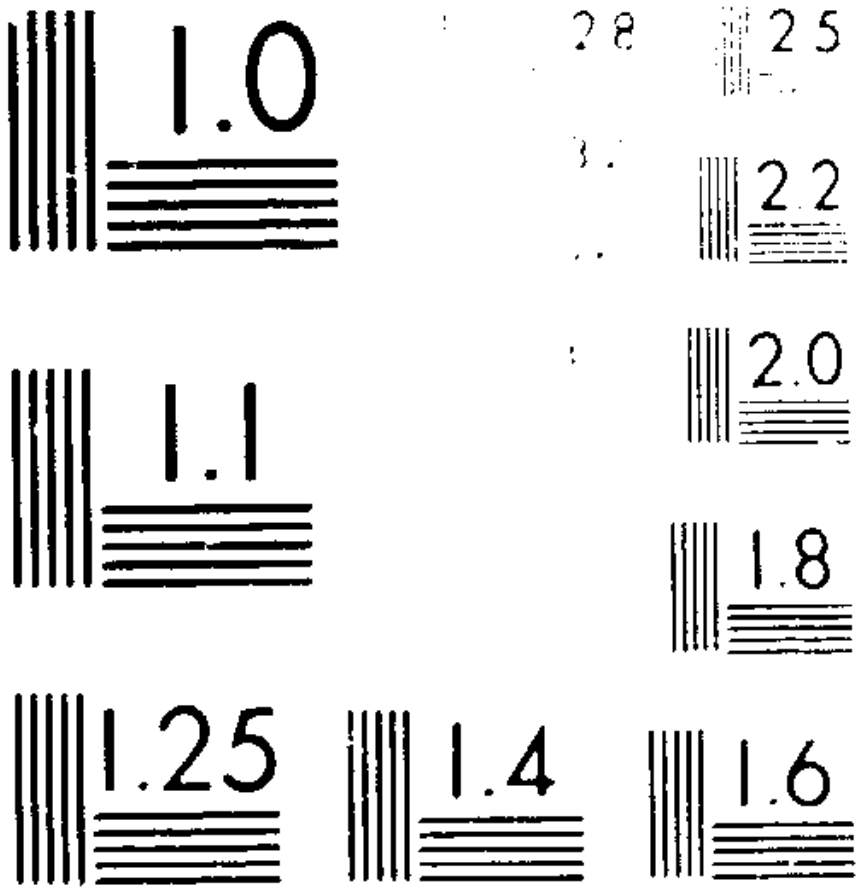
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INDUSTRIAL TECHNOLOGY INSTITUTIONS*

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CONTENTS

I. INSTITUTIONS AND INSTITUTION BUILDING

1. Policies, plans and programmes require institutions or instruments to implement them. Yet, the role of institutions should neither be over-estimated nor over-simplified, as if their mere establishment would solve all problems. The value of institutions lies in their ability to provide a measure of continuity and a collective interaction of experience so that they become, in due course, depositories of technological capabilities. However they can only be effective as the policies and programmes that they help to implement.

2. The institutional framework for industrialization is complex and may be grouped broadly according to function, for example, policy, planning, evaluation, monitoring, regulation and control; resource allocation; support services, research and development (R and D) and technology; manpower development etc. Industrialization involves the building and management of institutions that harmonize and integrate resources, technology and human effort for productive processes. As such it must be considered as a total system, consisting of a whole organization of sub-systems and elements. Technology institutions are but one of such sub-systems.

3. It is realized increasingly that the rate of industrial and economic growth is catalysed and propelled by the rate and level at which technology is applied and used. Therefore technology policy planning and programming is integrated with industrial policy and planning. The technology spectrum, apart from policy and planning, covers a wide range starting with a creative idea through research, development, engineering, design, process, production, product, commercialization, market, management etc. These are all sub-systems of the technology system. An integrated system's approach is thus called to integrate the various sub-systems of the technology system into the industry system.

4. Technological institutions contribute to industrialization at the following different stages:

(a) the formulation of industrial and technological strategies, policies, plans, programmes and projects;

(b) the initiation, implementation, evaluation and monotoring of industrial projects and programmes;

(c) the rendering of technical services to industrial plants.

A detailed account of the possible contributions of technological institutions is given in Annex I.

Institution building

5. "Institution building may be defined as the process of establishing or transforming an organization into an integrative organic part of the community in a way that will help the organization to plan a pro-active role and in projecting new values and become an agent of change in the community."[1/] An institution must be both efficient and effective. To be effective, its output should be increased both qualitatively and quantitatively against socio-economic objectives and benefits.

6. An institution should have set goals, objectives and criteria for priorities. It should have challenges and opportunities, carefully conceived roles, well-defined tasks, a clear sense of purpose and its programme should be representative of its role in society, as well as infused with societal values. An institution must have purpose, a function, an ability to survive and to serve its clientele relevant to needs, time and environment. The effectiveness of the institution is judged on its contacts with the industry, the public and by its involvement in decision-making on economic, industrial and social development.

7. The strategies and approaches to institution building will vary from country to country in accordance with environment, priorities and the level of existing institutions.

8. Much has been said about the strategies and approaches to institution building and about the master-plan approach and organization around-the-person approach. No one can deny that in any institution it is the people that count and not the buildings and equipment. This applies even more so in a creative innovative scientific institution. For a basic research establishment, where creative geniuses should be left alone, the organization-around-person approach has greater significane. Even here, in "big" science, trans-disciplinary activity needs a master-plan approach. Further experience in regard to some advances research centres built around-the-person

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1/ Institutions Building in Education and Research, ed. G. Rave Mathai et al, All India Management Association, New Delhi, India, 1972.

shows that when the person leaves, the institution collapses. Such an institution also has a tendency for a high degree of in-breeding. Rarely, one follows either the master-plan or organization-around-person approach and institutions are better built on the basis of goals, functions and programmes.

9. Experience shows that where goals are set clearly; technological tasks well defined; tasks matched with talents and a trans-disciplinary task force set-up; and given good leadership, authority and responsibility, and the necessary in-puts, time and again the institutions have delivered results on time, if not ahead of time.

Patterns of institutions[2/]

10. An integrated and co-ordinated approach is needed for science and technology competence building. Establishing institutes alone, or indiscriminately importing technology will not help in achieving the objectives. A total technology system should be covered to make each sub-system effective. Institutes should be based on goals, functions and programmes. They can be promotional, regulatory or service institutions. This calls for a netowork of institutions for:

(a) goal setting;

(b) technology information intelligence and assessment;

(c) Technology acquisition:

(d) technology generation;

(e) technology delivery and utilization;

(f) technology support services;

(g) technical manpower development;

(h) rural institutes;

(i) regional and international institutions.

2/ Ref. Patterns of Institutions Building, Y. Nayudamma, lecture at Nehru Science Centre.

The technology institutional infrastructure needed for industrial development has been well covered.[3/] Past experience in building a wide array of such institutions around the world should help in building new or reorganizing the old institutions. However, each country may choose its own patterns to suit its own conditions. The patterns of institutions to serve each functions are presented below, with illustrative models.

(a) Goal Setting

(i) Centre for Development Alternatives (CDA)

11. The basic question is development of what and for whom? Technology is the answer but what is the question... In regard to industrial development, there are presently two set models, namely the high-capital, -energy, -machinery, -management, -technology and pollution-intensive model, and the other, labour-intensive but less productive village industries model. Both are not acceptable; but then what are the alternatives? An institution may be needed to study each industry as a total production system. The sub-system of such a system are raw materials, processing, marketing, management, etc. One may study alternatives for each of these sub-systems against a set criteria, for example: the maximization of returns for natural, human and monetary resources; equitable distribution of net gains; additional gainful employment; the increasing of workers' skills and problem-solving capabilities so that they are self-reliant and self-confident and can live in harmony with their own environment. Criteria may vary from country to country depending upon the chosen path of development. Such a study will reveal that in one sub-system, sophistication is needed and another sub-system could well be labour-intensive. Such an analysis could be done only by a trans-disciplinary group of economists, production engineers, social scientists, scientists, technologists, systems analysts, financial, marketing and management experts, industrialists, bankers and administrators.

3/ Institutional Infrastructure for Industrial Development, Lawrence L. Barber, UNIDO/ICIS.36, July 1977

12. Arriving at such alternatives would help:

(a) The decision-maker both at the plant, policy and government levels to take more rational decisions;

(b) To build a trans-disciplinary culture and a task force approach to deal with trans-disciplinary development processes. Such a culture is lacking in many countries;

(c) To unpackage a total technology package and to improve the bargaining capacity in dealing with transnational companies;

(d) To keep the public, press and goverment aware of the alternatives so that they may, if required, apply "polite persuasion" and "concealed compulsion" to make the decision-maker take the right decisions.

13. Centres for development alternatives should be autonomous, with the freedom to present their findings based on systematic scientific study.

(ii) Policy and planning bodies. National Councils of Science and Technology (NCST)

14. Science and technology policies should be interwoven and integrated with economic, trade, industry, external international and other policies. From the national development goals and alternatives, flow the technology policies, and from policies the plans, programmes and priorities, sector-wise for each industry, and inter-sector-wise. For every country an autonomous institution such as a NCST is needed to undertake such a task and provide means and funds to implement technology plans. It may be located in the National Planning Commission or in the President's or Prime Minister's Office.

(iii) Promotional and Co-ordinating Agencies (PCA)

15. Promotional and Co-ordinating Agencies may act as good links between the science and technology community and policy-makers and provide a two-way flow for formulation and implementation of research policies and programmes. Such PCAs will interact with the NCST. The job of the PCA is to identify and define technology tasks; translate national needs into technological tasks; assign the tasks to the appropriate institutions, individuals or task forces; provide facilities and funds and monitor the progress of the projects.

16. Such PCAs may have laboratories under their own umbrella or support independent institutions. They may be government or private; autonomous, semi-autonomous, or registered societies, commissions or corporations. These could also be national science academies or professional institutions or associations.

17. Some examples are separate councils for secientific and industrial research; agricultural, medical, space, electronics or energy research etc. Yet another pattern found mostly in Latin America is the state-owned autonomous foundations or corporations, where the state and development banks join together, either to set up institutions and fund them or help the industrial sector to get its work done at the research institute. This pattern is used at the Institute for Industrial Technological Research and Technical Standards (ITINTEC, Lima Peru), the Centre for Research and Development (CEPED, Brazil) and the Institute for Industrial Development (INDI, Brazil).

(b) Technology Information, Intelligence and Assessment[4/]

18. Technology tasks and priorities are derived from development objectives. Technology choices depend upon available alternatives. This calls for technology intelligence which involves awareness; access to information; ability to search for, collect and assess indigenous or imported technologies and arrive at alternatives and choices. Skills are also needed to determine criteria for relevance and choice and to evaluate the economic and social cost-benefits for a project including environmental impact. Competence is needed to unpackage a technology package and to improve the bargaining position. An early warning system is also needed to make a country aware of the scientific advances which may have a great impact on national economics.

19. To obtain such knowlodge and competence a country may set up:

(a) science and technology information centres;

(b) technology banks and a registry of patent information and imported technologies;

(c) technology regulatory agencies for import and export;

(d) teams for technology assesment, feasibility and pre-investment studies etc.;

(e) teams in investment centres and industrial development banks.

4/ See the document Action in the Field of Industrial and Technological Information in Africa prepared for this Symposium.

(c) Technology Acquisition

20. All countries import technology: more so by developing countries. However, indicriminate imports are injurious to the country. Technologies should be screened in regard to:-

(a) national relevance and local factor conditions;
(b) determination of suitable terms and conditions;
(c) disaggregation of the technology package;
(d) adequate adaptation, absorption and improvement of imported technology.

21. A proper institutional mechanism is needed badly in developing countries in the area of technology acquisition. 5/

22. To screen and to choose, one should have choices and alternatives. Such alternatives may be found at institutions like CDA or technology information and assessment centres as described earlier. Such capabilities do not exist and where they do, they work in a disjointed fashion. This requires institutionalization, integrating such sub-systems into a total syste..

23. The choice should be arrived at jointly by the group that are interested in it and going to implement it: institutions concerned with goal setting, public and private industry, financial institutions, indigenous R and D and Consultancy Engineering firms and regulatory agencies. They should all be involved in choosing, adopting, absorbing and improving acquired technology.

24. Even where the scientific infrastructure is not big, a small trans-disciplinary team comprising economists, social scientists, scientists, technologists, systems analysts etc., will be able to serve this very important function. A well trained team associated with the President's or Prime Minister's office, will play a crucial role, particularly in regard to technology acquisiton.

25. The success of the Korea Institute of Science and Technology (KIST) in the Republic of South Korea is attributed mainly to its capacity in this area. Similarly, the succes of Japan is reportedly due to the fact that

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5/ See National Approaches to the Acquisition of Technology, Development and Transfer of Technology series No. 1; Functions and Organization of National Offices for Transfer of Technology (ID/WG.228/3/Rev.1). Recent Developments in the Regulation of Foreign Technology in Selected Developing Countries (ID/WG.275/8); Review of Legislative and Administrative Systems for the Regulation of Technology Transfer Agreements (ID/WG.206/2); Guidelines for Evaluation of Transfer of Technology Agreements, Development and Transfer of Technology series No. 12.

the Ministry of International Trade, export and import firms, the entrepreneur, the banker and the R and D institutes work in unision as a single team to collect information and to assess, select, adapt and improve upon the imported or indigenous technology.

(d) Technology generation

26. Scientific research is both basic and applied. A variety of research institutes exist. An institute will be effective only if it becomes a part of a total technology spectrum with well-defined goals and objectives.

27. The advice is often given that basic research is not essential for a developing country. What is basic today is tomorrow's applied reasearch. It is the basic research that gives breakthrough technologies and creative leadership.

28. Basic research is carried out mainly in universities, higher institutes of technologies, advanced research centres set up within or outside the university campus. These may be national, regional or international centres. Centres of excellence may be set up by the universities or separately funded by PCAs. As indicated earlier, the strategy of orientating organizations-around-the-person may be the best approach for such centres.

29. The applied and industrial research institutes are set up to conduct research both for problem-solving and forward-looking research and to generate, disseminate and sell technologies relevant to the national needs; to better utilize resources, to substitute imports and promote exports; to set standards, quality control and improve productivity. They should be planned as a part of the total system with firm linkages with industry and others concerned.

30. The applied and industrial institutes may be state, federal, regional, international autonomous, semi-autonomous; government corporations or societies; private, non-private foundations or research centres captive to the private industry or public enterprise, or to an individual ministry. Such institutes may be co-operative research associations, managed jointly by industry and government. Industrial research centres can also be located in technological universities and higher institutes of learning. What is important is that they are autonomous.

31. An institute may be oriented to a single discipline, for example chemistry and physics, or a single industry for example leather or food, or a single purpose or may be a multipurpose institute covering resource surveys, research, pilot plants, extension, training, standards etc. They could cover only basic or applied research for both. Institutes such as research laboratories may also be set up to meet the special needs and utilize resources of an undeveloped region.

32. These institutes may be funded fully or partly by the government or by the industry directly, or through research contracts. Some institutes may have to run partly on profits ploughed back from their production units. Yet another method of funding is to make the institute a technology partner with the industry to generate, acquire, adapt, absorb and improve upon technology. The institutes may have thus a captive industry of their own.

33. Another pattern is for the PCAs to define what the national priority projects are and to assign them to individual institutions or a group of institutions or to a trans-disciplinary, trans-organizational task force, utilizing the best of the abilities and facilities available, and to fund such projects as a national priority. Such a funding mechanism will also bring about a trans-disciplinary culture that is so much needed in several countries. National priority projects may also be put out for tender.

34. ITINTEC obtains funds through taxation of industry (two per cent); it scrutinizes the projects and their priorities and assigns the projects to the industry, individually or collectively to conduct research. 6/ If the industry does not accept the job, it will be assigned to national research institutions. Several countries offer incentives for encouraging industry to conduct research on its own or through contact research with the national laboratories and universities.

35. Research conducted by the industry undoubtedly has a greater prospect of being utilized. The motive for this research is profit maximization and the areas for research may or may not fit into the national goals and priorities. Incentives should be given to industry to conduct research only in the areas of relevance to national needs and priorities.

6/ The Industrial Research Institute in a Developing Country, a Comparative Analysis, J.P. Blackledge, USAID, 1975

(e) Technology Delivery and Utilization

36. It is not enough to conduct research, it is necessary to sell and deliver technology at the doors of those who need it. One reasonably sure way would be to have research responsible to industry itself. Even then, in developing countries with protected markets, there is no incentive for industry to do research and the industry set up with collaboration depends upon the foreign firm for research.

37. The technology delivery system may be organized as follows:-

(a) technology transfer centres;
(b) extension services centres;
(c) information centres;
(d) consultancy, design and engineering companies;
(e) poly-technology clinics;
(f) district industry centres;
(g) adoption of villages or districts by scientific institutions;
(h) voluntary agencies involved in the rural development;
(i) technology brokers;
(j) national R and D corporations etc.

The delivery systems may be a part of a research institute like in agricultural research or may be separate agencies with a strong link between a research generator and user. The consultancy services or the industrial technical service centres of the universities may also play a role.

38. If technology is for people, people should be involved. To people, seeing is believing. If it could be practically demonstrated how through the application of science and technology their living and working conditions can be improved, drudgery reduced, economic returns increased; then the people will believe in the use of technology. Their scientific attitudes and scientific temper will improve to constantly look out for a change for the better. Therefore, social transformation is a pre-requisite for technology to be fully utilized. Popularization of science through the media of journals, books, films, science centres, science museum etc. have yet to play a positive role in most developing countries. If only the potential creative, innovative abilities and problem-solving capabilities are improved, every person will become an asset in society.

(f) Technology Support Services

39. In the technology acquisition, generation, transfer and utilization, several institutions lend support.

40. Industrial service centres, management development centres, universities, professional associations, both local and foreign consultancy firms; standards organizations, national registries for patents, technology imports and technology transfer; repair and maintenance centres, market intelligence centres etc. provide such support services.

41. Technological extension, consultancy and advice would cover both the technical and managerial fields. Technical advice is related to selection of technology, equipment, plant layout; equipment installations, maintenance, modification; raw material use and changes; process improvement and innovation; productivity, quality control and testing; product design and re-design. Managerial advice is, however, related to investment, organization, personnel, purchase, market, public relations, project profiles and pre-investment studies etc. 7/

42. Development banks have a major role to play. They may help in ensuring institutes' results joined with industrial interests; jointly seek an entrepreneur, jointly provide the evaluation of projects; pre-investment studies; technology for environmental protection; identify gaps in the industrial spectrum and adoption and modification of technology for small and medium-scale industry development. The development banks may also provide risk capital to set up pilot plants, proving plants particularly for commercializing indigenous technology facing undue competition from proven imported technology. National development research corporations and others also may act as technology brokers.

(g) Technical Manpower Development

43. This topic has been dealt with in a separate paper,8/ but a brief mention may be made here to emphasize the need for trained manpower at different levels such as skilled workers, technicians, technologists, scientists, production engineers and managers. Special training is needed in the areas of selection, acquisition. adoption, absorption and development

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7/ Lawrence L. Barber, UNIDO/ICIS.36, July 1977

8/ See the document Industrial Technology Manpower in Africa prepared for this Symposium.

of technology. Similarly, special competence is needed for research management, policy and planning and evaluation of research.

(h) Rural Institutes

44. Modern technology is born out of urban industry. Even research institutes located in cities are cut away from rural realities. Further the technology for the rich and the elite may not necessarily suit the poor. There are technologies to increase the skills and productivity and problem-solving capabilities of the people, particularly in the rural areas. Traditional technologies have a place. The science behind tradition has to be studied, improved upon and alternative technologies developed to meet the real needs of the poor. Imported technologies may not be relevant or suited to local resources and the native genius of the people. Technologies have to be presented to the rural people in a manner and language understood by them. Therefore, technology should be aligned to the needs of the country.

45. The main question is how to institutionalize the system. One way is to locate research institutes in rural areas which would be aware of actual problems and make relevant research. Rural universities are based on this concept. In this case it should be ensured that creative research does not suffer because of intellectual isolation.

46. Another way is for urban research institutes to have a special rural cell or extension centre in the rural areas. Yet another way is to send the research workers to the villages at frequent intervals to familiarize themselves with rural problems, so that their research programmes can be reassessed and made relevant.

47. A number of institutes have sprung up in recent years for developing the so called village, rural, appropriate, intermediate, alternative, and soft technologies in several countries, including African countries. Some of these tend to work with considerable zeal but in an isolated fashion. How far these have been effective and if not why they have not been so deserves careful scrutiny.

48. The major function of the rural institute should be at two levels:-

(a) to improve tools, techniques and skills at the village level;

(b) to improve leadership and entrepreneurial qualities.

49. The examples of Brazil and Colombia in setting up institutes like the Foundation for the Development of Scientific and Technical Research (FICITEC) and a combine in Brazil like SEPLAC, CEPED, EPEX which help research institutes offer credit, technology and extension services for rural areas are models that can be tried. For instance in India, the Council of Science and Industrial Research (CSIR), has attempted with mixed success to adopt districts containing two to three million people, to bring science and technology to the doors of the rural people.

(i) Regional and International Institutes

50. Complexities and rising costs both in basic and applied research are forcing nations to co-operate and set up multilateral institutions. These may be simple co-operative efforts; a network of national institutions or international institutions set up by international, governmental or non-governmental organizations.

51. The national centres that have proved to be a success could also be considered as international centres, whose facilities could be utilized by other countries.

52. Some of the outstanding examples of international centres are the International Institute for Applied Systems Analysis (IIASA), the United Nations University and institutes like the International Rice Research Institute etc.

53. Another interesting pattern is that of the International Development Research Centre (IDRC) and the Consultative Group on International Agricultural Resources (CGIAR) which define problems of national and regional interest and fund research in appropriate institutions or set up international institutes in developing countries.

54. Networking of similar national research institutes in the region would help to pool abilities and facilities, reduce costs, time, achieve the desired results and build self-reliance. Networking of institutes in bio-sciences, chemistry etc. are being attempted by the Committee on Science and Technology for Development in Developing Countries and the International Council of Scientific Unions, COSTED/ICSU in Asia, Africa and Latin America. Centres of excellence for both basic and applied research sould serve as regional or international centres.

55. Some fruitful results have also been obtained by networking institutes in the developed countries with those obtained in developing countries. Some examples are the Battelle Institute collaborating with KIST.

56. Technology institutes should have close and firm linkages with related institutes within the country, forming a part of a total integrated system. To supplement and compliment their competence, they may establish close contacts with other institutes within the region, across the African continent and other developing and developed countries of the world.

II. AFRICAN INSTITUTIONAL ARRANGEMENTS FOR INDUSTRIAL TECHNOLOGY DEVELOPMENT

57. In the light of the above classification of institutions, according to type and function required for industrial development, it will be useful and essential at this stage to make an overall survey and assessment of the technological institutions now available in Africa, the functions performed by them and their relevance to national development objectives, government policies, programmes and perceptions, and industry's problems and needs.

58. It can be seen from Table 1 that policy-making for science and technology do exist in most countries in Africa. How effective these have been is yet to be assessed. The African regional science and technology promoting agencies are the Science and Technology Unit of ECA; UNESCO's Regional Office for Science and Technology (ROSTA) and the Science and Technology Commission of the Organization of African Unity. Several UN agencies like FAO, UNESCO and UNIDO deal with sectoral issues.

59. Contrary to widely held belief, Africa does possess a sizeable institutional structure for indigenous technology operation. In fact, most African countries do have some kind of basic institutional infrastructure for the development of industrial technology, it is even possible that the institutional preconditions for self-sufficiency in technology production in the region have been underestimated. Ten years ago, UNESCO studied the scientific and technical potential of 40 African states which indicated that 3,300 scientific and technical research

Table 1: Policy-Making Bodies for Science and Technology in African Countries

Country	Ministry of Science or ministerial science policy committee	Science planning body - general	Multisectoral body for co-ordinatig scientific research	Co-ordinating bodies for scientific research					
				Natural sciences research	Agricultural research	Medical research	Nuclear research	Industrial research	Environmental research
Algeria	x		x					x	
Burundi									
United Rep. of Cameroon		x	x		x	x		x	
Central African Empire		x	x		x				
Chad			x		x				
Congo			x		x	x		x	
Dahomey			x		x	x		x	x
Egypt	x		x	x	x	x	x	x	x
Ethiopia			x	x	x	x		x	x
Gabon	x	x	x	x	x			x	x
Ghana		x	x	x	x	x		x	x
Guinea	x	x	x	x	x	x		x	x
Ivory Coast	x	x	x	x	x	x		x	x
Kenya		x	x	x	x	x		x	
Lesotho									
Liberia		x		x	x	x		x	
Libya		x		x	x				
Madagascar	x		x	x	x				x
Malawi			x	x	x				
Mali		x	x	x	x	x		x	
Mauritana									
Mauritius									
Morocco					x		x		

Table 1: Policy-Making Bodies for Science and Technology in African Countries

Country	Ministry of Science or ministerial science policy committee	Science planning body – general	Multisectoral body for co-ordinating scientific research	Co-ordinating bodies for scientific research					
				Natural sciences research	Agricultural research	Medical research	Nuclear research	Industrial research	Environmental research
Niger		x	x	x	x			x	
Nigeria		x	x	x	x	x		x	
Rwanda		x			x				
Senegal		x	x	x	x	x		x	x
Sierra Leone									
Somalia									
Sudan		x	x		x	x		x	x
United Rep. of Tanzania		x	x	x	x	x		x	x
Togo	x		x		x	x			x
Tunisia	x	x		x	x	x			
Uganda		x	x		x	x			
Upper Volta	x	x	x		x	x		x	
Zaire		x	x	x	x	x	x		
Zambia		x	x		x	x	x	x	

Sources: (a) Science and technology in African Development (UNESCO document SC/CASTAFRICA/3), Table 1

(b) National Papers on UNCSTD

institutions existing at the time, and covering almost all branches of science, no less than 355 were involved in some aspect of industrial reasearch. 9/ It is safe to conclude that the number of industrial research institutions has grown since then. In addition, a fair number of bilateral, multilateral, subregional and regional industrial and technological institutions have been established also. Some examples are the Association of Industrial Technology Organizations, African Network of Scientific and Technological Institutes, African Regional Centre for Technology, the Remote Sensing Council, the Mineral Resources Development, Industrial Property Office, Network of Education Innovation for Development, the Regional Centre for Engineering Design and Manufacture, and the Regional Centre for Soler Energy. These are some intergovernmental agencies. The non-governmental agencies are the African University Associations, based in Ghana and the African Association for Advancement of Science and Technology, based in Senegal.

60. Some examples of industrial and technology development institutes are the Mauritius Sugar Industry Research Institute, the Nigerian Institute of Palm Oil Research, the Engineering Industrial Design Development Centre Egypt; the School of Industrial Technology, Mauritius; the Industrial Technology Consultancy Centre, Ghana, etc.

61. There are several rural technology institutes and centres in Botswana, Kenya, Lesotho, Liberia, Mali, Nigeria, Swaziland, Tunisia, the United Republic of Tanzania, Uganda, Upper Volta, Zaire and Zambia.

62. A recent document gives a detailed account of science and technology organizations and projects in Africa. 10/

63. In terms of numbers, Africa would appear to have more industrial and technological institutions and research personnel that it is frequently given credit for. While the impact, and perhaps also the overall number, of these institutions is still far short of the demand, it would be worthwhile assessing and evaluating their effectiveness in meeting the technological needs of the African countries. Such an evaluation is important, not only in improving effectiveness, but also in identifying the gaps that have to be filled by new institutions and in planning for the establishment of such new institutions.

9/ See the document Industrial Technology Manpower in Africa prepared for this Symposium.

10/ Prepared for the Conference of Governmental Experts and Technical Co-operation Among Developing Countries, Nairobi, Kenya (TCDC/AF/7, March 1980), 12-20 May 1980

III. ASSESSMENT OF PERFORMANCE OF EXISTING AFRICAN TECHNOLOGY INSTITUTIONS

64. The institutions may be assessed not only for their efficiency but also effectiveness in meeting national needs and acting as change agents. The institutions can also be examined in the light of its research to real needs, its indigenous competence to regulate imports of technology and for engineering, production, commercialization and utilizing technologies acquired or generated.

65. In an anxiety to catch up with advanced countries, developing countries have followed imitative strategies for growth and institution building. This has resulted in an enclave character with institutions becoming a part of an elite system, alienated from the majority of the people living in rural areas. Most research institutes have been oriented more towards science than technology. Though technology is people- location-resource and culture-specific, the research carried out has often been oriented internationally rather than within the context of a country. It is time institutes reexamined and reassessed programmes and also studied traditional technologies with a view to improving them. The existing skills in the country have to be upgraded, not uprooted.

66. Past experience has shown that science and technology will not automatically interact with society even if the infrastructure has been built, talented scientists recruited, funds and facilities provided. Several internal and external constraints affect the functioning of the institutes.

67. Institution building raises many problems relating to co-ordination and monitoring of activities. It is a difficult process that needs a good deal of time, effort and money before an institution can be expected to fulfil the functions for which it has been envisaged. It either takes over some of the functions of older institutions or assumes new functions. In either case, it could face a lukewarm reception or even hostility and lack of recognition. In the early years the success of a new institution largely depends on the tenure, personal qualities and standing of the director *vis-à-vis* government and business. Institutions that fail to assert themselves, establish their viability and prove their value in their early years usually exit afterwards in a limbo of marginality and frustration, as they continue in vain the search for a positive role that

would justify their support. Once an atmosphere of disenchantment has set in, internal discipline breaks down and it can become extremely difficult to revitalize a demoralized institution without resort to measures that may not be always socially acceptable.

68. As mentioned earlier, although a number of countries have science and technology policy bodies, apparently only a few have institutions to regulate the flow of foreign technology in Africa, for example, Algeria, Egypt, Ethiopia and Nigeria etc. These are still in their infancy and not much can be said about their effectiveness.

69. The result is that in a number of cases, inappropriate technology has been imported on terms and conditions that not only adversely affect the foreign exchange resources of the African countries, but inhibit local technological innovation. Furthermore, even where contracts with foreign firms and enterprises include clauses for the "Africanization" of the top technical and management cadres, there is no systematic government machinery to ensure that these obligations are fulfilled.

70. Further, for historical reasons, arising from not distinguishing between science and technology, emphasis in most African countries has been placed on the establishment of industrial R and D institutions, presumably to promote technological self-reliance and develop indigenous technologies. However, in order to create the required national technological capability, there is a need for an effective technological infrastructure which includes not only the research institutions, but also the other elements of the development process such as government entities, development banks, universities and polytechnic institutes etc.

71. A joint UNIDO/UNDP study shows, however, that once established, these institutions are usually left out of the mainstream of the industrial development process. 11/ In most cases the government is not fully aware of what the contribution of the institution should be. There is little monitoring of the effectiveness and evaluation of research results and then utilization. The staff of industrial research institutions do serve on various government committees from time to time; but there is no consistent attempt on the part of most governments to use their expertise regularly

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11/ Joint UNDP/UNIDO Evaluation of Industrial Research and Service Institutes, UNIDO/EX.79.

in planning similar functions. Technology acquisition, adaptation, absorption and improvement on imported technologies . The institutions need more goals, well defined technology tasks and greater active participation in formulation and implementation of technology policies, plans and programmes.

72. Several African governments are attempting to control or reduce importation of foreign technology in an attempt to reduce trade deficits and strengthen indigenous capacities. But the many hundreds of industrial research institutions in Africa still do not participate actively in technology transfer and adaptation which is the golden road to innovation. A systematic study of locally available technologies and the upgrading of these technologies through the application of modern science and technological know-how is an important activity of these institutions.

73. The survey by an UNCTAD team 12/ of a few African Technology Institutes shows lack of indigenous capabilities and adequate mechanisms for (a) identifying technology needs; (b) searching for alternative technologies; (c) evaluating and choosing relevant technologies from indigenous or imported sources; (d) adoptation, diffusion, generation and utilization of technologies.

74. The structure, size, organization and management of an institution is critical to its smooth operation. Its governing council comprising of enlightened leaders representing different interests like industry, government, academic bodies plays an important role in posing challenges, giving direction, support and guidance and providing active linkages. But unfortunately such councils tend to be more honorary than operationally oriented. In the absence of the government or industry making specific demands on the institution, the director and staff formulate programmes which they consider relevant or which are internationally oriented.

75. A venture-oriented, flexible, decentralized participative management and creative leadership are needed to maintain research institutes and provide an environment conducive to creative activity. Mobility of scientists and a fresh flow of talents are needed to make institutes effective. The present administrative set-up is rule and procedure oriented and not result and achievement oriented.

12/ Technical Report of Exploratory Mission 1976.

76. Not only in Africa, but in all developing countries, there are several internal and external constraints for technology institutes. These are the lack of:

- clear goals
- proper planning and co-ordination
- leadership
- finance and foreign exchange
- trained manpower
- incentives and prestige for technologists
- links with industry, government and other academic bodies; consultancy and engineering firms and extension services
- spare parts
- maintenance and repair services
- communication and intellectual interaction and an environment conducive to creative research and a critical mass in each discipline
- common research in industry-culture

Such constraints contribute to the ineffectiveness of any technological institution. Failure to define goals, objectives and technology tasks and provide links are the major causes for ineffectiveness. Despite such severe constraints some African technology institutions have a number of achievements to their credit.

IV. A FRAMEWORK FOR ACTION

77. A critical examination of the general patterns of institutions, the existing institutional arrangements in Africa and a preliminary assessment of their performance should help identify priority areas for new institution building and activate and strengthen the existing institutions. Short and long term plans may also be drawn up for action at national, regional and international levels. These are discussed below.

National Level

78. The priorities for strengthening existing institutions or building new ones can be seen in the light of action programme in the different areas discussed in the symposium, as well as in regard to the different industrial sectors. The Plan of Action for the Implementation of the Monrovia Strategy for the Economic Development of Africa [13/] have specified seven priority industrial sectors, as follows:

Food and agricultural industries
Building materials and construction industries
Engineering industries
Metal industry
Chemical industry
Forest-based industries
Energy industries

79. Taking each of these industries as a separate production system and knowing technology contributes to it in several ways, the specific tasks have to be delineated. Only then would the type of institutions, new or old, that would undertake these tasks become clear.

80. The earlier discussion also brings out clearly that the technology spectrum itself has many sub-systems. The institutional gaps, deficiencies and redundancies could be identified more clearly by using a check-list or a diagnostic matrix as given in table 2 below.

13/ Plan of Action for the Implementation of the Monrovia Strategy for the Economic Development of Africa (ECM/ECO/9(XIV) Rev. 1).

Table 2: Institutional gaps and deficiencies: A Diagnostic Matrix

Functions \ Sectors	Food and Agro-Industries	Bldg. material and Construction	Eng. Ind.	Metal industry	Chemical industry	Forest-based ind.	Energy industry	Other sectors
Selection of Technology								
1. Technological information and awareness								
2. Tech. evaluation								
3. Feasibility study								
4. Project evaluation								
Acquisition of Technology								
5. Acquisition process								
6. Negotiation								
Adaptation of Technology								
7. Adaptation of products								
8. Adaptation of processes								
9. Adaptation of equipment								
10. Adaptation of raw materials								
11. Survey of raw materials								
Absorption of technology								
12. Manpower planning								
13. Manpower training								
Development of technology								
14. R and D								
15. Pilot plant								
16. Scaling up								
17. Upgrading traditional technology								
18. Commercialization								
19. Extension								

Table 2: Institutional gaps and deficiencies: A Diagnostic Matrix

(Cont'd.)

Functions \ Sectors	Food and Agro-Industries	Bldg. material and Construction	Eng. Ind.	Metal industry	Chemical industry	Forest-based ind.	Energy industry	Other sectors
Technological Services								
20. Testing								
21. Quality control								
22. Standards								
23. Market analysis								
24. Techno-economic studies								
25. Consultancy								
26. Basic engineering								
27. Detailed engineering								
28. Problem-solving								
29. Production engineering								
30. Productivity								
31. Product design								
32. Technology awareness								
Contribution to Policy and Planning								
33. Tech. surveys								
34. Tech. programmes								
35. Tech. policy								
36. Tech. planning								
37. Development planning								
38. Tech. forecasting								

81. Once the national needs, technology tasks and priorities are determined, a systematic search may be made among the existing institutions capable of matching and serving these needs. For this purpose, as a first step, a Directory of Technological Institutions may be prepared for each country since information about the various institutions that constitute the technology spectrum is rather scanty.

82. A similar study might be made of the existing technical manpower, and the level of technical competence and also to assess the future technical manpower needs, based on the demands of industry.

83. The next step would be to analyse the strengths, weaknesses and opportunities of each technology institution and the factors which might affect them. A study should be made of their present efficiency and effectiveness against set goals and the gaps should be identified where new institutions might be created, existing ones strengthened or combined and non-productive ones phased out.

84. As regards the demand and supply side of the technology system, it may be better initially to think in terms of functions or services rather than institutions per se. A balanced approach would be to see how these functions or services could be provided either by the existing institutions or by setting up task forces and building new institutions where it is deemed essential.

85. An integrated and systems approach is called for in developing indigenous technology competence. Sporadic or disjointed efforts or establishing a few institutions here and there will only lead to waste. No matter what the other constraints are, every country should attempt to be self-reliant in that it should be sufficiently competent to make an autonomous decision. This may or may not require large institutions. A trans-disciplinary group of economists, scientists, technologists, production engineers, systems analysts, social scientists, planners,

financiers, industrialists and administrators may be entrusted with the task of collection, analysis and assessment of information and providing the decision-maker with alternatives and choices relevant to national needs and priorities. Even a small country with little or no infrastructure for industry and industrial technology will be greatly benefitted if such a group is set up and located close to the seat of power and decision-making. If it is to be institutionalized, Centres for Development Alternatives or national technology centres may be established.

86. Such a team or centre may also help in identifying the real needs of the country, translating these needs into technological tasks and assigning them to competent institutions. Goal setting and posing challenging problems are very important, particularly to science and technology institutions.

87. The main focus must be on setting clear goals, functions and services and getting the job done by trans-disciplinary and trans-organizational task forces matching the tasks with talents and facilities wherever they may be found. The emphasis is not on building institutions but on getting the job done by a teamwork approach.

Strengthening the Existing Institutions

88. Having recommended focusing on functions and services, rather than institutions. alternative mechanisms for performing functions or providing services should be carefully considered. If a country is willing to forego the prestige of having an institution, even one of doubtful value, it should consider the pragmatic approach of using existing institutions to do the new job. This could be achieved in a short period of time and without too much expense by restructuring the institution, providing firm linkages with other institutions and by allocating additional tasks and responsibilities together with supplemental inputs. This may be an interim measure that might well fail to meet fully the long-term national development

goals; but it safeguards against the establishment of institutions that are underutilized. Such an approach calls for considerable governmental guidance, management and supervision which, as has been noted earlier, are not often provided by governments to existing institutions. Examples of alternatives for a variety of functions are given below:

Functional Activities	Existing Institutions (Capable of undertaking the activities)
Support Services	
standard specification, analysis, testing, quality control, certification etc.	government or independent testing laboratories
technical information	national libraries, university libraries and departments
Technical Extension Services	
problem-solving, trouble-shooting, industrial engineering	productivity centres, consulting engineering firms, small industries service centres
Training	
graduate level	universities
vocational level	productivity centres factories
Research and Development	
product and process development, materials	R and D institutions universities

Policy and Planning

Technology, information assessment, acquisition	National Councils for Science and Technology Planning Commission

89. It has often happened in the past that more than one institution, even in the same country, works on the same problem. Such duplication should be avoided unless the approaches to tackle the problem are different. Even then, the lines of responsibility should be clarified and resources concentrated for achieving maximum benefit.

New Institutions

90. Where it is considered necessary to establish a new institution, the process may involve the following practical steps.

(a) Examine whether the new functions could not be entrusted to an existing institution;

(b) Examine the time horizon of the activity and check whether it is needed on a relatively short-term basis or whether it will be a permanent new function and investigate its long-term prospects of quantitative and qualitative development. It may well be that an ad hoc arrangement is more suitable to actual needs;

(c) Check whether the institution will be in a position to play the role envisaged for it in good time or whether there is need for interim measures that should be closely co-ordinated with the process of institution building;

(d) Elaborate a complete feasibility study detailing resources needed, time schedule and implementation phases. Wise planning would see to it that each phase could stand on its own and prove of value, even if consequent phases are delayed a very common occurence in developing countries.

91. Though many countries have national science and technology councils, the majority of them have not clearly established the competence for technology assessment, technology choice and technology acquisition. As stated earlier, a trans-disciplinary team or CDA may well tackle this task. But trained people are needed for this purpose. The task of training such a trans-disciplinary team of people in this very critical area may be taken up urgently.

Shared Programmes

92. Once a portfolio of projects of national priority is available for each country, they may be assigned to a competent institute, or institutions or task forces drawn from different organizations within the country and across the countries that have a mutual interest in these programmes. In the case of services and R and D institutions, effective linkage has a "Gestalt" effect, since the exchange of information on what other institutions can do, are doing, or have done is in essence the building-up of collective experience and wisdom. Linking up institutions is not without its problems, particularly if it infringes on the autonomy of the institutions or tends to establish a hierarchical structure of institutions. Setting goals, defining the tasks and subtasks clearly, who is to do what, authority and responsibility, distribution of benefits accrued thereby etc. have to be clearly spelt out at the very beginning of the project. How to give the individual researcher the desired degree of freedom and flexibility and yet make him or her a part of the team requires good management. Yet, an institution that is obviously better endowed and that has wider experience and contacts and which enjoys the respect of others could, and should, play the leading role in the network, national or regional, of similar institutions. By acting as a focal point for the exchange of information and experience, assignments beyond the capabilities of a single institution could be tackled with success. Furthermore, in the past, it has often been the case for external assistance from the same source to be fragmented, in a repetitive

manner, over similar institutions in the same country or in different countries, to the dissatisfaction of both the donor and the recipient. If this be rechannelled on a bi-multilateral basis from a single donor to an efficient network of institutions, the role of the leading institution in the recipient network becomes decisive in ensuring maximum benefit to all participants. There are indications that the sources of external assistance might also favour such an arrangement.

Twinning of Industrial Technology Institutes

93. Yet another way of supplementing and complementing an individual country's competence is to have a sister relationship between an institution in a country with a similar institution in another country in Africa or in any other developing or industrialized country. Exchange of personnel both at senior and junior level, exchange of information, manuals, books etc., joint research projects, sharing of equipment and facilities etc. over an agreed period of time would prove very helpful. UNIDO might assist in bringing about such a twinning programme.

Lead Centre or Centre of Excellence

94. Another variant of the same approach to effectively using leading institutions, is designating them as regional centres and entrusting them with regional responsibilities, in addition to their national ones and strengthening them as appropriate.

Networking of Institutions

95. Institutions set up for specialization of specific disciplines may be brought together as a network to cover the total spectrum. A network for bio-sciences, chemistry or design consultancy and engineering enterprises are examples. Each may specialize in a given area but put together the network provides total competence. Such networks could be national, regional and international.

96. In all such cases, clarity of objectives and tasks, each unit or centre's sense of involvement, pride of achievement and each supplementing and complementing others' competence is important. Co-operation is best among equals.

External Technical Assistance

97. This is discussed in detail in a separate paper. 14/ Foreign assistance plays a critical role in institution building and care should be exercized to recongize its relevance to local needs. Attention should also be paid to make good use of the African scientists and technologists that are presently abroad. Bilateral scientific and technology collaboration agreements could also be properly utilized for technical aid, assistance and co-operation.

Regional Level

98. The importance of regional and international co-operation among developing countries is well recognized as an instrument for promoting collective self-reliance. Some of the institutional arrangements in this regard are indicated below.

(1) Joint programmes for research and training in skills;
   (a) research management;
   (b) methodologies of evaluation of technology assessment and technology and future etc.

(2) Setting up of, or using the existing centres of excellence for serving the needs of a region.

(3) Regional activities could include such as:
   (a) studying development alternatives;
   (b) joint access to technology and patent information;
   (c) technology assessment, technology and future, joint acquisition of technology;

14/ See the document External Technical Assistance prepared for this Symposium.

(d) acquisition of technology;

(e) industrial technology generation, transfer and utilization;

(f) development of appropriate or alternative technologies and improvements on traditional tools, technologies and skills;

(g) setting standards;

(h) developing capacities for the production of instruments, equipment and process controls.

(4) Increased utilization of technological services of other developing countries;

(5) Greater inflow of techniques and processes between enterprises in developing countries;

(6) Networking similar or related institutions.

99. Such regional activities will be governed basically by the ground rules as applied to the joint endeavours within the country. Such co-operative ventures could be between the African countries and between them and other developing countries and developed countries.

International Level

100. International agencies that offer assistance in technology areas would include:

United Nations Agencies, International financial institutions, non-governmental and inter-governmental organizations, bilateral and multi-lateral aid agencies.

Some of the patterns of international institutions have been mentioned at the beginning.

101. By way of immediate action, UNIDO in co-operation with other organizations could help internationally in:

(a) Organizing a well designed training programme for a trans-disciplinary team from each country in the areas of technology assessment, technology choice, development alternatives etc. This may be done by keeping a core group at UNIDO and bringing the teams for each country to UNIDO or the core group or groups going to each country or by blending both mechanisms. The World Bank and others who may have a complementary role in this area may be utilized;

(b) preparing inventories of African technological institutions, their capabilities and identifying their needs for assistance;

(c) identifying common R and D and other problems that may be of mutual interest to a group or groups of countries promoting the implementation of action programmes in the relevant fields;

(d) helping to set up national centres, centres of excellence, regional centres, networks of institutions etc.;

(e) organizing joint training programmes in the area of research management and other special skills needed;

(f) helping to set up CDA type of networks and helping to build collective self-reliance in several sub-systems of the technology spectrum;

(g) promoting regional, international co-operation between the African countries themselves and between them and other developing and developed countries.

ANNEX I

POSSIBLE CONTRIBUTIONS OF TECHNOLOGICAL INSTITUTIONS TO INDUSTRIALIZATION [1/]

A. National industrial planning, programming and evaluation

1. Macro-planning stage

Technological forecasting
Techno-economic analysis
Provision of technical information and data required for:

- The preparation of national development strategy and plan
- The establishment of the required institutional framework
- Decisions on decentralization (industrial parks and estates)
- Development of small-scale industry
- Exports and import-substitution considerations
- The establishment of infrastructure and power requirements
- Manpower development
- Other technical inputs to the development plan

2. Sectoral planning stage

Identification of technical possibilities
Technology plan
Translation of macro-stage targets into sectoral targets
Provision of technical information and data required for:

- Establishment of sectoral priorities
- Development of a strategy for sectoral development
- Analysis of intersectoral relationships
- Development of sources of information and data
- Proposals of goals and programmes
- Manpower requirements

1/ UNIDO ID/WG.246/6 9 March 1977 Utilization of National Technical Institutes in the Developing Countries for Industrialization. Report of an Expert Group Meeting, Trinidad, February 1977.

3. Project planning stage

Provision of technical information and data required for:

Identification of project options

Selection of appropriate technology

Decisions on new projects or expansion of existing productive capability

Selection of indigenous or foreign technology

Development of industrial priorities

Manpower development

4. Specific considerations for planning

Assessment of availability and adequacy of project site

Assessment of inputs, such as raw materials, fuel and power, trained labour, managerial talent

Analysis of the social and economic appropriateness of technologies

Analysis of employment opportunities, marketing, industrial production and financial implications

Assessing a number of auxiliary factors such as housing and health services

5. Project evaluation

Development of evaluation criteria

Assessment of the relationship of the project plan to the sectoral and national development plans

B. The initiation of industrial projects

1. Identification of project concept (preliminary analysis) stage, project profile

Formation and technical analysis of project concepts (project profile)

Identification of:

Processes and products suitable for commercialization (indigenous and foreign sources)

Technical requirements

Functional and operational performance requirements

Technical approaches

Techno-economic analysis

Operational concepts

Market analysis

Manpower and materials requirements

Possible subcontracting arrangements

Financial requirements

2. Preliminary selection stage

Provision of technical information and data required for:

Deciding on alternative approaches

Developing a systematic basis for identifying benefits and penalties of alternative approaches

Minimizing disadvantages of alternative approaches

3. Feasibility (formulation) stage

Establishing evaluation and effectiveness criteria and weighing factors (for example, environmental, technical, economic and social)

Performing cost-benefit analysis

Conducting siting studies

Assessing alternative technologies

Developing or adapting network planning techniques and, where necessary providing computer support

Performing operations research studies, where necessary

Verifying the suitability of alternative technical approaches

Developing practical schedules

Developing preliminary cost plans

Evaluating and assessing the alternative approaches based on established criteria

Assessing manpower and training requirements

Studying backward integration

Identifying potential problems

Determining the need for standardization and quality control

Defining future R and D needs

4. Evaluation (post-feasibility evaluation) and decision to invest

Acting as consultant to decision maker and assisting him in the technical analysis and evaluation of the findings of feasibility studies

5. Acquisition of technology

Provisions of technical information and data required for:

Negotiating joint ventures

Negotiating technology transfer

Preparing tenders and bids for joint ventures

Evaluating the tenders for joint ventures

Negotiating licence agreements

C. Project implementation

Defining performance of systems engineering on industrial projects

Defining detailed project structure and scope

Providing technical inputs from indigenous and foreign sources

Planning in detail and controlling project implementation

Selecting raw materials and parts (indigenous or foreign sources)

Determining level of subcontracting

Factory siting

Carrying out geologic surveys

Acquiring land

Making detailed utility plan

Preparing a detailed manufacturing plan

Finalizing process and product

Selecting factory equipment

Establishing procurement specifications and data

Constructing factory building(s)

Production and plant layout

Installing and checking-out equipment

Preparing detailed process and product specifications

Commissioning plant

Recruiting and training personnel

Developing factory management skills, organization and procedures

Providing testing and analytical services

Trouble shooting and solving problems during the life of the project

Watching over the implementation of licensing or joint-venture agreements

D. To the evaluation and monitoring of projects and programmes

Technical evaluation and monitoring

Technical evaluation of on-going production

A continuing analysis of market and technological trends

Identification of new opportunities arising from market changes and new technology

Identification of changes arising from revised national and sectoral plans

Providing technical information and data required for assessing the short and long-range industrial and economic trends of the country and the changing needs of industry

Technical services to industrial plants

Testing, analysing and evaluating raw materials and intermediate products

Testing and analysing finished products for standardization, quality control and certification

Providing specific information on the current state of world knowledge on industrial, technological and techno-commercial fields

Carrying out instrument repair, maintenance and calibration

Designing specialized equipment, where possible

Trouble shooting in industrial plants

Carrying out technical and management consultancy in such areas as market studies, cost accounting, efficiency and productivity studies, industrial engineering, plan layout and management

Carrying out technical investigations designed to improve the quality of finished products and increase process efficiency

Developing new processes for current or new products, at both the laboratory and pilot plant levels

Carrying the results of technical investigations on products and processes into the commercialization stage

Carrying out techno-economic studies and market analysis

Undertaking engineering design and service work

Training technical staff

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