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INDUSTRIAL RESEARCH
IN THE WEST AFRICAN SUB-REGION

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CHAPTER I

INTRODUCTION

1. The Standing Committee for Industry, Natural Resources and Transport of the Economic Commission for Africa at its second session, held in December 1963, considered a report (E/CN.14/INR/41) on Institutes of Industrial Development and Research on sub-regional basis for Africa, based on a study of needs in selected countries in Africa by a consultant from the United Nations Centre for Industrial Development in New York.

2. This study discussed in bread and general terms the role of science and technology in development and, in particular, the development of industry in the new countries of Asia and Africa. It examined in some specific detail the urgent need for African countries to establish local centres of technology which would draw in the specific know-how from developed countries, make such adaptations as are necessary for local conditions and circumstances, carry out research into raw materials and processes in order to develop new uses for indigenous materials and new products, disseminate the imported and created know-how to industrialists and entrepreneurs, and offer direct technical services towards obtaining more efficient operation and management of both new and existing industrial ventures in these countries. It was rightly argued that these functions and services are essential if industrial development is to be accelerated at the rate desired and hoped for in African countries.

3. The objects in broad terms were "to aid in the development of selected natural resources which require research, in the establishment of new industries, and to render technical and engineering assistance to existing industry to improve its products, processes and economic status". In order to achieve these objects a multi-purpose industrial research and development institute would be required with a staff

of scientists having academic qualifications in the physical sciences and engineering besides extensive and varied experience in industrial technologies. In addition, the institute would also require adequate equipment, pilot plant and other facilities. Developing countries in general are, however, faced with acute shortage of scientific personnel and scientists with the experience and qualifications described earlier are scarce even in the more advanced countries and, when available, are expensive. Consequently, even the cost of operation of a modest unit with the minimum staff required to undertake effectively the range of services described was outside the financial resources of most countries in Africa. The sub-regional single multi-purpose institute was therefore suggested as a means of overcoming both the problem of scarce personnel and the funds necessary for this essential institution of industrial development.

4. The Standing Committee, in consideration of this report, made the following points in the discussion:

(i) "It was generally agreed that there was danger of research institutes concentrating their activities too much on theoretical research; the main emphasis should be on applied research closely linked with industrial development.

(ii) A distinction should be made between full scale industrial research institutes and smaller scale centres concerned with applied research and development.

(iii) The sub-regional approach suggested was one possibility but careful consideration should also be given ..... to smaller industrial development centres mainly concerned with and to serve individual countries."[1/]

5. These points endorsed fully the thesis presented that applied research and adaptive research are the greater need for African countries. On the other hand, and while accepting that the scope and functions assigned for an institute of industrial development

1/ United Nations Economic Commission for Africa, Report of the Second Session of the Standing Committee on Industry, Natural Resources and Transport (E/CN.14/245, E/CN.14/INR/54).

and research are necessary to ensure that plans of industrialization of a country are properly formulated and implemented with the least delay and minimum failures, there was tacit reluctance to giving unqualified support for the sub-regional approach. A single multi-purpose sub-regional industrial research institute preferred in that report confers many advantages to the country in which it is sited. The other countries served by this institute will not have even a nucleus or centre to which local industrialists can turn for direct assistance. The geographical distances between the only centre of technology and the industrialists in countries other than the country in which it is situated may often be too great for consultation. These real difficulties necessarily limit the use of the research institute by the associate countries, while the country in which it is situated will increasingly use its services. Since distances and cost of travel inhibit effective consultation and development of research market, the needs of these countries will also not be known and would in course of time be neglected. These fears perhaps led to the belief that even a centre with limited scope and resource in one's own country was better than a full-fledged multi-purpose sub-regional institute elsewhere.

6. These thoughts found expression in the final recommendations of the Committee, which required the Executive Secretary of the Economic Commission for Africa, in consultation with the United Nations Commissioner for Industrial Development and interested countries, to carry out further investigations on the establishment of such industrial development and research institutes on a national or sub-regional basis. A technical adviser of the Centre for Industrial Development visited selected African countries during July and August 1964, to develop information and discuss preferences in order to lay out an action programme for institute development that could be jointly undertaken by the appropriate members of the United Nations family and the countries of Africa.

7. This latter study, based on discussions with public officials and those of other development institutions in several countries, came to the conclusion that in spite of the acute shortage of scientific personnel that is prevalent, a start towards providing even the most meagre industrial research facilities should be made. It suggested that many countries have a nucleus of industrial research effort in the form of testing laboratories, food processing institute, government departmental laboratory, project evaluation centre or even the science laboratories of a national university and that on this nucleus could be built the beginnings of an industrial research effort. Emphasis was placed on the dictum that a start now, albeit modest, is better than none. The study recommended that the Standing Committee authorize the Economic Commission for Africa secretariat and the Centre for Industrial Development, with the aid of consultants, to detail, country by country, the type and scope of in-depth studies needed to accomplish the amended programme of industrial research effort.

8. This was followed by an ECA study (E/CN.14/INR/94) on industrial research for the East African sub-region in 1965. It proposed a variation of the multi-purpose single institute serving a number of countries which largely overcome many of the shortcomings referred to in the discussion of the earlier study of 1963 in paragraph 5. The study for East Africa recommended the establishment of a number of specialized institutes equitably distributed in the countries of the sub-region, each institute serving the whole sub-region in its specialized field and thereby obtaining the desired co-operation of the countries as equal partners. Co-ordination was provided through an Eastern African Industrial Research Council which consisted of representatives of the participating countries and in whom the powers and duties of the specialized institutes were vested. Five institutes - Building Research in Ethiopia, Metals

Institute in Zambia, Textiles and Polymer Institute in Tanzania, Food Research Institute in Uganda and Chemical and Process Engineering Institute in Kenya - were suggested as the initial nucleus under the Council which was further empowered to establish other institutes in other countries of the sub-region.

9. The present sudy follows on the three studies made earlier, incorporates the discussions, recommendations and conclusions reached at the Inter-regional Seminar on Industrial Research and Development Institutes in Developing Countries, held in Beirut, 30 November - 11 December 1964, considers the special problems and conditions prevailing in the West African sub-region with two linguistic groups, and the wide disparity in scientific infrastructure, population, area, and markets and suggests a combination of national and multinational approaches to industrial research.

CHAPTER II

SCIENTIFIC RESEARCH AND PRIORITIES FOR DEVELOPING COUNTRIES

10. Scientific research has been described by Alain Peyrefitte,[1/] Minister for Scientific Research in France, as the main ferment in the progress of societies. This will be understood as increased knowledge which research provides is one of the aims of development. Scientific research through invention and innovation stimulates development and provides also the driving force for production. Science and its disciplines pervades all forms of economic activity and guides these activities. Research is constantly challenging established structures and traditional procedures. Consequently it has become an instrument of policy among countries.

11. The importance of scientific research is therefore no longer a subject of debate. Its benefits are known and accepted by countries irrespective of their ideologies or size. For countries on the threshold of industrial development as most developing countries are, it has a special significance. The issue for these countries is not whether they can afford it but whether they can afford to be without it. The choice before the developing countries is the determination of how much and what type of research should be mounted nationally or in co-operation with their neighbours in order to maximize the benefits to be gained by the utilization of the scarce resources of scientific manpower and funds available to them.

12. The dimensions of science have changed. Until recently research was mainly a matter for the individual scientist following his own line of inquiry, or of the entrepreneur seeking its exploitation. The resources required were modest. This has changed as

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1/ OECD Observer Special Issue on Science, page 3.

a result of the greatly increasing cost of research and of recognition of the potential value of its results.

13. As a result of these changes, even the large developed countries find it difficult to provide the skilled manpower and finance to undertake all the research which their national interests might suggest as desirable. For smaller developed countries, the need for personnel and financial resources for scientific research and development far exceeds the available resources and hence choices have to be made between alternative programmes and projects. For developing countries the gap between demand and supply is even greater and it is therefore essential for them to determine priorities in regard to disciplines or types of research, in addition to selection of programmes and projects and also to consider as a matter of policy co-operative arrangements with their neighbours in order to make up for their limited means in manpower and funds. Consideration of these limiting factors in relation to industrial research involves a discussion of the types of research.

Types of Research - Definitions

14. The definition of the types of research is provided by the Research Board of the President of the United States. Two main divisions are recognized - basic research and applied research. "Basic research includes fundamental research and background research, and is the theoretical analysis, exploration or experimentation directed to the extension of knowledge of the general principles governing natural and social phenomena. Background research is the systematic observation, collection, organization and presentation of facts using known principles to reach objectives that are clearly defined before the research is undertaken, to provide a foundation for subsequent research or to provide standard reference data. Applied research is the extension of basic research to the determination of generally accepted principles with a view to specific applications, generally involving the devising of a specified novel product, process, technique or device.

Adaptive research is the adaptation of existing process, technique or device to suit special conditions prevailing. Finally comes the definition of development, that essential link between research and the industrial application of research results. Developmental research is related to work on an existing model, device, equipment, material or product process. Developmental research differs from applied research in that work is done on products, processes, techniques or devices that previously have been discovered or invented."

15. It is, however, accepted that scientific research is a broad spectrum shading from basic and background research at one end, through applied research and adaptive research, to development research at the other end. Industrial research is basic, applied, adaptive and developmental research undertaken with the object of application of results to industry.

16. Industrial research is therefore not only concerned with exploiting fundamental discoveries made by basic research. It bases itself squarely on the accumulated store of knowledge, attends to the needs of the particular industry or industries it serves and through its work brings new manufacture a stage nearer. This may be simply an improvement of an existing process, but it may be an entirely new one and the product may also be new.

17. Industry research has extended its scope to include the systematic study of industrial operations, the handling of materials and layout of the plant. And since it is concerned broadly with the economic efficiency of industry, it works to raise the level of productivity through the better use of resources human and material.

Research Needs of Developing Countries

18. In this context, the statement of the Secretary-General of the United Nations at the 36th Session of ECOSOC, on the United Nations Conference on the Application of Science and Technology for the benefit of less developed areas is of particular relevance. He stated, "First

it is necessary to build centres of scientific and technological strength in the less developed countries. Second, it is necessary to focus more resources in the advanced countries on science and technology for the benefit of the less developed countries. Third, it is necessary to make a judicious assessment of priorities....."[1] He further expressed the view that science and technology cannot be exported or "pushed" out from their habitat in the advanced countries, but that they have to be imported or "pulled" in for definite needs by the developing countries themselves. Such import of science and technology as was suggested can only be achieved through the centres of technology established in developing countries and effectively manned with qualified applied scientists capable of defining the needs of the country, acquiring the specific know-how, of adapting to local conditions and circumstances, and of disseminating this knowledge in the form suggested by adaptive research. This same conclusion was reached by a Working Group on Science and New Developing Nations at Stanford Research Institute.[2] Their initial approach was to consider the needs of developing countries in terms of scientific discoveries and technological inventions which might benefit them significantly. This "needed break-throughs" approach was examined area by area only to lead to the conclusion that sufficient knowledge is already available on many of the areas needed in the developed countries. The major problem is not that of a lack of available science and technology but that the world reservoir of existing knowledge is not being adequately drawn on by the developing countries.

Borrowing Known Technology

19. There are, however, particular limitations to borrowing known technology from advanced countries, although a large reservoir of such knowledge exists and awaits drawing upon. Most of the developing countries

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1/ No. ECOSOC/1588, 8 July 1963.

2/ Scientific Research and Progress in New Developing Countries, by E. Staley and D. C. Fulton. Stanford Research Institute, 1961.

are in or near the tropics, while all of the developed countries are in temperate zones. Consequently, the technologies available are for adoption in the temperate areas and cannot be transferred in that form directly to tropical conditions. Also, the developed countries have abundant capital, and skilled though expensive industrial manpower while in the developing countries there is abundant labour inexpensive but unskilled, and scarcity of capital. The industrialized countries therefore base their development and consequently their research effort on labour saving and capital intensive processes and techniques. The developing countries, on the other hand, with abundance of labour and scarcity of capital, would require techniques and processes which use comparatively more labour and smaller quantities of capital. The use of the results of research and technology developed in industrialized and advanced countries without the necessary adaptation to the conditions in the developing countries can in cases even be harmful.

Adaptive Research

20. In the transfer of techniques and know-how from an advanced to a less advanced country, some adaptive research is essential. In many cases the extent of the adaptation may be minor, while in others considerable changes in design and process may have to be effected to suit local conditions. Adaptive research is particularly useful in developing countries, as it not only provides a means of drawing upon the reservoir of existing world knowledge, but in the process also improves on it from the standpoint of suitability for particular needs or conditions. Some of the changes involved in adaptation are:

(a) Modifications necessary because of variations in properties of locally available or substitute raw materials;

(b) The difference in relative availability of capital and skilled labour;

(c) Modification of a process or operation to a scale (generally smaller than considered economic in developed countries with large markets) imposed by smaller local market conditions;

(d) A series of combinations of the above and of such factors as scarcity of foreign exchange available for import of capital goods; and modifications to machinery design.

21. Japan achieved considerable success in this area in their initial phase of industrial development some 40 years ago and demonstrated that considerable industrial development can be achieved using imported technology and adaptive research. The importance of adaptive research deserves the greatest emphasis in countries in the early stages of development.

Processing Research

22. Adaptive research alone would not meet the requirements of the new countries in Africa. The economies of African countries are largely dependent on agriculture and mining. Very few products are exported in the form in which they are harvested from the land. Some processing is almost always necessary, if only for preservation and storage. The degree and control of processing undertaken in the country also determines its quality and value. In mining, problems of beneficiation, refining, purification, preliminary processing to raise quality of ore and reduce impurities, might present themselves. Consuming countries of these export materials are also the industrialized countries. Their interest in these primary materials is at the lowest cost for conversion into manufactured products, and they are therefore unlikely to have mounted research programmes to improve the economic value or to develop new uses for these materials. Consequently, new knowledge of improved processing or new uses will not be available from the reservoir of knowledge and, unless generated within the country, will result in a number of resources, both agricultural and mineral, either obtaining uneconomic returns or being under-utilized. Overcoming this economic handicap by providing processes and techniques for improved export processed materials and finding new ones is the domain of applied research.

Basic Research and Applied Research

23. Basic or fundamental research aims at extension of knowledge for its own sake without direct preoccupation with the application of its results. Applied research on the other hand is undertaken to apply results to practical ends and therefore to production of new wealth. It is not to be inferred from this that basic research is unimportant. The results of a particular piece of basic research may have no direct practical application but nevertheless provide a new element of knowledge which in turn may contritute indirectly to a technological development. In fact, some basic but oriented research is often necessary in order to make break-throughs in applied research and technology. Also basic research, however limited, is essential as without the practice and understanding of its techniques, a country will not possess a breadth and depth of scientific understanding to enable it to select from the world's store of knowledge those elements which are relevant for its development.

24. The policy decision before developing countries is not the exclusion of one or the other but of determining what proportion of total research effort and resources should be allotted to basic and applied research in a country. Planners, economists, politicians and industrialists in most countries and particularly in the newly developing countries, have rightly argued that the meagre resources of research available should be directed towards established and planned economic development needs of a country. They have emphasized the urgent need for increased production and creation of new wealth through industrial, agricultural and mining development in order to raise the standard of living of the peoples. This envisages preferential support for applied research, a trend already emphasized in the earlier 1963 report and reconfirmed in the deliberations of the Beirut Seminar on Industrial Research held in 1964.

Industrial Research

25. Industrial research is scientific research directed towards application of results to industry. It includes basic and applied research and also development research. The research, both basic oriented and applied, leads to a new process or product. The adoption of the new process or method, or product in manufacture through steps involving production in increasing quantities is known as development. The combination of scientific research and technology to obtain advances in new methods of industrial production is the function of industrial research. The objects of industrial research are to provide the technology, adapted or created, required for industries in existence and planned for the future, and to provide the reservoir of systematized knowledge regarding raw materials, by-products are other resources. In order to satisfy these objects it undertakes a variety of research and development services.

Variety of Services and Scarcity of Funds

26. To be effective in new development, research will have to be undertaken in a wide range of industrial fields and these will necessarily include food processing and manufacture, mineral processing, production engineering, chemical technology, forest products, fibre technology, building materials, rubber and plastics, leather and footwear, to name only a few. To this already over-burdened responsibility have been added other necessary services in developing countries, such as industrial extension, consultation with industry and trouble-shooting, industrial testing and standards, and feasibility studies.

27. These are essential needs in Africa and some mechanism will have to be found to meet these needs quickly. The complexity of the problems involved in providing these services will be seen from the gross inadequacy of funds and personnel available by a comparison of expenditure in developed countries with those of the developing countries. The annual expenditure in scientific research per capita in USA is $78.40;

in UK, $35; in France, $27, and in Poland, $9, while in the majority of developing countries the corresponding expenditure is only US. $0.10 to $0.30. Since the per capita incomes in most African countries are low they cannot possibly match the research expenditure of the developed countries. Considerable economies in resources, through effecient organization, judicious choice of research programmes and priorities directly linked to the national and sub-regional development programmes, will therefore be required to bridge the inexorable gap between need and available scarce human and financial resources. Assuming these economies the Beirut Seminar recommended the expenditure on industrial research of 0.1 per cent of a country's GNP as the minimum. Their recommendations on organisation, discussed in the next chapter, are of interest to the sub-region.

CHAPTER III

BEIRUT SEMINAR ON INSTITUTES OF INDUSTRIAL RESEARCH AND DEVELOPMENT

Organization

28. The organizational forms in developed and developing countries were considered and their experiences evaluated. The choice of form was, however, thought to be dependent on a number of factors, such as:

(a) The special needs of any predominant raw materials - agricultural and mineral - and accessibility to the centres of these productions.

(b) The type and scale of operations of industries existing and/or planned.

(c) The level of economic and industrial development and expected growth.

(d) The financial resources and availability of scientific and technical personnel.

(e) The scientific infrastructure that exists in the form of universities, technical institutions and government agencies.

29. Certain successful principles and procedures of organization, operation and financing, however, emerged, and these were particularly emphasized and recommended for adoption in new institutions to be established or in the re-organization of existing organizations. These can be briefly stated as follows:

(a) The most successful organizations for research are independent corporate bodies set up under an autonomous board or council vested with the powers and duties of the research institute.

(b) Government, or governments, have the responsibility and obligation to guarantee adequate financial support on long-term basis to ensure continuity, although ad hoc services

to the private sector might yield a sizable income when industry has learned the value of research and the institute gained its confidence.

(c) Close co-operation should be cultivated with universities in order to bring about a free interchange and cross-fertilization of ideas. Basic problems may also, with advantage, be farmed out to universities, but the primary responsibility for industrial research should rest with the institute.

(d) Industrial research institutes should maintain close working relationships with other research organizations, local and foreign, as well as institutions concerned with industrial development and finance, the government agencies for industrial policy and planning, and industries themselves. Some countries have closer ties between research institutes and financing organizations through inter-linked boards.

(e) The main deficiencies in existing organizations were poor liaison with industry, lack of adequate industrial extension and communication with industry, entrepreneurs and government agencies; inadequate training of indigenous staff, and the non-identification of research problems.

30. The deficiencies mentioned under (e) have been the causes for poor performance of research institutes in developing countries and suggestions for overcoming these are therefore of some importance. Some aspects of these are discussed in succeeding chapters.

CHAPTER IV

THE PROBLEMS OF TRANSFER OF TECHNOLOGICAL KNOWLEDGE AND INDUSTRIAL EXTENSION

31. The image of research in the minds of most people stops with discovery; but if a scientist only discovers, he would not have contributed to world well-being. The applied scientist transforms a new discovery into a technology for producing goods. Technology thus created has little value by itself. It has to be used towards making a new, improved or lower cost product. Its use implies finding a sponsor or entrepreneur who will invest money, machinery, materials and men to produce new wealth. Technology has, therefore, to be sold. The funcion of selling technology and finding the markets for the products of both search and research is as important to the success of an industrial research institute as creating the technology itself.

Sources of Technological Knowledge

32. In the field of technology, the needs of users not only cover the most recent developments and modern techniques, but also the large body of knowledge already used elsewhere. The sources of this information are diverse. Books and journals only provide a small part of this information, and to translate even this to industrial practice requires both knowledge of the appropriate technology and expertize. This is understandable if one recognizes that treatment and diagnosis of various diseases are adequately covered in books and yet it would be considered insane for the average person to consult a medical library instead of a physician. The library is essential to an institute and is its most important equipment. It is the depository of scientific journals which disseminate scientific information in a precise form and of other books which deal with fields of technology and the scientific principles involved in general terms. No book published, however, gives one a blue-print of a factory or the detailed information which will

enable a layman to set up a factory to suit particular conditions of a market, size, or of type of labour. The information that can be gathered from books of practical value is therefore limited - although in the hands of a technologist with wide experience in a particular industry it has high value and purpose.

33. A good part of technological knowledge is largely unpublished and in the hands of technicians and scientists in the industry, in the skills of industrial personnel, and in procedures and practices in individual industrial enterprises. These, sometimes referred to as 'know-how', are rarely transmitted except by special agreements between concerns and, invariably, at a price. It includes also much of the written technological information of a specialized nature, such as patents, drawings, confidential and classified documents, specifications of materials in process and of end-product, etc.

34. The major and direct sources of technological knowledge still available are industry research institutes in advanced countries, machinery manufacturers, chemical manufacturers, independent consultants, international agencies of aid, and friendly governments. The 'pulling in' of this knowledge is by no means simple. It demands the capacity not only to acquire systematically, codify and document such information, but also to discriminate carefully with respect to what does need to be acquired and what should be avoided. This, then, is the first problem, and can only be overcome by a proper library and trained librarians and scientists to gather and sift the information and make it readily available in assimilable practical form.

Choice of Technology and its Adaptation

35. The methods and procedures of operation and technology in the advanced countries cannot and should not be transplanted directly in the developing countries; a careful appraisal should be made to find more appropriate solutions to suit local environmental conditions of materials, markets and labour. The problem of choice and adaptation can be broken down into two related problems:

(a) The choice among several methods on which reasonably complete information is available.

(b) The incorporation of changes in processes, machinery, equipment, procedures, and practices requiring technical work and re-design.

Choice of Technology

36. The choice of technology is not an easy matter. It is dependent on two factors - technological and economic. To evaluate the technological factor, several alternative designs of the plant, employing different processes, will have to be worked out in detail- which would involve accurate information on costs of machinery and equipment, materials and labour. This type of information is difficult to come by since channels of communication in the technological field are varied and full of obstacles. There is therefore a large degree of uncertainty involved in the choice.

37. The second factor is the economic appraisal of different technological alternatives. The choice may depend on the economic criteria which are given priority in a country, such as large employment generated per unit of capital, or lowest capital cost per unit of output, or lowest foreign exchange utilization. One or more of these factors may have to be taken into consideration and a choice may be easier if the experience in other developing countries on the technology becomes available. When such information is not available, it leads, in many cases, to a choice made on offers of machinery through salesmen, who are more interested in selling the most costly equipment than in the economic interests of the country. In many cases, the offers of machinery are for production levels very much in excess of the low market requirements of a country.

38. Different industries present a wide range of technological characteristics; while in some special cases such as the major chemical processes, there is no alternative to an up-to-date plant of minimum

economic size using automated control, there are, however, a large range of industries which provide alternate, if not so up-to-date technologies more suitable for developing countries with lower skills, poor maintenance of machinery, smaller market and scarce capital. It is in the interests of developing countries to explore the latter possibilities and this function of choice is an important activity of an industrial research organization.

Industrial Extension Services

39. The preceding paragraphs discussed the problems of gathering technological knowledge from the advanced countries, sifting such information, codifying it, and making the choice. The task is, however, not complete until the information is disseminated to those who need it or are seeking it, the transferred technology is used in local production and assisted through various services, such as trouble-shooting, testing, quality control, etc. The dissemination and associated technical services are termed industrial extension.

40. Several problems arise. First, the institute must identify the users of technology, the potential entrepreneur, and the existing industrialist in need of technology and other services. Second, it should establish liaison, render services even at lower than actual cost and win the confidence of the public it serves, the press and government. In order to stimulate interest in technology and to inform the country of the availability of its varied services, the institute should make maximum use of various tools of extension, such as personal visits and contacts, demonstrations, training courses, in-plant trials, radio, press articles, exhibits and seminars, technical inquiry and answer service, field days, etc.

41. Industrial extension is of importance not only because it provides a means of direct technical service, but also because it brings to the knowledge of the institute the needs of industries and their live problems. Industrial extension is a dynamic activity and the institute, to be successful, should take the lead in industrial management and training for industry, in bringing handicaps faced by industry to the notice of government, in improving productivity, in assuring quality to the consumer by standards and testing, and generally in promoting industrial development. If efficiently carried out, it could be the most satisfying and acceptable function of an industrial research institute.

CHAPTER V

PROJECT FORMULATION AND SELECTION[1/]

42. The role of a national industrial research institute is that of active assistance to the nation in implementing its industrial plans and policies in all its phases. A sub-regional institute, or a number of specialized institutes under one sub-regional council, on the other hand, will be charged with this same responsibility, but for a group of countries. This responsibility it would discharge only if it provided the technology of the right amount and the right kind at the right time. Research should, therefore, be directed towards meeting established and planned needs of the country or countries a research institute serves.

43. Too many research institutes have failed to contribute to the economic well-being of the countries they served principally because of their poor selection of programmes for research. Often they considered research a superior intellectual activity, and one to which no one else except the scientific staff could contribute. They operated in an ivory tower, divorced from policy makers, planners and even the industrialists. Consequently, the projects did not always reflect the needs and a development of high scientific merit, which the scientists believed was going to revolutionize the economy, found no takers.

44. The developing countries with scarce financial resources need to harness their scientific manpower to areas and to solutions of problems which will bring immediate and sizable gains. Planners, economists and industrialists may not understand the language or method of science, but they know what break-throughs are necessary for the development planned and can also provide useful information on limits of cost,

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1/ Formulation and Selection of Projects for a National Institute of Industrial Research, by A. Sundralingam. Discussion Paper No. 6, Inter-Regional Seminar on Industrial Research and Development Institutes, Beirut 30 November - 11 December 1964.

capital, quality and quantum. Scientists are expected to translate these into specific problems, build in the economic factors, and work out techniques to provide a solution satisfying the limits set. Consultation is essential in order to determine essential needs and to identify the live technological problems of the country and its industry, and it is a pity that scientific organizations avoid this for fear of interference by non-scientific administrators and others. While scientists thrive in an atmosphere of intellectual freedom and this should be guaranteed by the State and administration, it is incumbent on them to think in terms of development of the money economy, which alone contributes to their country's well-being.

45. The research programme can spell failure or success of a country's development and is therefore of paramount importance to a research institute. The preconditions of formulation of such a programme would include the objectives in relation to economic plans, the identifiable needs of technology to meet the industrial plans, and a critical review of the mineral, agricultural and other resources.

Industrial Plans and Identifiable Needs of Technology

46. A new country passes through three stages of economic development: the exploitive stage, the stage of industrial development, and the stage of industrial maturity. Most of the countries of the sub-region are still in the exploitive stage with little industrial development and some are entering the second stage through plans of industrial development based on sound economic decisions.

47. Each of these countries will build the industrial sector on the strength of what it has - agriculture, mining, or both. Basic industries of fertilizer will evolve from availability of oil, rock phosphate, or extremely large forest reserves; iron and steel from rich iron ore; aluminium from both bauxite and cheap power; heavy chemicals from salt, sulphur or other inorganic deposits; cement from clay and limestone; fabricated copper from rich copper ores, etc.

48. The basic industries are generally specified in the plans but secondary industries producing consumer goods are rarely mentioned. The latter have larger employment potential in relation to capital employed and the sum total of goods substituting for imports can also be sizable; yet, because the industrial units are usually of small- or medium-scale and this field comes generally under the private sector, the country's plans indicate only over-all investment and employment, and not even a list of viable industries is included. While basic industries, because of their size and complexity, have built-in know-how and management arrangements provided, the secondary industries in the private sector are not so provided. As overseas expertize and know-how would be too expensive for such small units, entrepreneurs would not enter industry, unless some reliable institution or source is available to assist them.

49. The industrial research institute should therefore seek detailed information on the nature of these secondary industries from the trade and entrepreneur groups, and establish liaison and intelligence on the new industries to be established in order to determine the adaptation of technology and raw material substitution that will be required. In addition, the basic industries planned, process industries existing and planned, and secondary industries existing and planned would have to be listed, their raw materials and processes examined to reveal those problems which require immediate and future solution.

Resources

50. The resources of a country and their optimum utilization in industry are key factors in development. Consequently, these are of vital importance in research and in determining the research programme. There are two distinct ways in which the subject of resources and industries can be handled. One is the descriptive method which is a description of the mineral, agricultural and other resources known and available, their nature, quality and quantity. The other is the functional method, which places emphasis on analysis, correlation and appraisal.

For the purpose of project formulation, it is necessary to use both methods. One would therefore catalogue the resources, their quality, nature, and quantity, and also apply the technique of analysis and questioning in order to elicit the problems associated with the resources.

51. It is necessary to know the composition of a resource to determine whether beneficiation is likely to enhance the quality to the extent desired for use within the country or for export. One will question why a particular resource is either not exploited or under-exploited, either unutilized locally or under-utilized. A material similar to a local resource in use in a process or industry already existing will suggest an investigation into that resource. Lowering of quality in the final product by the use of a local resource would again suggest a project on the pre-processing of the resource or adaptation of the technology used in the particular process. Some minerals and most of the agricultural resources provide by-products often going to waste because no immediate use is found in the area. Investigations into possible uses for these waste products can often be fruitful.

52. The African continent is very rich in minerals and power resources. The mineral resources of the West African sub-region include iron, titanium, bauxite, copper, lead, zinc, tin, tungsten, wolfram, gypsum, limestone, dolomite, manganese, gold, diamonds, petroleum, natural gas, coal, salt, tantalite, columbite, kaolin, carbon dioxide, beryl, monazite, ilmenite, rutile, chromite, phosphates and others. The agricultural resources are large and varied, the principal ones being coffee, cocoa, yam, tobacco, cassava, cane sugar, cotton, cashew, coconut oil palm, ground-nut, soya, etc. The minor resources include tannin extracts, timber and forest products, abaca, tea, corn, gum copal, gum arabic, kapok, beeswax, vegetables and fruits.

Over-all Programme and Final Selection

53. The over-all programme would be an inventory of projects resulting from an analysis and appraisal of the needs of technology and services necessary for enhancing the resources and developing the existing and planned industries of a sub-region. The projects formulated at this stage will represent ideas, with perhaps concise information on scope, disciplines, and state of existing knowledge. If a council of research serves a group of countries or controls a number of laboratories in specialized fields, the spectrum of disciplines and the number of projects will be extremely large. A preliminary evaluation and screening will then be necessary.

54. Preliminary evaluation and screening will entail consideration of the relative importance of a group of projects in a particular industry or on a resource, and elimination of those which bring in small gains in relation to research effort, those which require technologies which are scarce or unobtainable, those on which existing technology is satisfactory and may be postponed for later consideration, and those on which outside knowledge has since been found to be available and could be adopted at lower cost.

55. After the preliminary screening, the projects remaining will have to be prepared in some detail for the final selection. The scope and object of the project and the specific problems to be solved should be stated first. Then follows a brief summary of the literature search made on the particular subjects and the gaps in knowledge which the project is expected to fill.

56. The utility factor should be presented next. A basic research project to provide new knowledge towards solution of other applied problems has utility, even though it would be difficult to estimate in advance the time required for completion of such a project and, hence, the cost. In applied research, the utility factor can be more specifically stated as a new or better raw material, improved product or process or

operation, or a new product. Estimation of the time, cost and magnitude of the attack on such problems can only be, at best, an intelligent prediction based on previous experience of similar problems. Research is essentially an exploration into uncharted areas and therefore defies more definite estimates. What is presented as time and costs are notional probabilities.

57. In the case of developmental projects which involve pilot plant operation, determination of unit cost of production, market research and evaluation of final product, it would be possible to determine more closely the utility and usability factors and to predict within close limits the results that will be achieved in a particular time and at a particular cost.

58. The final selection and establishment of priorities should be the responsibility of the Research Council or a Committee of Directors of Research, assisted by representatives of planning bodies and the governments. The final list as approved should be for a definite period of five years and should be the research plan. On the basis of the plan, it would be possible to work out manpower requirements, disciplines, equipment and facilities and annual cost of operation for the full period. Having provided the budget, the Director should be given a free hand to implement the plan and to report progress to the selection body once in every six months.

CHAPTER VI

INDUSTRIAL RESEARCH TO MEET AFRICAN INDUSTRIAL NEEDS

59. In Africa, industrial research will endeavour to effect break-throughs in technologies particularly in areas where utilization of indigenous materials would be an advantage and would develop these to the production stage. Such break-throughs are rare and even if an institute did have the good fortune to have more than a normal share of these, it would still be required to conduct adaptive research and to adapt technology to meet immediate production needs. It would also be expected to provide certain essential services, such as industrial testing, in-plant standardization and quality control, industrial engineering, trouble-shooting, feasibility studies, project evaluation, machine maintenance and design, etc., and to actively assist in the emplementation of national industrial plans.

60. In order to justify these assertions, it is necessary to review the factors and problems of industrialization in African countries. The peoples of Africa are predominantly engaged in agriculture, pastoral and fishing activities, and forestry. Consequently, they understand agriculture which has been the traditional occupation for centuries and capital resources which are modest are preferentially directed to this and related activity. Because of the non-existence of industrial tradition, lack of knowledge of the technologies and know-how of production, lack of technical and industrial skills, lack of entrepreneurial talent, and lack of an institute where technical services could be obtained to overcome these handicaps, Africa has failed to attract sufficient internal capital to generate industrial activity at the rate most of the new countries have planned for. Industrial investment from the indigenous population has therefore been meagre. In addition to this, limitations of national boundaries and inability to offset this by economic integration of a group of countries, coupled with low consumption of goods, have meant poor markets for industrial products.

61. Against this background let us examine the areas of support that will be required before entrepreneurs will venture into industry. For this purpose four different groups can be envisaged.

(a) Local entrepreneurs wishing to enter industry where some limited knowledge and experience exists.

(b) Local investors wishing to enter into a small-scale industry where no local knowledge or experience is available and it is not proposed to import know-how from abroad.

(c) Local industrialists entering into medium-scale industry, in technical and or financial collaboration with an overseas manufacturer or trading company.

(d) The government intending to set up a large-scale plant for a basic industry such as cement, oil refining, heavy chemicals, fertilizers, paper and pulp, iron and steel, or a large-scale textile mill.

Processing Industries

62. In the first category will be a majority of products now exported in the raw or unprocessed forms and a number of products locally consumed such as processed food, timber products, bricks, tiles or weaving. If the products replace a hitherto lower priced export commodity, it is necessary to know whether this would be preferred in the traditional market and, if so, in what quantities, price and quality. When raw products are imported into a consuming country for use in various manufactures, there already exist units for processing them into forms acceptable to an end-product manufacturer and these interests are likely to thwart attempts of a primary producing country entering into competition with them. Consequently, the traders who supply the processing factories abroad will also be unhelpful, not because they are unpatriotic but because they have no contacts with the end-use manufacturers and will therefore lose an existing trade. The

enthusiasm of the local entreprencur is likely to vanish at the end of this preliminary enquiry unless he has ready access to an impartial organization which could advise him of the end uses of the processed product and direct him to information regarding manufacturers to whom he can apply for details of price, quality and specification, and quantities required.

63. Having obtained this information and established a potential market at a price which appears to be advantageous both to country and the sponsor, he will now search for details of size of economic production, type and cost of machinery, industrial skills required, management, supplies of raw material, attainment of quality specifications, cost of processing, etc. He will require specialized assistance in all these areas and continual services of testing his product, assistance in overcoming process or machinery breakdown and in improving effeciency of operation.

Consumer Industries

64. In the case of production for local consumption he would require information on total demand, what proportion of this is already met, what plans, if any, the local manufacturers have for expansion and, if these do not exist, the reasons for not expanding production. If the reason is lower demand caused by poor quality or too high a price, further information may be called for on the desired quality, optimum price and the techniques and technologies of production required to meet both quality and price. This will lead to further enquiries on size of production, source and type of machinery, specifications of quality of raw material, capital required and cost of production. Where a local entrepreneur enters a field of industry on which no know-how or experience exists, he will require the assurance of competence and availability of sources which can also provide the adaptation of technology, layout of selected machinery and technical supervision of production besides other services referred to earlier.

Medium-scale Industries

65. In the case of medium-scale industries which are to be established by local enterprise in collaboration with foreign technical know-how and/or financial participation, the problems are many and varied. "Foreign know-how" is in many cases that supplied by machinery salesmen with access to persons experienced in the industry and their main objective is to sell the most expensive equipment at the best possible price. The machinery offered may not be the best of its type, or the most desirable for the size of production envisaged. Where industrial skills are unavailable it may be unwise to have ultra-modern equipment with push-button controls, as these require accurate adjustments and maintenance which involve higher skills, even if the higher cost of such equipment may not be a major factor. The machinery may, on the other hand, use a technology without modification to local conditions, or have a capacity several times in excess of anticipated production. The know-how is of limited value as it does not have the assurance and reliability of a reputable manufacture. The manager supplied by the machinery manufacturer is an individual who might make unreasonable demands on the local company and hold it to ransom. Many cases of this type have been reported in the less advanced countries of Asia and elsewhere and this may well be the experience in Africa. It can only be avoided if the local industrialist has access to competent help in the formulation, supervision and operation of his concern.

66. Where collaboration with a foreign manufacturer is envisaged the particular problem mentioned above may not arise, but advice will be required on the minimum and maximum number of local personnel in various categories of management and their training, the disclosure of know-how, the conditions of purchase of raw materials, and generally on the type and contents of a technical agreement between a local sponsor and an overseas manufacturer.

Basic and large-scale Industries

67. In the case of basic industries, which are coming increasingly under public ownership in the underdeveloped countries, largely because of high initial capital and inadequate return on investment, a local institute may not have the competence to prepare full and detailed project reports and to make technical and economic feasibility studies. It could, however, make the initial survey of the quantity and quality of raw materials available, of the availability of technical and skilled manpower for the particular industry, of the market existing with projection for consumption at the time when industry will be established, and make a preliminary feasibility study for consideration of the government. If in the view of the institute the prospects of economic operation seem satisfactory or even marginal, it could make recommendations for the choice of a specialized consultant in the particular industry, and provide such a consultant with all the local background data he will require.

Feasibility Sudies, Project Evaluation and Loan Surveys

68. There is yet another and important field of activity by which an institute could assist industrialization. As indigenous industrial investment in industry is likely to be meagre for some considerable period of time, the entreprenour looks to industrial banks, development corporations and commercial banks to provide loans on long-term credit. Quite naturally the banks themselves require evidence of fundability before they can consider providing long-term credits. The local entrepreneur will be unable to prepare a project report with all the details of capital cost of land, buildings, machinery, cost of installation and services, raw materials and labour required, market potentials, cost of production, etc. and consequently a worthwhile project might never be started. Assistance in the preparation of feasibility studies which would lead either to a bankable project or to the rejection of uneconomic projects which are a drain on the resources of the country will be a

service of great value to industrialization in the less advanced countries and should therefore be included in the functions of an industrial research institute.

Functions of Industrial Research

69. Against the background of the discussion of research and other services and of needs in African countries which have preceded the following functions for industrial research emerge:

(a) Surveys and studies of the natural resources, by-products of industry and agriculture and their utilization;

(b) Investigations and research into and development of new products and processes for industry, and the development of new technologies for the utilization of local raw materials;

(c) Laboratory services of analysis and testing of industrial products and export products;

(d) Assistance to governments in the development and formulation of standards for industrial products;

(e) Techno-economic feasibility studies, loan surveys and project evaluation for financing institutions, public and private sector of industry, and other bodies;

(f) Consultation service to industry on production management, industrial engineering, marketing, cost accounting, quality control, inventory control, in-plant standards, and general engineering technology and production problems.

(g) Technical information services based on a specialized library for the purpose of disseminating information on known processes, operations, and technologies; and publication of suitable pamphlets or brochures on the characteristics, utilization and industrial possibilities of the natural resources;

(h) Foster training in collaboration with the universities and other educational institutions, of research workers, engineers, technologists, managers;

(i) Produce liaison with other institutes both in Africa and elsewhere and thereby foster the spirit of co-operation and the universality of knowledge.

Financing of Industrial Research

70. The annual cost of operation of a multi-purpose research institute with functions and services stipulated above is around US. $350,000 while that of a specialized institute working in a particular industrial field will be lower but not much below $200,000 per year. In addition to recurrent costs is the cost of equipment, land and buildings for each institute and this capital cost is assessed at $1 million.

71. While this order of expenditure is within the means of countries like Nigeria, Ghana, Ivory Coast and Senegal it may be considered a burden on the other countries of the sub-region. Co-operative arrangements and reimbursement for services rendered to the private sector will then be necessary and advantageous.

72. Multinational co-operation such as that envisaged for the Solar Energy Centre at Niamey which works for the three countries, Niger, Mali and Upper Volta, is one of the successful approaches in obtaining economy in personnel and funds per country. Such co-operation in the research field is not new. It has been practised in the developed countries for many years and the Industry Research Associations in the UK are examples.

73. Industrial research institutes work for the private sector of industry as well as for governmental bodies. The services for the private sector include testing of products, trouble-shooting, quality control, project evaluation, feasibility studies, loan surveys,

process development, and managerial consultancy services. In most countries the private sector has been willing to reimburse the cost of such direct services and the income from this source can be as much as 30-40 per cent of the recurrent budget each year. This implies, however, that a developed indigeneous private sector of industry exists. The countries in the West African sub-region are still industrially underdeveloped and present industrial production is low. The governments will, therefore, have the major responsibility for guaranteeing financial support both for establishment and recurrent expenditure. However, if the corporate and independent status of the institute is assured and it wins through impartial service the confidence of the industrial sector, it can earn a substantial income from the private sector within 5-7 years and every institute should be encouraged and empowered to become fully self-supporting in 10 years with government only paying directly for services like any other client.

CHAPTER VII

STAFF AND TRAINING

Quality and qualifications of staff

74. The efficiency of a research institute depends almost exclusively on its direction and the quality of its staff. For industrial research the professional staff member should have a first honours degree in chemistry, chemical engineering, mechanical engineering, physics, or industrial economics, followed by a post-graduate degree in an applied science, a diploma in industrial management and at least one year in factories of chosen field of specialization. Ceylon experience shows that it takes five to seven years after the first degree to make a research officer of the calibre required.

75. The high quality and calibre of technical manpower required for research is forcibly expressed by Teale in the following terms:

> "I think that the premium on imagination, on flexibility, on the capacity to deal with questions that have never been asked before will be very much more substantial than it has been in the past. I think the capacity to deal with new knowledge that is piling up at the rate that is hard to exaggerate, is of utmost consequence. It demands the capacity not only to acquire and use knowledge but also to discriminate carefully with respect to what does not need to be acquired and what should be avoided." 1/

The training for original thinking, and the acquisition of scientific method, is the function of the university and the research conducted in the field of fundamental or basic research by students as fulfilment of post-graduate studies is expected to satisfy this. This is an essential training not only for techniques of research but also for imparting scientific understanding in trainees to select from the world's store of knowledge those elements required for the development of their countries. A post-graduate degree alone is

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1/ Stanley F. Teale, Proceedings of a Conference on Technological Planning at the Corporate Level, sponsored by Harvard Business School, 1961.

insufficient as industrial research workers should also possess experience in industry and industrial management and acquire the hard discipline of industry.

76. It is common experience in the developing countries for persons to believe that university degrees and diplomas are all that counts. In the field of research generally, and particularly in the difficult discipline of industrial research, the university degree is only the beginning. Individual success depends on preparation and training coupled with dedication to the task. In developing countries an industrial research worker needs to be a specialist turned generalist and this requires a research man to acquire additional knowledge in a variety of fields by practical experience and study.

77. A research worker cannot delegate. He should carry out each and every operation himself, however menial this may be, as this is the only way of assuring that every experiment conducted will result in accurate observations and deductions. In most of the developing countries - and, this is also true of Africa - the educational and social systems have given a prominent place to white-collar jobs and consequently young men have the erroneous belief that soiling their hands is degrading. This attitude is out of harmony with industrial development and is disastrous for research activity. If an institute is to be efficient and to provide the services expected of it, its staff of scientists should not only be highly qualified and experienced, but also believe in and practice dignity of labour. This situation is further aggravated by higher financial rewards and better prospects offered in executive positions in governments. Consequently, research, which requires the highest intellect in the country, is often neglected, and countries become dependent on foreign scientists. These, besides being expensive, cannot be expected to provide the type of leadership, dedication and identification with the aspirations of the country that only indigenous scientists can. The solution is to be found in investment in training over a long period of time for the research men and in compensating them at a higher level than the administraitve or civil service in a country.

78. The countries of the sub-region are conscious of the need for training of their own scientists for research. The following statement by the delegate for Togo to the Lagos Conference, 28 July to 6 August 1964, is succinct and clear: "The general development of a country as a whole necessarily requires a large number of professionally qualified staff. They can only be made available if countries set about training them, in their own universities or abroad.....and technical assistance, whether from Europe, the United States or elsewhere, is never more than a palliative; besides it is limited in extent and in duration, and can never be counted on indefinitely. Each developing country must now start training its own research scientists who can progressively take over the role played by foreign assistance." He further dealt with the lack of opportunity in the following terms: "Some(obstacles to scientific careers) are connected with the existence of traditional hierarchies, reinforced by colonial alienation. The authority and prestige belong to the administrator, the legislator, the technician being only the - in general, modest - collaborator. His prospects in an administrative career are better than if he launches out on his own. Superficially, his social importance is not evident .... It would be high time, however, and good for the future of our countries, to end the paradox that consists of having a grave shortage of skilled scientists and technicians, while vocations are hindered or stifled ..."

Training

79. Research is a highly intellectual activity and a severe discipline. Training is therefore of longer duration than the professions, and should be planned for. The most severe handicap faced by research institutes in the sub-region is the shortage of staff both local and foreign. The Federal Institute of Industrial Research has only one Nigerian on the senior research cadre and almost a third of the senior posts provided, including the post of Director, are vacant. Similar situations exist in the other countries. The majority of research in the French-speaking countries has been

entrusted by conventions to the French specialized institutes such as IRAT, IRCT, IRHO, IFAC, ORSTOM, BRGM, CRBTP and CTFT which maintain stations staffed largely by French scientists and visiting missions. Because most of this assistance in technical personnel is in the form of aid from France, the countries themselves have not planned for the training of these key personnel.

80. With persons of the training, experience and attitude mentioned above a multi-purpose institute could be operated efficiently with a professional staff of 16 to 20 persons. Specialized institutes on a chosen field of industry would require a professional cadre of 8 to 10 persons. In order to replace expatriate staff in existing industrial research institutes - which include besides the multi-purpose institutes like the F.I.I.R. in Nigeria, also the food research, building research, leather, forest products and mining and geological research institutes - 100 persons will have to be trained, and to meet the requirements of new institutes (including industrial engineers, cost accountants, market research men and project evaluation specialists) a further 100 will have to be trained. Most of this training may have to be done overseas, but local universities could at least provide basic degree courses in chemistry, engineering, physics, chemical engineering, industrial engineering, etc.

81. The staffing position even for junior staff such as laboratory technicians, laboratory and research assistants, workshop and maintenance service men, is also unsatisfactory. On the basis of the ratio of one research officer to two supporting staff the requirements in the sub-region for junior staff in the specialized area of industrial research is around 300, assuming that some posts are already satisfactorily filled. To this should be added the requirements of agricultural and forestry institutes, medical research, and the university and higher secondary schools teaching science. The volume of training required is sufficiently large to support full-time courses for laboratory technicians and assistants in at least two or three universities, polytechnics and technical colleges.

The basic academic requirement for junior staff is the G.C.E. 'A' level in science and additional training consists of the Junior Technical Officer Course in chemistry, chemical engineering, mechanical engineering, physics, workshop practice, etc., or the City and Guilds Laboratory Technician Course. The academic background could be lowered to G.C.E. 'O' level provided the duration of the specialized courses are increased from the normal two years to $2\frac{1}{2}$ years.

CHAPTER VIII

EXISTING SITUATION, PROSPECTS AND CONCLUSIONS

Lanugage Barrier

82. The fourteen countries of the sub-region present a heterogeneous picture. Two linguistic groups exist. Five countries - Gambia, Ghana, Liberia, Nigeria and Sierra Leone - have adopted English as the language of administration. These countries, however, are not contiguous. Two countries - Ghana and Nigeria - have already developed national institutions. While Liberia and Sierra Leone are neighbours, Gambia is separated by three countries which administer in a language other than English. The remaining nine countries are French-speaking, contiguous, and have a record of joint administration and common institutions.

Population and GDP per capita

83. Nigeria is the most populous with 58 million people in its four regions. The next largest, Ghana, has only 7.74 million. All the other countries have populations under 5 million each with two countries, Gambia and Mauritania, having populations of under 1 million.

84. The GDP *per caput* average for the whole sub-region in 1965 is US$ 97 with variations ranging from Upper Volta at US$ 47 to $249 and $250 for Ivory Coast and Liberia. In general the most populated countries have lower GDP *per capita* - with the exception of Ghana, Ivory Coast and Senegal. Nigeria with a population of 58 million has a GDP *per capita* estimated at US$ 74 while Mali with a population of 4.58 million has a GDP of US$ 71 and Upper Volta with a population of 4.78 million has the lowest GDP in the sub-region of US$ 47. These are detailed in Annex I and it will be seen that a number of smaller populated countries have low GDP *per capita*, e.g., Dahomey US$ 69, Gambia, $71, Sierra Leone $84 and Togo $87.

Scientific Infrastructure

85. A review of the existing institutions in the agricultural, industrial, mining and geological fields, and of universities, polytechnics and university colleges is provided as an annex to a companion study on standardization in the West African sub-region (E/CN.14/INR/116). In this study the industrial research and development institutions are shown in Annex II.

86. Nigeria is the most advanced with five universities, a multi-purpose industrial research institute, four development corporations, and research institutes for food, building and forest products. Ghana, a smaller country both in area and population, ranks high with three universities, an academy of science co-ordinating research, and research institutes in food preservation, building, forest products, isotopes and cocoa technology. Senegal and Ivory Coast are the only other countries which have a satisfactory scientific infrastructure on which a multi-purpose industrial research institute on a national basis could be established. Senegal has a university with faculties in science and engineering, a newly established food technology institute, the Organisme de Recherches pour l'Alimentation et la Nutrition Africaines (ORANA) and a building research institute. Ivory Coast has seen rapid economic development in the last five years. It has the University of Abidjan, an applied research institute working principally on food and fruit preservation, a building research unit and a rubber research unit.

87. Seven countries - Dahomey, Gambia, Mali, Mauritania, Niger, Togo and Upper Volta - do not have a university or polytechnic and these are also the poorest in scientific infrastructure necessary for industrial research. In the intermediate position are Guinea, Liberia and Sierra Leone which have a university, ploytechnic or colleges of university level but lack other research institutes in the industrial field.

Scientific Policy and Objectives

88. In the ten countries listed above as having poor or intermediate positions in scientific infrastructure, no national science policy has as yet been precisely defined. In Niger research effort is co-ordinated by the Planning Commission, in Mali by the Research Council, and in Dahomey by the National Survey and Planning Directorate. These countries have largely agrarian economies and their main research activity has been in agronomy and in mining and geology. The French-speaking countries in this group have only had an operational nucleus of scientific and technical facilities set up before independence by agencies in France such as the IRAT, IRCT, IRHO, IFAC, ORSTOM, BRGM, and CTFT and only a limited number of these have worked in any one country. These organizations work largely in the agricultural and geological fields. The CEBTP has only research stations in Ivory Coast and Senegal and has through these stations undertaken building research for the other countries of the former federation of French West Africa.

89. The scientific policy as stated by Togo applies to all these countries. It states "Research will no doubt proceed from the general to the particular and from urgent to the less urgent. The executive agency need not necessarily, as in some countries, be responsible also for research planning, but this is likely to happen in African countries whose means are limited, having only a small number of technicians and research workers and only one or two specialized institutions. A division of work that is not purely national but of common interest to two or three countries is also a possibility."

90. The co-operation in research among a group of countries was fostered in the colonial period by the research agencies of the metropolitan countries. Thus grew the West African Cocoa Research Institute, the West African Oil Palm Research Institute, the West African Building Research and others set up by the UK. The research

stations set up and serviced by various French research organizations have already been alluded to earlier. In many cases the research programmes and services catered to the needs of a group of countries. While in the francophone countries these organizations have continued to operate and to serve as before, (and more often than not also financed by France), the West African institutes in the anglophone countries have in the flush of independence ceased to operate as sub-regional centres and have become national bodies. In this age of co-operation and joint action in the political and economic fields, the breakdown in co-operation in the vital research area is regrettable although the reasons for this break up may have been due to the attainment of independent status by the various countries at different dates. With all the countries now fully independent and equal, it is hoped that this co-operation will be re-established not only for forging African unity but also for accelerated group development at the lowest cost and optimum utilization of scarce resources.

91. In all countries of the sub-region industrial development has become a crusade although agriculture is still the predominant economic sector. National economic policies and plans have, however, emphasized industrialization and governments are increasingly convinced that this development is impossible without parallel scientific planning, co-ordination and development.

92. The policy of Ghana is pertinent. It states "On the industrial side, the aim is to prospect for essential industrial minerals which will lay the foundation for chemical and other industries, and also to investigate the local manufacture of essential industrial chemicals. Research aims at providing semi-processed goods where possible for export rather than exporting the raw unprocessed materials. Research in the utilization of local materials for building and construction work is also given priority. In order to ensure the maximum and most efficient utilization of the results of research

the national research policy ensures the most effective liaison with those engaged in extension services. ..... Finally, the research facilities are at the disposal of all neighbouring countries whose problems are similar to those of Ghana, and for that matter at the disposal of the whole of Africa."

Prospects

93. The Beirut Seminar on Industrial Research and Development Institutes recommended the expenditure of 0.1 per cent of a country's GDP as a minimum for industrial research if the services are to meet urgent needs. The cost of operation of a modest multi-service institute has earlier been estimated at US$ 350,000 per year. To this should be added the heavy initial cost of equipment, land and buildings for its establishment and the cost of essential training of scientific and technical staff.

94. Elsewhere in this study, the average expenditure on all research in developing countries has been estimated at only US$ 0.10 to 0.30 per capita which indicates that present expenditure on research which includes university, agricultural, mining and industrial and health research is much below 0.1 per cent of GDP. There may have been competing social demands in new countries which necessitated this. The inevitable conclusion is that greater expenditure on research is essential if the accelerated development and consequent higher standards of living of the peoples desired is to be achieved.

95. Assuming, however, that as a policy the governments of the countries are willing to spend one half of 0.1 per cent immediately, only four of them, namely, Nigeria, Ghana, Senegal and Ivory Coast can afford multi-service industrial research institutes. The rest of the countries need a much larger per capita outlay. Consequently, co-operative arrangements among themselves with specialized institutes distributed equitably in fields such as solar energy, building, food technology, textile technology, oil and fats, metalurgy, etc., and controlled by an over-riding Research Council composed of representatives of participating countries would be a solution for them.

Conclusions

Nigeria

96. Nigeria established the Federal Institute of Industrial Research in 1956 on the recommendations of the 1954 World Bank Mission. Industrial research and other forms of scientific research require an atmosphere of freedom for their success. The F.I.I.R. functions as a Government department under the Federal Ministry of Industry and the financial and administrative regulations applicable, although appropraite for public administration, hamper research activity in many ways.

97. Industrial Research should cater for all types of industry, large and small, public and private and should develop technologies to suit local conditions. This it can do only if it serves industry effectively through industrial extension and consultancy services on a confidential basis. The Institute should also generate the dynamism that is necessary to develop the research market and potential. This has not been created in Nigeria and liaison with industry leaves much to be desired.

98. As a department of Government, the Institute is governed by public service salary scales, and recruitment procedures. The scales are inadequate to attract the talent that is required for research and a large percentage of the senior posts are vacant and only one Nigerian has been attracted to a research career. The scales would have to be raised if the situation is to improve and this can only be done if the Institute has both financial and operational autonomy.

99. Besides the F.I.I.R., Nigeria has specialized institutes in building research, forest products, food, leather, stored products and an industrial laboratory for the Northern Region. Economy in the use of scarce resources, if not the requirements of planning would suggest that these activities be co-ordinated under an autonomous Industrial Research Council. There is reason to believe that

the full potential of industrial research is not being harnessed effectively for the benefit of the nation due largely to the institute's dependence as a Government department and the poor direction now obtaining without a full-time director.

100. The Government has under consideration a proposal to set up a national research council with complete autonomy, presumably to deal with all scientific research. The linkage between the various industrial research organizations and the proposed council should be the subject of a detailed study for which United Nations assistance is appropriate.

Ghana, Sierra Leone, Liberia and Gambia

101. Ghana in pre-colonial times formed part of British West Africa which then consisted of Nigeria, Ghana and Sierra Leone. The West African research institutes established served these three territories. With the grant of independence first to Nigeria and then to Ghana and still later to Sierra Leone these research organizations have lost their multinational character.

102. Independence saw considerable expansion of research facilities in Ghana in spite of the break up of the West African institutes and the present structure of science, despite the lack of a multipurpose industrial research institute, is one of the best in the sub-region. The Government has also expressed its desire to cooperate in the field of research not only with its neighbours but also to make available its research services to other countries in Africa. It is therefore reasonable to assume that a multinational grouping of Ghana with Sierra Leone, Liberia and Gambia would be acceptable.

103. The Ghana Academy of Sciences was formed in 1963 and took over under its over-all policy administration a number of research institutes in the country including the building research, food preservation unit, food research and forest products research unit.

This might appear to be a heavy concentration of specialized institutes in one country but may be offset by the establishment of a multi-purpose industrial research institute in Sierra Leone, a rubber research or metals institute in Liberia and an oil and fats research institute in Gambia.

The Francophone Countries

104. These are nine countries - Dahomey, Guinea, Ivory Coast, Mali, Mauritania, Niger, Senegal, Togo and Upper Volta. Only Senegal which already has a newly established Food Technology Institute and Ivory Coast with the Institut Technique des Industries et Produits Tropicaux have the nucleus and the financial resources for a national multi-purpose industrial research institute. It is problematical, however, whether they will have the scientific man-power to direct and staff such a research institute.

105. These nine countries have a record of fruitful association in the past and are conscious of the benefits and strength of collective action. Although the building research stations of CEBTP are in Senegal and Upper Volta there are other fields on which specialized institutes could be established - the Solar Energy Centre in Niger being one. The raison d'être for the specialization can only be determined by detailed study and consultation with the Governments of these countries. Such study and recommendations should form the basis of inter-governmental agreements and the establishment of a multinational council of industrial and scientific research for the nine countries. Of all the various fields of economic and social activity, science provides by its very nature the easiest area of co-operation, and these nations are unlikely to throw out this opportunity of building goodwill and solidarity which we hope will later lead to still greater and more fruitful co-operation in the economic and political fields.

ANNEX I

POPULATION, GDP, AREA

	Year	DAHOMEY	GAMBIA	GHANA	GUINEA	IVORY COAST	LIBERIA	MALI	MAURI-TANIA	NIGER	NIGERIA	SENEGAL	SIERRA LEONE	TOGO	UPPER VOLTA
Population in Millions	1965	2.35	0.32	7.74	3.48	3.83	1.05	4.58	0.74	3.27	58.00	3.47	2.71	1.64	4.78
GDP per Caput $	1965	69	71	202	72	249	250	71	192	90	74	202	84	87	47
0.1% of GDP in $'000	1965	162.2	22.7	1563.5	250.6	953.7	262.5	325.2	142.1	294.3	4292.0	700.9	227.6	142.7	224.7
Area in '000 Sq.Km.		115.76	10.37	237.87	245.85	322.46	111.37	1204.0	1085.8	1267.0	923.7	197.1	72.32	56.6	274.2

ANNEX II

INDUSTRIAL RESEARCH, SCIENCE COUNCIL & UNIVERSITIES

Country	Dahomey	Gambia	Ghana	Guinea	Ivory Coast	Liberia	Mali	Mauri-tania	Niger	Nigeria	Senegal	Sierra Leone	Togo	Upper Volta
University or Polytechnic	Nil	Nil	3	1	1	1U	Nil	Nil	Nil	5	1	2C	Nil	Nil
Multi-purpose Industrial Research	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	2	Nil	Nil	Nil	Nil
Food Res. and Food Preserv.	Nil	Nil	1	Nil	1	Nil	Nil	Nil	Nil	1	1	Nil	Nil	Nil
Building Research	Nil	Nil	1	1	1	Nil	Nil	Nil	Nil	1	1	Nil	Nil	Nil
Applied Physics e.g. Solar Energy Sotope	Nil	Nil	1	Nil	Nil	Nil	Nil	Nil	1	-	1	Nil	Nil	Nil
Development Corporation or Bank	1	Nil	1	BCRG Cen-tral Bank	1	1	Nil	1	1	4	1	Nil	Credit du Togo	1
Geology & Mines (1) GOV (2) Other e.g.BRGM	1	Nil	1	1	1 1	1	1 1	1	1	1	1	1	1	1 1
Agro-Allied Technology			Cocoa		Rub-ber	Fire-stone Rubber		Date Palm		Oil Palm	Nutri-tion ORANA			

U = University or Polytechnic C = College