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PROCEEDINGS OF AN EXPERT GROUP MEETING
ON
STRENGTHENING RESEARCH AND DEVELOPMENT CAPACITY AND LINKAGES
WITH THE PRODUCTION SECTORS IN COUNTRIES
OF THE ESCWA REGION

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PREFACE

In a field where information is scarce, inputs from people with long experience in the field acquire added significance. In preparing this study, ESCWA was fortunate in having the co-operation of a number of such people in the region. Their inputs to this study were invaluable. ESCWA would like to thank particularly the following: Mr. Mohammed Kamel Mahmoud, ex-President of the Academy for Scientific Research and Technology in Egypt; Mr. Usama Al-Kholy, first Advisor to the Director of the Kuwait Institute for Scientific Research; Mr. Fakhruddin Daghestani, ex-President of the Royal Scientific Society in Jordan; and Mr. Ghazi Darwish, Advisor, Ministry of Heavy Industry and Minerals in Iraq;

The study has also greatly benefited from the comments, discussions and papers which were presented at the Expert Group Meeting ESCWA organized in Amman during November 1987, on Strengthening R and D Capacity and Linkages with Production Sectors in Countries of the ESCWA Region. The list of the papers presented with their authors is presented in annex II to the present study. ESCWA would like to thank the authors of these papers and the participants in the Meeting for their valuable contribution.

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INTRODUCTION

Research and development (R and D) is considered an integral part of science and technology. In fact many would consider it to be in the centre of the scientific and technological activities that are needed in the development process. Other scientific and technological activities are important to the extent that they are closely related to R and D. This emphasis on the importance of R and D is the result of decades of experience.

There is now an increasing realization in the region that, until suitable measures are adopted to develop local scientific and technological capabilities, there will be little or no significant development in the technology, a situation which would perpetuate the existing heavy reliance on foreign technology. R and D happened to be the arena where home-based scientific and technological capabilities can grow to secure the required dynamism for the economy.

Policy makers in the concerned ESCWA countries have noted the growing importance of R and D. Neither the discovery of natural resources, nor the accumulation of capital secured real economic development. The experience of the region in the last decade has shown that accumulation of capital without improvements in knowledge could not bring about real progress. The world is also witnessing a situation whereby the income and production gaps between countries have been widened by the degree of accumulation of scientific knowledge and technology, by their appliciation to production and organization in industry, trade and agriculture, and by the commercial exploitation of knowledge.

R and D activities are the field where technological capabilites are strengthened, and at the same time contributions to the production capacities are made. In the context of the countries concerned, the "modern" and the "traditional" sectors must be emphasized. Considering the relative importance of the latter in the economies of the countries under discussion, one can visualize how the dynamic process of technical change and improvements could transfer the traditional technologies that are currently in use into highly competitive alternatives. R and D is the main source that can make this technological transformation possible.

Since the Vienna Conference on Science and Technology for Development in 1979, there have been marked changes in the status of science and technology in general and R and D in particular in the development priorities of the ESCWA countries. A number of central R and D institutions have been established. R and D activities are now included in the development plans and programmes of these countries. Moreover, the location of their policy making bodies has shifted closer to the decision-making centres of power. Part of this public concern about R and D has also been triggered by the realization that the benefits to R and D accrue more to the society at large than to any individual private investor and that R and D addresses a collective need in a number of areas which would not be of interest to the private investor.

The evidence in the present study will show that there were R and D bases in some of the countries considered. One direct effect of the recent concern about R and D has been to narrow the gap that existed between the countries of

the region in terms of qualified manpower, infrastructure and R and D facilities. Nevetheless, despite this increased concern, there is still extremely little information about the activities and impact of R and D institutions in the region.

In the face of this problem, this study had to be confined to fewer countries than one would have wished. These countries included Egypt, Iraq, Jordan, Kuwait and Saudi Arabia. Furthermore, as the study is the first such attempt in the region it had to be restricted to addressing basic questions rather than investigating any one problem in the depth it deserves.

The questions that have been considered in the study relate to: the structure of the existing R and D institutions and analysis of their activities; the degree of relevance of these activities and programmes to the ongoing and planned investments; the linkages between the R and D institutions on the one hand and universities, consulting, engineering, design houses and the production sectors on the other; the national policies affecting R and D activities; and the obstacles and constraints that have been affecting the performance of R and D institutions. The aim, of course, is to serve policy-makers in the region by suggesting policy measures and mechanisms that would help to enhance R and D activities and increase their effectiveness.

These issues have been dealt with in this study as follows: the first chapters will review the structural composition, functions and activities of the main R and D institutions as well as the financial physical and manpower resources that are available to them. In a subsequent chapter, the R and D plans and programmes are analysed. Chapter VII contains an analysis of the linkages that exist between the R and D activities and the production sectors together with the problems encountered. Chapter VIII contains the summary and conclusions of the study. Chapter IX, includes the main recommendations of the Expert Group Meeting organized by ESCWA.

It would be useful to note that, as far as possible, the definitions applied for "scientific research", "research and development", "experimental development", "R and D institutions", and "R and D units" have been according to the definitions developed by UNESCO.[1/] Nevertheless, lack of uniformity regarding R and D definitions and data has been a serious problem. Often, faced with a lack of data, the authors of the study were obliged to accept whatever R and D concept happened to have been applied by the providers of the information. One important recommendation of the Expert Group Meeting relates to the introduction of a formal system for compiling and classifying R and D data.

The countries reviewed in this study represent different types of experience in the development of R and D. It was relatively easy to find detailed information concerning their R and D activities.

1/ UNESCO, Manual for Statistics on Scientific and Technological Activities Statistics on Science and Technology, Office of Statistics (ST-84/WS/12), June 1984.

The definitions used in the study are as follows:

Research and development (R and D)

Covers all activities concerned with the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology. This includes research (R) and experimental development (D), scientific and technical education and training as well as scientific and technological services. Thus any systematic and creative work which increases the stock of knowledge in all fields of science including culture and humanities will be considered here as research and experimental development.

Scientific research

Refers to any systematic and creative activity that aims at increasing the stock of scientific knowledge and applying it in practice (whether fundamental or applied research).

Experimental development

Refers to any systematic work, drawing on existing knowledge gained from research or practical experience that is directed to producing new materials, products and devices for installing new processes, systems and services, and to improving substantially those already produced or installed.

R and D institution

The term "institution" is used as a "catch-all" term to cover a very broad range of entities with legal, financial, economic and social status, such as faculties, institutes, academies, organizations, establishments, enterprises, ministries, centres and associations.

Chapter I

RESEARCH AND DEVELOPMENT INSTITUTIONS IN EGYPT

In this and the following chapters, the institutions and establishments that are involved in R and D activities in the countries concerned are reviewed. The review will give a brief account of the historical developments which led to the creation of the institutions concerned. It will show how R and D institutions are grouped, their organizational structure, their mandated functions, their main activities, the resources that are available to them and how they have developed, and the source of their financing. Whenever possible, recent developments regarding R and D activities are also mentioned.

A. Background

In Egypt, there are a total of 297 institutions concerned with science and technology activities; of these, 275 institutions carry out R and D activities. In the following text, a review of the R and D institutions and their activities in Egypt is conducted in two parts, the first covering the institutions, their functions and activities, and the second providing some general information concerning the resources allocated to R and D. In reviewing the R and D institutions, two methods have been followed. First, the main R and D institutions are discussed, introduced by a brief historical account of how they were developed. Then the presentation follows the three main research lines, namely agriculture, industry and energy. The research institutions concerned with each of the three lines are discussed as a group.

In Egypt, the first Central Organization for Science and Technology was established in 1939. It was an autonomous body to sponsor scientific research leading to advancements in agriculture, industry, other national economic activities and defence. Its effective operation dates back to 1948. However, in 1953 it was amalgamated with the newly created National Institute for Scientific Research. The latter was changed in 1956 to the National Research Centre, concerned exclusively with research activities and leaving scientific policy to the Supreme Council for Sciences, which became responsible for directing and co-ordinating scientific research. It was this Council which formulated Egypt's first Five-Year Scientific Plan (for the period 1960/1961-1964/1965). The Council was also instrumental in initiating legislation for establishing a number of permanent research committees and research departments in the ministries involved with production of goods.

In the years following 1956, Egypt's economy underwent radical changes. The role of the public sector was greatly enhanced and national development plans were introduced. This, in 1963, was followed by the establishment of the first Ministry of Scientific Research. In 1964, the Ministry's organizational structure and functions were defined by a presidential decree to include a consultative board on science policy and the specialized research councils. This structure superceded the Supreme Council for Science and the National Research Centre referred to above. Numerous research centres and laboratories in the country were also placed under the authority of this

Ministry. The organizational changes in the following years included the setting up of the Consultative Board for Scientific Research, and the re-establishment of the National Research Centre, all under the Ministry. Moreover, the Ministry's operations were formally linked to the Development Plan. In 1971, the Academy for Scientific Research and Technology (henceforth referred to as the Academy) was established to be responsible, inter alia, for applied research and the national research plans. At the moment, Egypt has the Academy and the Ministry for Scientific Research. The latter represents the interest of the higher education and research community in the Cabinet. It is also responsible for co-ordinating and harmonizing the activities of the Academy with the country's general development policies and strategies. It approves the decisions of the Council of the Academy. The Academy, on the other hand, is the principal government organization for science and technology. It is responsible for co-ordinating the scientific and technological activities in the country. These functions will be discussed in detail below. A number of ministries also have their own research units. These ministries, while generally abiding by the macro-policy resolutions drawn up by the two institutions just mentioned, nevertheless follow their own scientific, technological and R and D policies at the sectoral level.

1. R and D institutions in Egypt: general structural composition

Most of the R and D institutions in Egypt belong to the Government. They can be grouped, according to their affiliation in the Government, into three main categories: universities, which are affiliated with the Ministry of Higher Education; R and D centres and institutions affiliated with the Academy; and the R and D institutions in the Ministries. There are 8 research centres and institutions affiliated with the Academy, 13 with the Ministry of Industry and Mineral Resources, and 11 with the Ministry of Health. There are 13 universities in Egypt. Eleven of them are funded and affiliated with the Ministry of Higher Education, as mentioned above. Al-Azhar University belongs to the Ministry of Wakf and Al-Azhar, and the American University in Cairo is a private university.

In the following text, the review will proceed first by considering the R and D institutions in the Academy, followed by the R and D activities in the universities and finally, the R and D institutions in the Ministries. In the latter, however, the institutions, as mentioned above, are grouped according to the three main research lines: agriculture, industry and energy. The activities of those institutions in the Academy whose main research functions fall under one of these three categories will also be shown here, as the Academy and its affiliates, are the principle R and D centres in Egypt. The box below presents the main functions of the Academy, and figure 1 shows its organizational structure, its departments and its research affiliates.

2. The Academy of Scientific Research and Technology (The Academy)

The Academy is by far the most important R and D institution in Egypt. It is responsible for preparing the National Research Plan and co-ordinating technology policy.

In the highest echelon of the Academy, there is the President of the Academy, assisted by a Vice-President in charge of the Specialized Councils. There is also the Academy Council, which is the policy-making body of the

Academy. Its role is to direct the Academy to serve the policies and plans adopted by the goods and services producing sectors. The main functions of this council are described below.

The Specialized Councils are important to the Academy. They are responsible for drawing up the National Research Plan and for co-ordinating scientific research at the national level. The operations of these councils will be considered in detail below.

The main functions of the Egypt Academy for Scientific Research and Technology

(a) Formulating policies that ensure strong linkages at the national level between science and technology organizations working to realize the national development plans;

(b) Formulating programmes that include research projects which aim at solving national problems or introducing new technological activities;

(c) Participating in studying the science and technology aspects of the major projects proposed for the socio-economic development programme;

(d) Encouraging research in the disciplines of basic research;

(e) Providing organization of science and technology information services;

(f) Promoting scientific and technological relations with other countries and with international organizations.

The main functions of the Council of the Academy of Scientific Research and Technology

(a) Formulating policies and mobilizing national science and technology institutions to work on the priority problems of socio-economic development;

(b) Introducing resolutions based on the recommendations made by the Specialized Research Councils;

(c) Making decisions concerning State-owned science and technology awards;

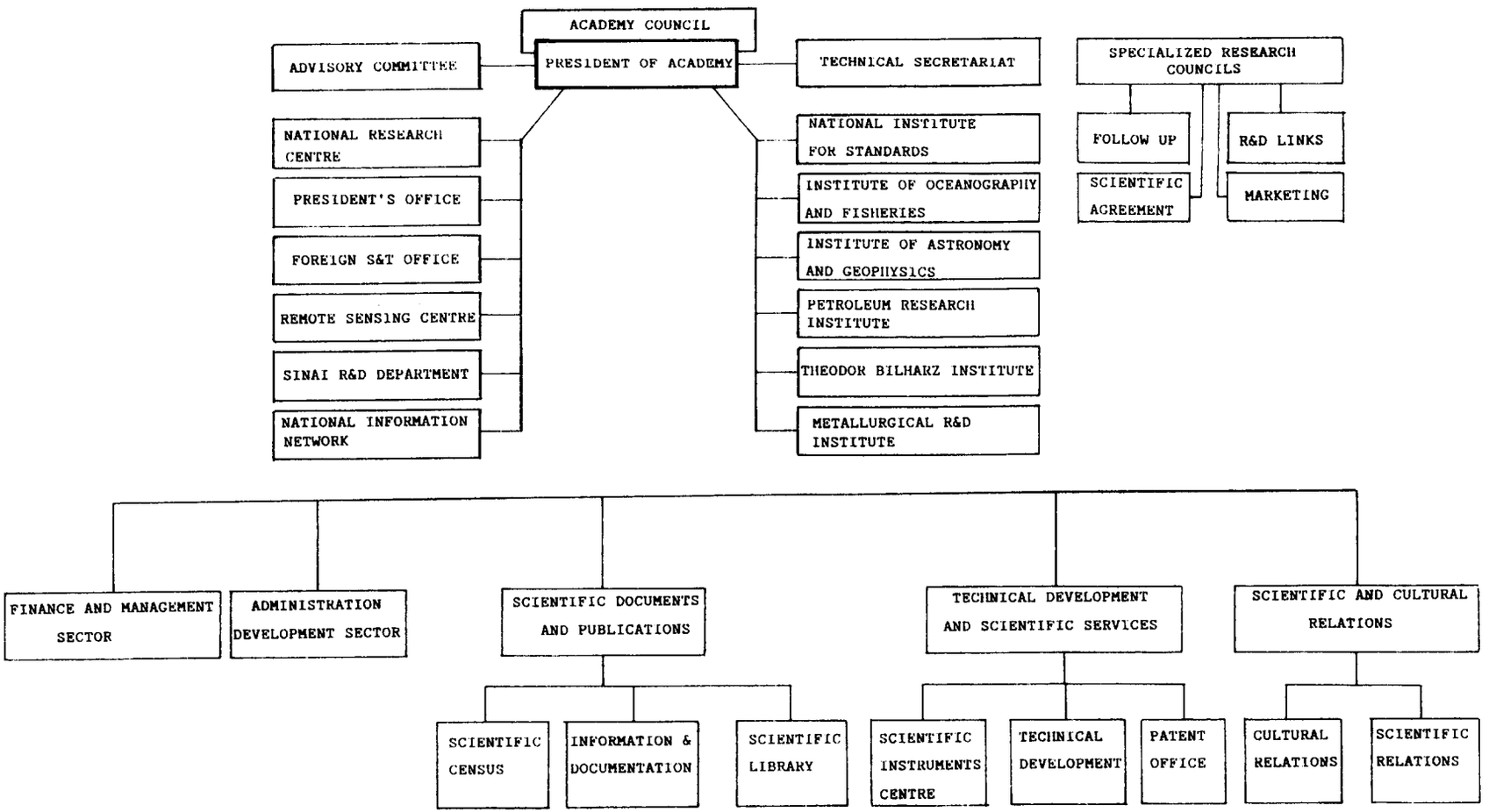
(d) Approving budget and expenditure of Research Programmes that are financed by the Academy;

(e) Dealing with the issues assigned to the Council by the Ministerial Cabinet or the Academy's President.

3. National Research Centre (NRC)

The NRC is the largest among the R and D centres affiliated with the Academy. It represents about 70 per cent of the total human and material resources under the Academy. It is a multi-purpose establishment which was founded by the Government in 1956, to cater for the R and D needs of the public sector. It conducts R and D activities mainly in the field of industry, agriculture and health.

Figure 1. Organizational structure of the Academy of Scientific Research and Technology



The Centre has its own campus with fully integrated laboratories, administration offices, pilot plants and support facilities. It has 13 departments which in turn are subdivided into specialized laboratories. A total of 56 laboratories and two institutes provide the research and development facilities in NRC (see figures 2 and 3). It can be seen in figure 2 that the higher administrative echelon is composed of a General Director, who reports to the President of the Academy, assisted by a Board of Directors, which provides general policy guidance for the NRC, and two councils, one for selecting research projects, and the other for technical advice.

(a) Human resources in NRC

Table 1 shows the number of researchers employed by NRC, broken down by type of posts and qualifications. It can be seen in the table that there were in May 1987 (the latest month for which data could be obtained) a total of 3,598 staff members.

Out of the total manpower working in NRC, 1,301 were research staff. The rest were technicians and administrative staff. About 70 per cent of the researchers were Ph.D. holders, and the ratio of supporting staff to researchers was 1.7:1.

Table 1. Number of researchers and supporting staff in NRC and their composition by type of post and qualifications
(Number) (1980)

Type of Posts	Qualifications	Number
Research Professor	Ph.D.	160
Associate Research Professor	Ph.D.	225
Researcher	Ph.D.	312
Teacher Assistant	M.Sc.	296
Research Assistant	B.Sc.	308
Total Number of Research Staff		1301
Technicians	Diploma	634
Assistant Technicians	Diploma	347
Total		2374
Administrative and Management		1224
Grand Total		3598

Source: M.K. Mahmoud. Research and Experimental Development Institutes in Egypt. A case-study prepared for ESCWA, December 1986, p. 95, (unpublished).

Figure 2. Organizational structure of the National Research Centre in Egypt

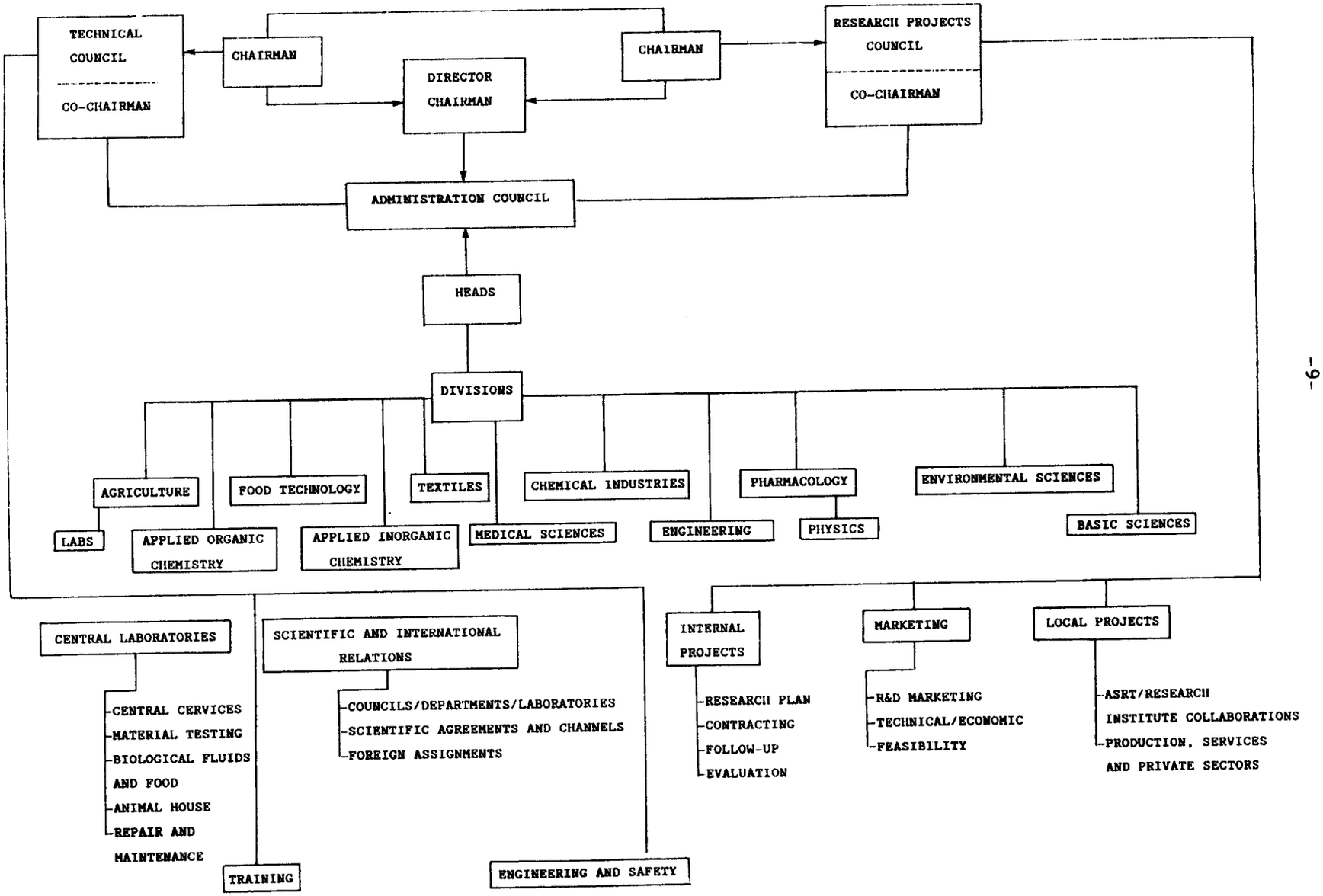
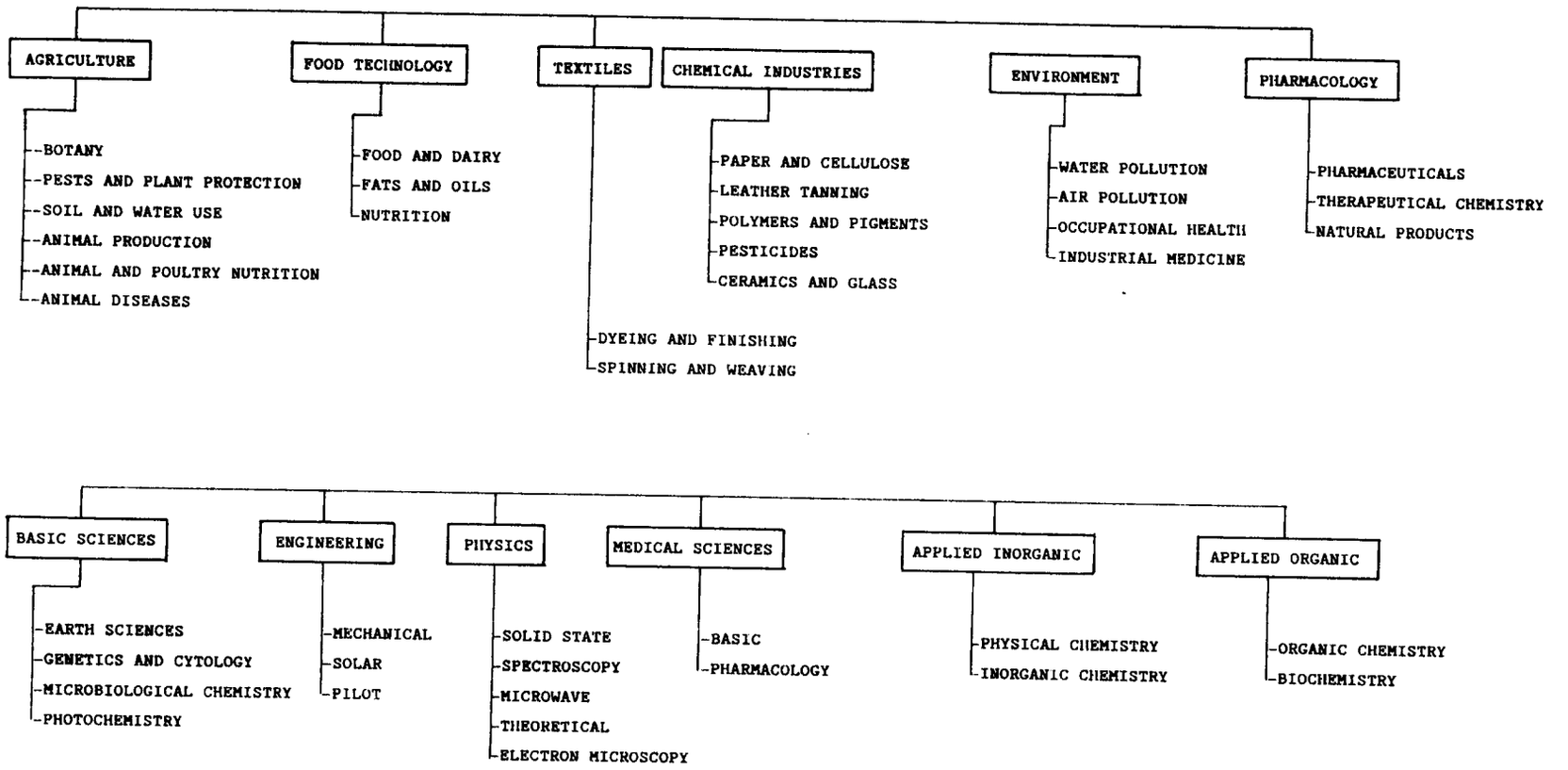


Figure 3. Organizational structure of the National Research Centre in Egypt/division and their laboratories



Note: Since this report was written, other changes have been introduced into the organizational structure of NRC.

The main source of NRC funds is from the Government's annual budget allocations. But it also gets funds through grants from the Academy, and recently from other local and foreign organizations. It conducts contract research for clients. The grants and the research contracts contributed 20 per cent to the NRC annual budget, which in 1984-1985, amounted to $US 9.4 million. This covered wages and salaries, operating and maintenance costs and expenditure on fixed capital formation as follows: $US 6.3 million; $US 1.6 million and $US 1.5 million respectively.1/

(b) Research programmes in NRC

Before referring to the research programme in NRC, it would be interesting to note the changes that have occurred in the method of conducting research in NRC.

Previously, the system for promotion for the senior researchers relied on the number of scholarly publications; for staff members without a Ph.D. degree it relied on thesis work. Therefore, often the output of the research was of the type described as "self-oriented" research. The relevance of the research work to national development was of secondary importance in the researchers preference list.2/ From 1975 onwards, a new system was applied for selection of research projects. In an attempt to improve utilization of its resources, research planning has become a more centralized and management responsibility. A number of high priority research problems were identified in close relation with the National Development Plans. Selection of research projects were from this list, and researchers were encouraged to focus on the high priority research problems through an incentive and award scheme. In addition, a Programming Office was also established within the Administration to co-ordinate this effort.

It would be impossible to provide a complete account of the research activities undertaken by NRC. Below a brief reference is made to the new R and D programmes continued since 1986. Each of the programmes mentioned represented a high priority area in the Five-Year Research Plan.

- Food sufficiency. This is an integrated research programme on plant and animal production, food and agricultural by-products, and unconventional methods of food production.

- Health. This programme is concerned with public health, nutrition, eye diseases and manufacturing of drugs from local products.

- Natural resources. The research here is concerned with the properties and beneficiation of various ores that exist in Egypt.

- Energy. Includes renewable sources (solar, biogas and wind).

1/ See NRC Annual Report for 1984-1985.

2/ M.K. Mahmoud. Research and Experimental Development Institutions in Egypt. A case-study prepared for ESCWA 1986, P. 94,(unpublished).

- Environment. The research programme covers water, air and noise pollution as well as recycling of solid waste.

- Industry. There are R and D programmes for a number of local industries, such as textiles, food processing and pharmaceuticals.

- Fundamental research. This programme covers basic and applied research in Mathematics, Physics, Geology and Biology.

- Rural development. This programme includes a number of multidisciplinary demonstration projects to increase production and improve living conditions of the inhabitants of rural areas in Egypt.

4. Other R and D institutes in the Academy

(a) Institute of Oceanography and Fisheries

The organization and activities of this institute will be discussed below in connection with R and D activities in agriculture.

(b) National Institute for Standards (NIS)

This institute was established jointly by the Egyptian Government and the United Nations Development Programme (UNDP) and it started its activities in 1970.

The principal functions of NIS are:

- To maintain the national standards for measurement of physical units and their use for purpose of measurement and calibration;

- To give advice, upon request, to industry and public services in problems related to measurement;

- To undertake research work on metrological problems in collaboration with interested organizations and industries;

- To provide the Egyptian Organization for Standardizations (EOS) with essential scientific requirements for an adequate quality control system in industrial production;

- To offer training opportunities for metrologists;

- To develop safety tests;

- To approve prototypes of measuring instruments.

(c) National Institute for Astronomy and Geophysics

This is one of the oldest institutions in Egypt. It began its activities in 1903. It deals with two main branches: astronomy and geophysics.

It has two telescopes, one in Helwan and the other in Kettamia. It carries out astronomical programmes, sometimes in co-operation with international institutes.

The Institute is also undertaking programmes in geomagnetism and seismology in the field of geophysics.

(d) Theodor Bilharz Research Institute (TBRI)

This Institute was named after the German scientist Theodor Bilharz, who discovered that the bilharzia worm caused the disease bilharziasis. TBRI was established by the Government with the assistance of the Federal Republic of Germany. It consists of an outpatient clinic, a hospital and research divisions.

The Institute carries out its research according to an approved plan between the Ministry of Health, the Medical Research Council of the Academy and the medical schools.

(e) Central Metallurgical Research and Development Institute

The organization, functions and activities of this Institute will be discussed below in connection with industrial research in Egypt.

(f) Egyptian Petroleum Research Institute

Similarly, a summary on this Institute will be given below in connection with energy research.

(g) Remote Sensing Centre

This centre started its activities in the early 1970s as a co-operative venture between the United States Government and the Academy. At present, the centre is considered one of the most advanced centres in the field of remote sensing.

It employs a core of highly qualified scientists covering the areas of geology, mineral and energy resources, hydrogeology, agriculture, soils, geophysics, photogrammetry, engineering and physics. It possesses a large inventory of modern equipment including ground, laboratory and air-borne equipment. Since its establishment, it has conducted major research and field projects with direct applications to large natural resources surveys or other development projects in Egypt and other countries.

(h) Regional Research Centres

Recently, the Academy established research centres in the eight economic regions into which the country has been divided. These centres are to operate as a joint venture between the Academy, the regional universities and the local authorities in each region. The first of these centres was inaugurated in September 1986, in Tanta, to serve the socio-economic development plans of the "Middle Delta Region". The inauguration of the others is to follow.

B. R and D activities in Egyptian universities

There are, as mentioned above, 13 universities in Egypt, 12 of which are government-funded and linked to the Ministry of Higher Education. Organizationally, universities in Egypt are autonomous bodies and are not organized into a system. However, many decisions concerning universities are made by the Supreme Council of Universities, which consists of the Minister of Higher Education (as chairman) and the Presidents of the Universities.

There are about 72 scientific and technical faculties in the 13 Egyptian universities. They employ 15,465 researchers and 3,464 technicians.

Table 2 shows the faculties, the number in each type, the number of researchers and technicians. The table shows that the greatest number of scientific researchers in Egyptian universities is in medicine, followed by engineering research and sciences; agriculture comes fourth.

Table 2. University faculties engaged in R and D activities and the researchers and technicians working in them (1986)

Faculties	No. of Faculties	Researchers	Technicians
Medicine	21	4,187	943
Science	13	3,633	703
Engineering	15	3,508	1,073
Agriculture	13	2,946	475
Pharmacy	6	685	188
Veterinary medicine	4	506	72
Total	72	15,465	3,465

Source: Applied Science and Technology. An Egyptian American Co-operative Programme, Board of Science and Technology for International Development, National Research Council, Washington, D.C., p. 5.

The quantity and quality of research among Egyptian universities differ markedly. For example, the four oldest universities (Cairo, Alexandria, Ain Shams and Assiut) produce most of the research output in Egyptian universities. More discussions of the role of universities in R and D activities in Egypt will be presented below when reviewing the current Five-Year Research Plan.

However, it would be useful to mention some of the recent efforts that have been made to improve the potential of R and D activities in Egyptian universities. The main feature has been a drive to set up independent R and D facilities in the universities. There are four examples in this respect:

(a) Alexandria University, with support from UNESCO, has established the Graduate Studies and Research Centre, to promote graduate studies and foster linkages between the University and economic sectors in the Alexandria region.

(b) Cairo University has, through a joint effort with the Massachusetts Institute of Technology, established the Development Research and Planning Centre to promote development research and planning studies in the major goods and services-producing sectors.

(c) The Supreme Council of Universities has established, with funds from United States Agency for International Development, a Foreign Relations Co-ordination Unit (FRCU). This Unit has been responsible for implementing the University Linkages Project which was designed to engage Egyptian university faculty members in applied research of relevance to Egypt's development. The Unit is a joint Egyptian-United States effort to focus research on high priority development areas and to enhance the research capacity of Egyptian universities through the awarding of grants and financing of research. Data however, were not available regarding the magnitude of the assistance offered, the type of research sponsored and its effectiveness.

(d) Finally, the Academy has jointly, with the small regional universities set up the Regional Research Centres to promote R and D activities oriented to assist with the region's socio-economic development plans. Here again, little information existed to allow an assessment of the significance of this.

C. R and D activities in agriculture, fisheries, water and land reclamation

Despite development in its industrial sector over the last three decades or more, Egypt still remains basically an agricultural country. For example, in 1984-1985, the agricultural sector produced the second highest share of the GDP (17.3 per cent), and employed the highest number of the population, 4.5 million. In addition, Egypt's agriculture faces some acute problems exemplified by the fact that out of the total land area only 2.6 per cent is cultivable. Most of this land is small and fragmented private holdings. Over the last three decades, the per capita area has declined from 1/2 feddan to 1/3 feddan. As a result, there are serious efforts to expand cultivation both vertically and horizontally. This situation has reflected itself in the concentration and composition of R and D activities in Egypt.

Agriculture is the largest sector in terms of share in R and D activities. For example, in 1983, 57.8 per cent of the total number of researchers in the goods producing sectors were in agriculture.

Although the primary responsibility for agricultural research and extension services lies with the Ministry of Agriculture, a number of agricultural research activities are also carried out by universities, institutions affiliated to the Academy and the Ministry of Irrigation. The following is an overview of these institutions and their research.

1. The Agricultural Research Centre (ARC)

This Centre was established in 1983, and was given overall authority for agricultural research and extension in the country. It is composed of 13

research institutes, with 3,800 researchers. Some 800 of them are holders of a Ph.D. 1,200 have an M.Sc. and 3,000 a B.Sc. Research support staff number 13,000. The Centre and its experimental stations around the country are all financed by the Government.

Organizationally, the ARC is divided into three areas: research, extension and production. The institutes affiliated to ARC provide their research facilities to staff and university students. Research work for theses is supervised jointly by a professor from the university and a scientist from the institute concerned.

The ARC research programme under the Five-Year Research Plan has three components. The first includes 12 national programmes for research: cotton and fibre crops; wheat and barley; maize; rice; oil and onions; sugar crops; legumes and feed crops; fruits; vegetables and medicinal and aromatic plants; animal production; adaptation and development of agricultural mechanization; and crop rotation and agricultural economics. The second component is concerned with upgrading the quality of research in the institutes under ARC. The third includes programmes for improving and upgrading the conditions and operations of the 11 experimental stations under its supervision.

2. Agricultural research in universities

The universities do not have organized agricultural research programmes, yet considerable research on agriculture goes on in the Universities. This is either through graduate students who are pursuing advanced degrees or through the University faculties who apparently conduct extensive research despite the meagre support from the Government budget. They utilize the land and laboratory facilities that are available to faculty researchers. Recently, there have been a number of foreign donations to support these facilities.

3. Council of Food and Agriculture in the Academy

This is one of the most important specialized councils in the Academy. It is a prestigious group which includes several former ministers, the Director of ARC, and a large number of experienced members. This Council is responsible for preparing the research plan for the agricultural sector. It will therefore be discussed in planning research activities. It sufices here to say that the Council is currently supporting research and extension to improve production of maize, rice and wheat.

4. The Agricultural, Biological and Food Industries and Nutrition Divisions of the National Research Centre

Although most of the programmes of these two Divisions involve research, they also carry out extension services such as work to increase production of certain crops. An example is the "More and Better Food" project which was initiated in 1978 and completed in 1985, as part of the applied Science and Technology programme funded by the United States Government. The output of this project confirmed the significance of transferring and fully developing simple technology packages that can then be easily applied on a large scale. Similar projects were also developed for maize and tomato, in which several authorities co-operated; this included the Organization for Rural Development, Ministry of Local Governments, and the extension staff of the Ministry of Agriculture.

5. Institute of Oceanography and Fisheries (IOF)

IOF is the largest research body dealing with fisheries and related aquatic sciences in Egypt. It has a staff of 305 persons. It is composed of:

- The Mediterranean Sea Branch, at Alexandria.
- The Red Sea Branch at Suez.
- Shore Protection at Alexandria;
- Inland Waters and Fish Culture in Cairo, with a field station at Aswan.

The Mediterranean Sea Branch is the largest with a staff of 147. The principal research activities centre around the biology of important fish resource species, aquaculture and acclimatization in connection with fish stocking. Results are evident and include specifications of legal mesh sizes in fishing gear, fishery regulations including licencing of boats, and statistics for catches in key centres of fishing. Fishermen have also received useful guidance on the identification of fishing grounds and stocks for exploitation.

6. The Water Research Centre

This Centre is affiliated to the Ministry of Irrigation. It consists of 11 research institutes, a project for the Water Master Plan, a department for technical training and a department for research services.

There are joint activities between the Water Master Plan, the Soil and Water Research Institute and the Agricultural Mechanization Research Institute of the Agricultural Research Centre.

In 1976, the Drainage Research Institute was established to include the following divisions: drainage technology, open drainage, experiments and laboratory analysis, economics, evaluation and foreign public relations. It conducts studies in all areas of drainage systems management and control. This institute is currently conducting studies on development and management of ground-water resources, feasibility and conservation of their use.

7. Desert Research Institute and other facilities of the Ministry of Land Reclamation

The Institute is affiliated to the Ministry of Land Reclamation which was recently added to the responsibilities of the Minister of Agriculture in November 1986. It has some 100 research scientists on its staff. It conducts studies on sheep, goat and camel breeding, range management, horticulture, reclamation of saline soils, irrigation techniques and the use of saline water for crop production.

In addition to the Desert Research Institute, the Ministry of Land Reclamation has two other centres which undertakes R and D studies: the International Centre for Rural Development and the General Company for Research and Ground Water. The first carries out studies to guide the management and settlement of new lands. The second carries out research on well-drilling, ground water and geological behaviour corrosion, pump performance, soil surveys, and land classification.

D. R and D activities in industry, health and housing

Having shown the main R and D institutions in Egypt, and the R and D institutions that work in Agriculture, the study now considers the R and D institution that operate in industry. Here again, one notes that R and D activities are widespread and fragmented among many ministries and organizations. In addition to the Academy and the universities, there are at least four ministries which conduct industry-related R and D. They include the Ministries of Industry and Mineral Wealth, Petroleum, Health and Housing, Reconstruction and New Settlements. They are discussed below.

The Academy carries out the largest share of industrial R and D. The Academy's research affiliates also have their industrial R and D programmes.

The Industrial Research Council funds a number of industrial R and D projects in the field of chemical, metallurgical, engineering, electrical and electronic industries. It has developed specific criteria for adopting research projects in industry. These include "developing new products using the latest technology",1/ improving quality and minimizing costs by using local raw materials, recycling factory wastes economically, replacing imported raw materials by local ones and producing local intermediates. The Academy has also other councils whose research work relates to industrial activity. They include the following:

- The Petroleum, Energy and Mineral Resources Council has a Five-Year Research Plan to cover the areas of petroleum exploration, drilling, refining and petrochemicals. As minerals represent an important asset for Egypt, the Council has given priority to completing the geological mapping of the country and exploring coal and other mineral deposits.

- The Medical Research Council is sponsoring projects in drug synthesis, use of local plants for drug production, and development of milk substitutes for children and animals. The Environment Research Council is carrying out research on technologies for potable water treatment, technologies for treatment of industrial wastes and industrial vocational diseases.

- The Construction and Housing Council has research projects on building materials. Its research in this respect has specific aims, which include: furnishing materials for rural housing to replace Nile silt currently used by farmers; study of use of resins in concrete and building units and improving the use of mortar in the building industry.

1. National Research Centre (NRC)

Several divisions and laboratories of NRC are engaged in industrial research. The industrial R and D of the NRC is relatively the largest in the country and covers a wide array of industries as follows:

1/ M.K. Mahmoud, "Research and experimental development institutions in Egypt", study prepared for ESCWA, 1986, p. 114, (Unpublished).

Dairy, Fats and Oils.
.es: Spinning, Weaving, Dyeing and Finishing.
:ies: Paper and Cellulose, Leather Tanning, Polymers and Pigments, Pesticides, Ceramics and Glass.
Synthetic and Natural Drugs.
Equipment for renewable energy (Solar, Wind and Biogas).

Research Centre also has a specialized institute for elec... pilot plant facilities for the chemical, food, and textile industries.

The activities of the Centre include, in addition to R and D, problem solving, services, consultations and training of high level industrial personnel.

2. The Central Metallurgical Research and Development Institute

This Centre has been established as a joint venture between the Academy, the Ministry of Industry and UNIDO. It specializes in R and D activities for the Metallurgical Industries. It is a good model of a contract research institute. It covers all stages of the industrial process, from information collecting through to the final product.

It has four major divisions namely, ore evaluation and mineral benificiation, extractive metallurgy, metal working and forming, and technical services and a welding research facility.

3. Egyptian Petroleum Research Institute

The R and D of this institute serves the Egyptian Petroleum Industry. Its Board of Directors is chaired by the Minister of Petroleum. The Institute includes divisions for exploration, production, evaluation and analysis, refining, uses, petrochemicals and process development. In addition to R and D, the Institute is also involved in problem solving, services, consultations and training activities.

4. R and D Institutions in the Ministry of Industry and Mineral Resources

In addition to the industrial R and D carried out by the specialized research institutions which are affiliated to the Academy, industrial research is also carried out in the ministries and the universities.

This Ministry has, in close co-operation with United Nations organizations, mainly the United Nations Development Programme (UNDP) and the United Nations Industrial Development Organization (UNIDO), established a number of R and D institutions. They include:

Tibbin Institute for Metallurgical Studies; R and D Centre for Electronic Industries; Engineering and Industrial Design Development Centre; Food Canning Development Centre; Plastic Development Centre; and Textile Research and Development Centre. The latter is a joint venture between the Cotton Consolidation Fund in Alexandria and UNIDO. These are all separate centres

which are supervised by the General Organization for Industrialization of them, the Engineering Design Centre and the R and D Centre for Electr Industries serve the whole industrial sector. The others serve the respective sectors only.

Generally, the R and D activities of these Centres included improving production and applying modern technology; providing consultancies, particularly for techno-economic feasibility studies; solving current problems arising in manufacturing factories; organizing training courses and conferences for industrial personnel and publishing scientific and technical information. The Tibbin Institute for Metallurgical Studies also conducts formal courses leading to Diploma.

In addition to the above-mentioned R and D centres, the Ministry, also has R and D units in the public manufacturing companies. According to a survey conducted by the General Organization for Industrialization, there are about 65 R and d units in manufacturing companies. They vary in size and level of performance. The majority of these units are in food (12), followed by textiles (11), engineering (10) and chemical factories (6). In at least two cases, sugar and iron and steel companies, these units have made a noticeable contribution. They contributed successfully to solving technology transfer problems.

Industrial R and D is also, as mentioned above, carried out in universities. Reference has already been made to the engineering and sciences faculties and the research activities that are co-ordinated with and supported by the Academy. Industrial research is also carried out through contracts with industrial companies or through foreign aid programmes channelled by the university linkage programme. Detailed information on the content of this research was not available. However, (according to a publication by the Academy in 1980, and another by the Supreme Council of Universities in 1983),[1/] out of 107 R and D projects in various industrial and energy fields, universities contributed 40 projects; out of 86 projects funded by the university linkage programme, only 12 projects fall under industrial R and D.

5. R and D institutions in the Ministry of Petroleum

There are in Egypt, in this field, two main organizations which carry out R and D activities as part of their work programme, and they are both supported by this Ministry. These are the Geological Survey and Mining Authority, and the Agency for Nuclear Materials.

The former is carrying out geological surveys and mining studies, in addition to being responsible for all mining projects in the country. The latter is primarily concerned with nuclear materials surveys and development studies. There are also some up-to-date research and analytical laboratories in the Misr Petroleum Company.

1/ a. Inventory of ongoing Research Project, Academy of Scientific Research and Technology, National Information and Documentation Centre, 1980.

b. Supreme Council of Universities, Foreign Relations, Co-ordination Unit, University Linkages Project, Cairo, 1983.

6. R and D in the Ministry of Health

In Egypt, the Ministry of Health produces drugs, biological preparations and vaccines. It has two organizations: the National Organization for Drug Control and Research, and the Organization for Biological and Vaccine Production, which has the R and D facilities to develop these products. In addition, nearly all drug manufacturing companies have their own R and D units.

7. R and D in the Ministry of Housing, Reconstruction and New Settlements

This Ministry is responsible for producing building materials (cement, bricks, etc.). It has the General Organization for Housing, Building and Planning Research, which is concerned with building materials. Recently, this organization launched a successful R and D programme for the production of bricks from clay instead of Nile silt.

E. R and D activities in energy

R and D activities in petroleum have already been referred to under R and D in industry. Here the discussion will be concerned with R and D in nuclear energy and renewable sources of energy.

1. R and D in nuclear energy

The establishment which is in charge of nuclear research in Egypt is the Atomic Energy Establishment. It was set up in 1955, and it is at present affiliated to the Ministry of Electricity and Energy. It has two main centres, the Nuclear Research Centre, and the National Centre for Radiation Research and Technology.

The Nuclear Research Centre conducts R and D in the following 12 Departments: Nuclear Chemistry, Nuclear Metallurgy, Reactor, Reactor and Neutron Physics, Experimental Nuclear Physics, Theoretical Physics, Plasma and Accelerators, Radiation Biology, Protection and Civil Defence, Engineering and Scientific Equipment, and the Hot Laboratory Project.

The National Centre for Radiation Research and Technology, which was established in the 1970s, works with the following: industrial and medical applications of electron beam treatments; radiation sterilization of medical products; R and D in the use of the technology of rubber vulcanization, wood modification, food pasteurization, protection and improvement of field crops and stored grains.

In addition to the Atomic Energy Establishment, the Ministry of Electricity has also established an Organization for Nuclear Stations, and another one for Nuclear Safety. The former is currently involved in the preparatory work to set up the first nuclear power reactor for producing electricity in Egypt.

2. R and D in renewable sources of energy

The National Research Centre in the Academy and several universities' departments carry out R and D activities related to utilization of solar and wind energies and biomass. A number of successful small and large-scale

demonstration projects have been conducted to test the technical feasibility of using these types of energy, particularly in rural and remote areas of the country. It is useful to note here that most of the activities in this field are funded either by the Academy or from foreign sources. Currently, plans are underway to establish a Centre for Renewable Energy Development funded jointly by the Ministry of Electricity and Energy and the European Common Market.

F. R and D resources in Egypt

1. Financing R and D in Egypt

Accurate statistics on R and D expenditure in Egypt are not available. One informed source estimates that expenditures on science and technology (including R and D) increased from 0.3 per cent of the national income in 1959, to 0.5 per cent in 1969, and to 0.8 per cent in 1979. This ratio has increased to 1.2 per cent of the gross national product during the 1980s.[1/] Based on a rough estimate for one year (1982-1983) table 3 shows that the total expenditure in Egypt amounted to nearly $US 40.4 million. About 15 per cent of this was in capital expenditure, the rest in wages and benefits.

Table 3. Total expenditures on R and D by sector of performance and type of expenditure

(million US$) (1982-1983)

Sector	Total	Current expenditure		Capital expenditure
		Labour	Others	
Higher education	31,385	29,434	5,479	1,951
Goods producing sectors (Integrated)	1,285	0,116	0,050	1,169
Goods-producing sectors (Non-Integrated)	6,239	3,642	0,438	2,597
Service producing sectors	1,469	1,050	0,220	0,419
Total	40,378	34,242	6,187	6,136

Source: Report on the Result of Scientific and Technological Activities Survey, Academy of Scientific Research and Technology, Cairo, 1983-1984, p.57.

The research plan by the Academy for the years 1982/1983-1986/1987 allocates a sum of $US 112 million for R and D activities over the five year period.

R and D in Egypt is financed mainly by the Government through allocations from its annual budget to the institution concerned. Contributions from foreign, national and international sources have been relatively small.

1/ Based on the result of the Scientific and Technological Activities Survey, Arab Republic of Egypt, Academy of Scientific Research and Technology 1983-1984. p.57.

Table 4. Number of personnel engaged in R and D by sector of performance and category of personnel (1982-1983)

Sector of performance	Higher education sectors		Productive sectors				General service sectors		Total	
Category of personnel	No.	Percentage	Integrated R and D	Non-integrated R and D	No.	Total Percentage	No.	Percentage	No.	Percentage
Scientists (FTE)[a/]	9,989	45.28	1,015	4,512	5,527	31.90	4,425	57.58	19,941	42.61
Technicians	2,791	12.65	0,597	2,249	2,846	16.71	1,041	13.55	6,678	14.28
Auxiliary	9,281	42.07	1,121	7,557	8,678	51.39	2,219	28.87	20,178	43.11
Total	22,061	100.00	2,733	14,318	17,051	100.00	7,685	100.00	46,797	100.00

Source: This table is shown in a study for ESCWA, entitled "Research and Experimental Development Institutions in Egypt" (based on the report of the results of the Scientific and Technological Activities Survey: the Academy for Scientific Research and Technology Cairo) (no page number given in the original report).

a/ The actual number is divided by a denominator of 3 on the assumption that only one third of the personnel time is devoted to R and D.

Table 3 shows that the greatest share, nearly 77 per cent of the R and D annual expenditures went to Higher education. Research expenditure in the goods-producing sectors of the economy (including integrated and non-integrated researchers) amounted to 18.5 per cent.

2. R and D manpower in Egypt

Table 4 shows the number of scientists, technicians and auxiliary workers who were engaged in R and D activities divided according to the three main employment categories: higher education; goods-producing sectors and service producing sectors. Table 5 is based on table 4. It shows the distribution of researchers (scientists and technicians) between the three main employment categories. These two tables show that most researchers in Egypt were the higher educated; the figure is 48 per cent when only full-time researchers are counted, and 73.5 per cent when part-time researchers are also counted. There was a large number of part-time researchers in higher education (see table 6).

Table 5. Distribution of personnel engaged in R and D in Egypt by sectors of performance and categories of personnel (1982-1983) (Full-time employee) (Number and percentage)

Sector of performance / Category of personnel	Higher education		Goods producing sectors		Service producing sectors		Total	
	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
Scientists	9,989	45.3	5,527	31.9	4,425	57.6	11,941	42.6
Technicians	2,791	12.6	2,846	16.7	1,041	13.5	6,678	14.3
Auxiliary	9,281	42.1	8,678	51.4	2,219	28.9	20,178	43.1
Total	22,061	100.0	17,051	100.0	7,685	100.0	46,797	100.0

Source: Based on table 4.

Table 6. Distribution of total and full-time researchers by main employment sectors (Numbers and percentages) (1982-1983)

Researchers		Higher education	Goods-producing sectors	Service-producing sectors	Total
Full-time	No.	12.780	8.473	5.466	26.719
	%	48.0	32.0	20.0	100.0
Full-time + Part-time	No.	38,341	8,382	5,466	52,180
	%	73.5	16.1	10.5	100.0

Source: See table 4.

Researchers in goods-producing sectors represented 16.1 per cent and in services 0.5 per cent of the respective totals. In table 7, nearly 28 per cent of all the researchers were holders of a Ph.D. degree (14,703). A similar number had a B.Sc. degree. Holders of M.Sc. degrees and Diploma counted for 19.5 per cent and 23.9 per cent respectively. Table 8 shows that scientists who were working in research were more or less equally distributed between natural sciences, engineering and technology, medical sciences and agriculture. The smallest percentage was for social sciences and humanities.

Table 7. Composition of researchers by type of degree

Researchers	Ph.D.	M.Sc.	B.Sc.	Diploma	Total
Number	14,703	10,247	14,969	12,261	52,180
Percentage	28.0	19.5	28.6	23.9	100

Source: See table 4

Table 8. Distribution of researchers among scientific fields (Number and percentage) (1982-1983)

Grand total	Total scientists	Natural sciences	Engineering and technology	Medical sciences	Agricultural sciences	Social sciences humanities
46,797	19,941	4,322	3,850	4,180	4,070	3,519
100	42.6	9.2	8.2	8.9	8.7	7.5

Source: See table 4.

Note: The total figure for researchers given in the previous tables is adjusted in the original source for part-time workers by adding 1/3 of the part-time researchers to the full-time researchers. (total numbers of technicians and auxiliary workers were 6,678 and 20,178 respectively).

Finally in table 9 the distribution of scientists and engineers within the goods-producing sectors is shown. Nearly 58 per cent of the total in these sectors were engaged in R and D in agriculture (3,194) followed by manufacturing with 24.0 per cent (1,327) and extracting industries with 12.0 per cent (651).

Table 9. Composition of researchers engaged in the goods producing sectors by type of sectors (Number and percentages) (1982-1983)

Researchers	Agriculture	Extracting Industries	Manufacturing	Construction	Transport and communication	Electricity and gas	Water
Number	3,194	651	1,327	111	34	-	210
Percentage	58.0	12.0	24.0	2.0	0.6	-	3.8

Source: See table 4.

Note: Total number of scientists and engineers was 5,527 which included integrated and non-integrated researchers.

Chapter II

RESEARCH AND DEVELOPMENT INSTITUTIONS IN IRAQ

A. Background

The first centre for scientific research in Iraq was established in 1963. It was known as the Organization for Scientific Research. It had a budget of less than $US 3 million, representing less than 0.1 per cent of the GNP. Almost a decade later (in 1972) there were only 2,000 scientists in the country. The great majority of them were university teachers. During the 1970s, however, government allocations for scientific research increased and reached 0.3 per cent of the GNP. The number of technical and vocational schools and the R and D units in the Ministries and research centres in the universities increased markedly. The 1970s also saw changes in the orientation and composition of scientific research in the country. More emphasis was put on applied research versus basic research. The Government also introduced a number of measures to strengthen the links between research and production sectors.

The 1976-1980 National Development Plan gave more impetus to this trend. Research facilities and infrastructure required for the application of science and technology for development were allocated more funds. Allocations for scientific research increased from 0.3 per cent in 1972, to 0.9 per cent of GNP in 1980. The 1981-1985 Development Plan aimed at increasing this ratio to 1.2 per cent of GNP. It aimed also at increasing the number of researchers and technicians engaged in research activities from their 1975 level of 2 persons and 0.4 persons per every 1,000 population, to 9 persons respectively in 1980. The Plan aimed at increasing the number of researchers, graduates of engineering colleges, technical colleges and post-graduate students. However, how much of these planned increases have been realized is not known.

The box below shows the R and D centres and units in Iraq. It should be noted that, because of the present moratorium on publication of statistical data in Iraq, the review with respect to Iraq in this and the following chapters will be conducted mainly in terms of attributes and not magnitude.

B. The Scientific Research Council

This is the main research centre in Iraq. It was established in 1980 to replace the Organization for Scientific Research mentioned above, but was given greater responsibility. The law which established the Council in 1980 entrusted to it the responsibility for formulating the Five-Year Scientific Research Plans, and supervising the strategy for scientific research. The Council is headed by a president who has ministerial rank. Structurally, it is composed of eight centres and two research units. The Council's main activities are in applied research. It is also responsible for following up and co-ordinating scientific research in the country.

The Council's functions are defined as follows: to formulate objectives and strategies for scientific research within the framework of the national development plans; to guide government departments to draw up their own research plans; to co-ordinate the activities of other research centres in the country and establish communications between the researchers; to study and co-ordinate the research programmes of its composite research centres and supervise their implementation; to provide human and national resources for its research centres to implement their research programmes; to evaluate research activities in the centres; to formulate principles and measures for applying the findings of successful research; and to provide suitable working conditions for its employees.

The Council also supervises the activities of several Iraqi national committees. These include the National Committee for Transfer of Technology, the International Hydrological Programme and a number of ad hoc committees. It has working relations with the research centres in the Ministry of Agriculture, Ministry of Heavy Industries and Minerals, the Iraqi Atomic Energy Organization and the six universities in the country. It has developed a Scientific Documentation Centre which serves the need of scientists and technologists in the country. The Council operates also as a government focal point with United Nations organizations and agencies working in the field of science and technology.

C. Research centres in Iraqi universities

There are six universities in Iraq. The oldest is the University of Baghdad, followed by the University of Basrah, the University of Mosul, the University of Mustansaria, the University of Salahadine, and the University of Technology in Baghdad.

Universities in Iraq are autonomous bodies linked with the Ministry of Higher Education. The research centres in the universities are shown in the box below. In the relatively two new universities, Mustansaria and Salahadine, there are colleges for technology, statistics and an institute for agricultural co-operation studies, in the former. In the latter, there are faculties of science, engineering, agriculture and medicine. The University of Technology, which was founded in 1974, has departments for mechanical engineering, chemical engineering, electrical engineering and applied sciences. It runs courses in building and construction, production and metallurgy and control systems.

The list in the box below is not complete with regard to research centres in Iraqi universities. Generally, research centres in Iraq are adequately equipped for research, testing and training. Some have their own applied research centres to cater for the specific needs of agriculture and industry in the region.

On average more than 300 applied research work activities a year are produced by the university research centres. A number of research activities are conducted in co-operation with industrial enterprises.

University teachers take part in a large number of scientific, technical and economic committees. Engineering design and consultancy offices have also been established in the universities to secure participation of university teachers in the country's large investment plans.

D. Research centres in the ministries

The box below also shows the research centres and units in the ministries. There are several ministries which have either research centres or units or both. These are the Ministries of Planning, Heavy Industry and Minerals, Industry, Housing and Construction, Labour and Social Security, Agriculture and Irrigation.

Agricultural research, which is one of the most important areas of research in the country, is carried out at the Agricultural Research Centre in the Scientific Research Council, at the Centre for Applied Research at the Unversity of Mosul (the Date and Date Palm Research Centre), and at the Ministry of Agriculture.

In the field of industry, in addition to the research centres and units shown in the box below, there is the Committee for Applied Industrial Research (CAIR), which was established in 1972, to involve the university know-how in industrial research activities. This committee comprises a number of sub-committees corresponding to industrial branches. Altogether there are 17 such sub-committees. One for leather industries, canning, soft drinks, dairy products, tobacco, glass, artificial silk, batteries, oil, etc. More than 70 university teachers and 50 industrialists are involved in these committees.

The Atomic Energy Organization was first established in 1956. The organization is an autonomous body which is linked to the Office of the Prime Minister. The Organization controls the Institute for Nuclear Research and the Institute for Radiology and Nuclear Medicine and the Health Radioisotope Institute. The research in the Institute is directed towards producing radioisotopes for local problems in medicine, agriculture and manufacturing. The Nuclear Research Institute, for example, has studied corrosion in pipelines, carried out chemical analysis of industrial materials and used radioactive sources for the study of ground-water sources. It has departments for nuclear reactors, nuclear physics, chemistry, biology, radioisotope production and health physics.

Finally in 1982, the National Committee for Transfer of Technology was established. Administratively the Committee is linked to the Scientific Research Council. The President of the Council acts as the President of the Committee, the President of the Technology University is his Deputy. There are in addition 14 members in the Committee representing all the ministries and organizations which are directly or indirectly involved in the technology transfer process.

Some of the main duties of this Committee include devising methods for co-ordinating between the production sectors in the process of technology requisition and adaptation. Among the means open to this Committee to attain this objective is the formation of working groups to prepare studies concerning the transfer and development of knowledge and encouraging special research and studies concerning technology transfer.

Scientific Research Centres Linked to the Scientific Research Councils, Universities and Ministries in Iraq until 1984

Research Centres Linked to Scientific Research Council	Research Centres Linked to the Iraqi Universities	Research Centres Linked to Ministries
1. Agricultural Research and Water Resources Centre	Baghdad University	Ministry of Planning
2. Biological Research Centre	1. Natural History Research Museum	1. Natural Planning Institute
	2. Psychological Care Centre	2. National Centre for Consulting and Administrative Development of Computers
3. Solar Energy Research Centre	3. Urban and Regional Planning Centre	3. National Centre for Electronic Computers
4. Building Research Centres	4. Palestinian Studies Centre	Ministry of Heavy Industry and Minerals
5. Oil Research Centre	5. Educational and Psychological Research Centre	1. Specialized Institute for Engineering Studies
6. Outerspace and Astronomy Research Centre	6. The Arab Scientific Inheritance Centre	2. Research and Development Office in the General Organization for Food Industries
7. Scientific Documentation Centre	Basrah University	Ministry of Industry
8. Electronic Research Centre	1. Arab Gulf Studies Centre	Ministry of Housing and Construction
	2. Maritime Science Centre	1. National Centre for Construction Laboratories
9. Earthquake Observation Unit	Mosul University	2. National Centre for Engineering and Architectural Consultancy
	1. Applied Agricultural Research Centre	Ministry of Labour and Social Security
10. Cellulose Research Unit	2. Archaeological and Civilization Research Centre	1. Centre for Social Research and Crimes
	3. Applied Research Centre	Ministry of Agriculture and Agricultural Reform
	Technology University	The Council for Applied Agricultural Research
	1. Teaching Methods Centre	1. Centre for Improvement of Rainfall and Desert Areas
	2. Development and Electronic Research Centre	2. Centre for Fertilization Research
	University of Al-Mustansiria	3. Centre for Research on the Maintenance of Soil and Water
	University of Salahadine	4. Gypsum Soil Research Centre
		5. Analysis of Soil Plants Research Centre
		Ministry of Irrigation
		General Organization for Soil and Land Reform
		1. Irrigation, Desalination and Land Reform Research Centre
		Atomic Energy Organization
		Nuclear Research Centre

Chapter III

RESEARCH AND DEVELOPMENT INSTITUTIONS IN JORDAN

A. Background

Government concern with scientific research in Jordan dates to 1964, when the Scientific Research Council (SRC) was established to support research activities and represent the Government in international forums. The Council spent a small annual amount of $US 70,000 on R and D during the period between 1964-1974.[1/] In 1970, the Government set up the Royal Scientific Society (RSS) to conduct research and studies and offer scientific and technological consultations in relation to development. In 1977, SRC was abolished to be replaced, in 1980, by a new Directorate for Science and Technology in the Ministry of Planning.

With the setting up of the Directorate, a Five-Year Investment Programme to develop R and D supporting activities was also included in the National Development Plan. The Plan documents, as will be seen, also include sets of "organizational measures" to bring about the required changes needed to attain the objectives of the Plan. These measures, as well as the content of the Development Plans concerning R and D, will be discussed below.

These developments have led to a marked expansion in the facilities available for R and D activities and to substantial increases in R and D activities during the 1980s. Two new universities with research facilities were established, bringing the number of universities in Jordan to four. Thus during the 1980s, there were in Jordan nearly 30 institutions and establishments which were either fully or partly engaged in R and D activities. They are, in table 10, divided into four main groups according to their affiliation i.e., RSS, ministries, universities, and finally, those which have an autonomous existence.

Below, the discussion of R and D institutions in Jordan will begin by considering first, the two institutions of organizational importance, followed by the discussion of the R and D institutions proper.

1/ Report of the National Committee for Science and Technology Policy. Amman, October 1986, p.23, table 1.

Table 10. Scientific research centres linked to Ministries, Royal Scientific Society and universities in Jordan

Research Centres linked to Ministries	Research Centres linked to the Royal Scientific Society	Research Centres linked to the Universities
Ministry of Industry and Trade		Jordan University
1. Directorate of Quality Control and Measurement	1. Industrial Chemical Department	Scientific Colleges
2. Directorate of Energy	2. Economic Department	1. College of Medicine
3. Central Statistical Organization	3. Solar Energy Department	2. College of Engineering and Technology
	4. Mechanical Engineering Department	3. College of Pharmacy
Ministry of Education and Culture	5. Electronic Computer Centre	4. College of Science
1. Agricultural Teachers Training Institute	6. Building material Centre	5. College of Agriculture
2. Industrial Teachers Training Institute	7. Electronic Services Training Centre	6. College of Dentistry
3. Polytechnic Institute		Scientific Research Centres
4. Department of Research and Studies	Autonomous Boards and Bodies	1. Documentation Centre
Ministry of Agriculture	1. Board of Higher Education	2. Measurement and Testing Centre
1. Directorate of Scientific Research and Agricultural Guidance	2. The Showman Organization for Scientific Research	3. Electronic Computer Centre
2. Water Resources Authority	3. Natural Resources Authority	4. Consultancy Seervices and Studies Centre
	4. Development, Research and Studies Department in the Jordanian Phosphate Industry	5. Water Studies Centre
Ministry of Transportation		6. Maritime Studies
1. Institute for Railway Training		Al-Yarmouk University
2. Institute for Aviation		Scientific Colleges
Ministry of Planning		1. College of Engineering
1. Department of Science and Technology		2. College of Medicine
		3. College of Science
Ministry of Health		Scientific Research Centres
1. Institute of Veterinary Centre for Health Studies		1. Research and Development Centre
2. Protection of Environment Centre		2. Electronic Computer Centre
Ministry of Communications		
1. Institute for Telecommunications		
Ministry of Culture and Youth		
The National Centre for Documentation and Information		

Directorate of Science and Technology in the Ministry of Planning

The establishment of this Directorate was one of the outcomes of Jordan's preparation for the Vienna Conference on Science and Technology for Development held in August 1979.

Although this Directorate does not carry out any R and D activity itself, it assists in supporting R and D activities through administering government funds allocated for this purpose. It has been responsible for formulating national science and technology policy, co-ordinating science and technology projects which involve co-operation between institutions; monitoring laws and regulations governing transfer of technology; assessing national capacity for supplying scientists and technicians; and mobilizing and allocating research funds.

The annual financial support for R and D activities through this Directorate ranged from $US 900,000 to just over $US 1 million annually during the period 1980-1985. The breakdown of this fund between the various R and D institutions is shown in the second part of this chapter. Some of the main functions of this Directorate have now been moved to the newly created Higher Council for Science and Technology.

The Higher Council for Science and Technology

In September 1987, the Jordanian Government promulgated a law establishing the "Higher Council for Science and Technology". The Council is to be headed by the Crown Prince and will consist of 13 members: 6 ministers and 7 representatives of organizations.

The Council, as will be seen in discussing the R and D related projects in Jordan's Five-Year Development Plan, will fill an important institutional gap in the country. Its main function will be to raise funds for R and D activities; to support R and D units and institutions; and to participate in developing the required manpower for R and D activities. It will also be responsible for formulating the country's science and technology policy and preparing the science and technology plans and programmes. The latter are, at the moment, the responsibility of the Directorate for Science and Technology in the Ministry of Planning. Government support for the Council will be measured by its commitment to raise the share of expenditure on R and D from its current dismal ratio of 0.2 per cent to at least 1.0 per cent of the annual national income in the coming years.

However, based on the relative size of the annual expenditure on R and D activities, one can distinguish eight main R and D institutions in the table referred to above. These are:

1. The Royal Scientific Society.
2. Jordan University.
3. Al-Yarmouk University.
4. Mauta University.
5. The Phosphate Mining Company.
6. The Central Bank of Jordan.
7. The Directorate of Agricultural Research and Extension in the Ministry of Agriculture.
8. Others (to be elaborated on below).

In the following, a brief description of these institutions is given, followed by an analysis of the financial and manpower resources allocated to R and D in Jordan

1. The Royal Scientific Society (RSS)

This is the principal research and development centre in Jordan. It was established (in 1970) as an independent non-profit-making body to carry out research and studies in relation to the socio-economic development of the Kingdom.

To indicate the relative importance of the RSS in the field of R and D in Jordan, the great majority of industrial R and D and technical services were carried out by RSS. In terms of expenditure, this represented nearly 27 per cent of the total in the country during the period 1980-1985.1/ RSS also employed 264 researchers and technicians representing about 15 per cent of the total in 1985.1/ RSS operates under a Board of Trustees headed by the Crown Prince. Its daily operations are administered by a president.

The mandated functions of the RSS are shown below. They include the essential job of carrying out research for application and implementation, as well as providing consultation and technical services for both the public and the private sector.

Research work in the RSS is conducted in seven Departments. These are:

(a) Department of Economic Development and Planning;
(b) Department of Mechanical Engineering;
(c) Department of Industrial Chemistry;
(d) Solar Energy Department including Solar Research Station in Aqaba;
(e) Electronic Centre including Computer Training College;
(f) Building Services and Training Centre;
(g) Computer Centre.

The main functions of the RSS are: (1) Follow up the latest advances in science and technological development; (2) establish laboratories for scientific research, application and experimentation; (3) carry out feasibility studies for industries; (4) extend to the Government and private organizations technical services and consultations in scientific research and technological development; (5) engage local scientists and technicians in applied research; (6) assist those with outstanding capabilities to find opportunities for attaining higher degrees in specialized fields; (7) support scientific research by providing translations, publications and documentation; (8) co-operate with local and foreign research and development institutions to enhance scientific research.

1/ Fakhruddin Daghestani, paper presented in ESCWA Expert Group Meeting on Strengthening R and D Capacity and Linkages with the Production Sectors in Countries of the ESCWA Region, 15-19 November 1987, Amman, Jordan, pp. 19-20, tables 7 and 8.

2. University of Jordan

This University was established in 1962. It has 10 faculties, six of which are in sciences. It provides B.Sc. and B.A. degrees in 36 fields of study, and M.Sc. and M.A. courses in 14 fields. The student population in 1984-1985 was 24,043.

The University performs technical and professional consultancy services in agriculture, engineering, basic sciences, medicine, social sciences, humanities and administration. In 1972, the University formed a Deanship for Scientific Research and Graduate Studies. This Deanship has organized support and promoted scientific research in relation to Jordan and the Arab countries. It has already surveyed the research needs of various institutions in the private and public sectors. A comprehensive plan for research has been drawn up. This, however, was not available for the consideration of this study. The University has also completed a number of important infrastructural facilities which included: a computer centre; a centre for water studies; a unit for an atomic research accelerator; a centre for strategic studies; a scanning microscope unit; a unit for amino-acid analysis; and an atomic absorption unit. Two additional interesting developments included the establishment of a Centre for Consultation and Technical Services to link the activities of the University with the public and private sectors, and the setting up of the following: the University Unit for Repairing Electric Equipment; a Glass Blowing Unit and a Mechanical Workshop for Design and Manufacturing of simple instruments and parts. Detailed information on the activities of these units was not available, nor is it known how much the University spends on its research activities and how R and D expenditure has changed over the years. The 1981-1985 Development Plan, however, allocated nearly $US 56 million for completion of laboratories, faculty buildings and other University facilities. The amount of $US 2.4 million was spent by the University itself on the acquisition of various types of equipment. In the current Development Plan nearly $US 22 million has been allocated to develop a Cancer Research Centre; an Ophthalmology and Ophthalmic Survey Centre; Neurological Centre and a Faculty of Graduate Studies. Another $US 8 million has been allocated for the expansion of a number of science and engineering faculties, laboratory equipment and hardware for the Computer Centre.

3. Yarmouk University

Yarmouk University was established in 1976. It has a student population of around 10,000 and offers only B.Sc. and B.A. degrees. Nearly 42 per cent of the students are enrolled in science courses. The previous Development Plan allocated $US 115 million for the construction of its infrastructure and faculty buildings for engineering, science, medical science and other facilities. The present Development Plan has earmarked funds to complete the construction of faculty facilities and acquire laboratory equipment. Nearly $US 110 million has been earmarked in the current plan for these two purposes.

4. Mauta University

This University was established in 1980. In 1984 the College of Science was opened. It included four departments: physics, chemistry, biology and mathematics. The current Development Plan has earmarked $US 90 million to complete the campus and the infrastructural building of the University.

5. University of Technology

The Science and Technology University in Jordan was established in September 1986; student enrollment began in 1987. Out of the total 2,642 students, there were 173 who were pursuing graduate courses, mainly in engineering. The University has seven faculties: Faculty of Engineering (which includes departments of mechanical engineering, chemical engineering, electrical engineering and architecture), Faculty of Medicine, Faculty of Dentistry, Faculty of Pharmacy, Faculty of Nursing, Faculty of Agriculture and Faculty of Science. At the moment, R and D activities in the University are directed to supporting graduate students to specialize in specific science and engineering fields.

6. R and D in the Phosphate Mining Company. The Central Bank of Jordan and others

The research activities carried out by the remaining R and D institutions including the Phosphate Mining Company and the Central Bank are very limited. For example, R and D activities in the Phosphate Mining Company are mainly to improve the quality of phosphate. The research work in the Central Bank is related to its usual operations. However, in the following, expenditure on R and D activities in these institutions are presented separately.

7. The Directorate of Agriculture Research and Extension

The expenditure of this Directorate on R and D rated fourth in the country during the period 1980-1985. Recently (in 1986) as a measure to emphasize its importance, the Government changed the Directorate into a National Centre for Agricultural Research and Transfer of Technology. How this development will affect the allocation of resources to agricultural research is not clear yet.

8. Directorate of Standards and Specifications (DSS), Ministry of Industry and Commerce

Although the activities of this institution should not be counted as R and D, an account of the development of its activities would be useful.

The main research function of DSS is to prepare national standard specifications (usually based on appropriate modifications of foreign systems) and monitor testing to ensure adherence to national standards.[1/] The work of DSS has expanded markedly during the 1980s. From 1980-1983 onwards nearly 325 standard specifications were issued concerning food, building materials and chemical products. There are also plans to deal with air pollution and solid waste products.

There are many other organizations which monitor national standards and specifications. The Ministry of Health has laboratories to carry out microbiological tests with the assistance of the RSS. The Municipality of Amman has field laboratories to test food and water. The Ministry of Public Works has laboratories to test construction materials. RSS also has a chemistry laboratory to analyse ceramics, aluminium profiles, iron rods, electrical cables and batteries.

1/ DSS is also responsible for the provision and maintenance of national standards of length, mass, temperature, frequency, voltage etc.

B. R and D resources in Jordan

Aggregate data for manpower and expenditure allocated to R and D in Jordan were available for the years 1980-1985. Disaggregated data at the level of R and D institutions which have just been discussed were available for expenditure only. These data are presented below. The data concerning planned expenditure on R and D related activities in the five-year development plans will be considered in the chapter on planning R and D activities.

Financing R and D in Jordan

Table A shows the annual change in the ratio of total expenditures on R and D in the GNP during the period 1980-1985. Table B shows the relative contribution of each of the six main R and D institutions in Jordan to total R and D expenditure during the same period, and table C gives the yearly breakdown of the R and D expenditure, in each of the six main institutions mentioned above. Analysis of how the expenditure estimate in each institution have been arrived at, is mentioned in the note to table C.

It can be seen in table A that the average ratio of expenditure on R and D in the GNP during 1980-1985, was around 0.15 per cent. This is about one fifth of the planned ratio stated in the successive Five-Year Development Plans.

Table B shows that during the period 1980-1985, the largest contribution to the total expenditure on R and D in Jordan was by RSS, with 27 per cent, followed by Jordan University, with 25 per cent, Yarmouk University contributed 15 per cent, and the Ministry of Agriculture 10.7 per cent.

Table C shows the magnitude of this contribution annually. The highest annual increase in expenditure on R and D is recorded by the universities. The expenditure in the Phosphate Mining Company and the Directorate of Agricultural Research has either declined or remained stagnant. The expenditure in the RSS has doubled. But this is a lower rate of increase than that recorded for the universities. The implication is that the increase in the allocation for R and D, which was generally very modest, was also tilting more towards basic research rather than R and D.

Table A. Share of expenditure on R and D in the GNP in Jordan during the period 1980-1985 (Percentage and millions $US)

Year	R and D expenditure	GNP	R and D percentage of GNP
1980	4.98	3570	0.14
1981	4.71	4449	0.11
1982	7.08	5028	0.14
1983	8.58	5310	0.16
1984	9.30	5532	0.17
1985	10.50	5568	0.19
Average ratio 1980-1985			0.15

Source: United Nations Economic and Social Commission for Western Asia, Research and Development in Jordan: Policy, Resources and Problems. Report presented in ESCWA Expert Group Meeting on "Strengthening R and D Capacity and Linkages with the Production Sectors in Countries of the ESCWA Region", Amman, November 1987 (E/ESCWA/NR/87/WG.1/WP), p. 19, 1987.

Table B. The relative contribution of main R and D institutions in the total R and D expenditure in Jordan, (1980-1985) (Percentage)

Institutions	Percentage share
The Royal Scientific Society	27.0
Jordan University	25.0
Yarmouk University	15.0
Mauta University	0.3
Ministry of Agriculture	10.7
Other Institutions	22.0

Source: See source to table A.

Table C. Expenditure on R and D by main R and D institutions in Jordan (1980-1985) (Millions $US)

Research institutions	1980	1981	1982	1983	1984	1985
Royal Scientific Society	1.4	0.8	2.1	2.5	2.4	3.0
Jordan University	1.2	1.4	1.8	2.1	2.4	2.7
Yarmouk University	0.3	0.4	0.7	1.5	1.7	2.2
Mauta University	0.0	0.0	0.1	0.1	0.2	0.9
Directorate of Agriculture Research	0.7	0.7	0.8	0.8	0.8	0.8
Other institutions	1.4	1.3	1.6	1.8	2.0	1.9

Source: See source to table A.

Note to table C:

How the R and D estimates have been made.

Estimate of expenditure on R and D in RSS.

The main source of RSS revenue is the allocation from the Ministry of Planning and revenues from contract research. The greatest part of its contracts is to provide technical services both to the private and public sectors. The major part of its expenditure is on science and technology services. The part used for R and D activities has been estimated at 25 per cent of its annual revenue.

Estimate of expenditure on R and D in the universities

The universities expenditure on R and D are calculated as follows: (a) the direct R and D budget allocated to the Deanship of Scientific Research; (b) 10

per cent of the total salaries of the faculty staff members in lieu of the time devoted to research; (c) 2 per cent of the total salary of the administration staff, for the same reason as in (b); and 30 per cent of the resulting sum from items (b) and (c) as recurrent expenses, materials, depreciation of equipment and facilities.

Estimate of expenditure on R and D in the Directorate of Agricultural Research and Extension.

Here it has been assumed that the annual budget of the Directorate is used entirely in R and D activities.

Estimate of expenditure on R and D in other institutions

R and D expenditure in the remaining main institutions referred to in table C has been estimated to be about 10 per cent of the total revenues of the institutions involved.

The estimates discussed here are based on the figures given in the report of the National Science and Technology Policy Committee, pp. 34-36, reproduced in Daghestani's paper, pp. 15-17.

As mentioned above, part of the R and D expenditure in RSS, the universities and other institutions is financed from the annual allocation by the Ministry of Planning for this purpose. Table D below shows the breakdown of this source between the benefiting institutions. As can be seen in the table, the greater part of this financial support went to RSS. The amounts actually spent on contract research were frequently far below the amounts available, and the amounts available were not only very modest but also remained stagnament through the years.

Table D. Distribution of annual financial support for R and D activities given by the Ministry of Planning (Thousands $US)

Type of support	1980	1981	1982	1983	1984	1985
1. Direct support						
RSS	200	660	750	750	730	
Jordan University	75	45	75	75	60	
Yarmouk University	75	45	75	75	60	
2. Contract research						
Allocated	n.a.	450	450	450	150	
Utilized		219	317	72	150	

Source: See table A above.

Note: Figures for 1983 were incomplete.

Manpower in Jordan

The information concerning manpower employed in R and D activities in Jordan is contained in tables 11 to 13. They show the total number of researchers, their composition by sector of employment and type of research (tables 11 and 12) their breakdown by public sector, private sector, universities and the RSS (table 13) and finally their composition by the type of degree qualification the researchers possess (tables E and F page 42).

There were, until 1981, only 1,241 persons working in R and D in Jordan. The greatest majority were employed by the Universities (669 researchers), followed by the RSS as the main supplier of scientific and technological services in Jordan. Together they employed 67 per cent of total researchers in the country. The production sectors came last with 22 per cent. Within the higher education sector, the highest concentration of researchers was in social sciences (39 per cent) followed by natural sciences (27 per cent) and engineering sciences, which engaged only 67 researchers (10 per cent). There were, however, a larger number of engineers (153) in R and D in the production sectors. This is shown in table 13. This table shows also that the public sector outside the universities and the RSS employed only about 29 per cent of the total researchers. The private sector employed a mere 4 per cent (49 persons).

Table 11. Composition of R and D personnel by sectors of employment and type of research (1980-1981)(Number and percentage)

Areas of operation	Natural sciences		Agricultural sciences		Biological sciences		Engineering sciences		Social sciences and humanities		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Higher education	180	27	51	7	114	17	67	10	257	39	669	100
Scientific and technological services	70	24	28	10	2	1	120	41	73	24	293	100
Production sectors	60	22	13	4	2	1	153	55	51	18	279	100
Total	310	25	92	7	118	10	340	27	381	31	1,241	100

Source: Jordan National Committee for Culture, Education and Science, Paper prepared for CASTARAB II, 1983, table 24, p. 57.

Table 12. Composition of R and D personnel by type of research and sectors of ownership (Number and percentage)

Areas of employment	Natural sciences		Agricultural sciences		Medical sciences		Engineering sciences		Social sciences and humanities		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Public sector	80	22	41	12	2	1	134	38	100	27	357	100
Private Sector	7	15	1	2	2	4	36	73	3	6	49	100
Universities and RSS	223	26	50	6	114	14	170	20	278	34	835	100
Total	310	25	92	7	118	10	340	27	381	31	1,241	100

Source: Jordan National Committee for of Culture Education, and Science, Paper prepared for CASTARAB II, 1983, table 20, p.55.

The great majority of the researchers have Ph.D. degrees (43 per cent); 32 per cent have a B.Sc. and 20 per cent an M.Sc.

Table 13. Composition of R and D personnel by degree of qualification and sector of ownership (1980-1981) (Number and percentage)

Sector of employment	Ph.D.		M.Sc.		B.Sc.		Diploma		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Public sector	32	9	105	29	195	54	20	8	357	100
Private sector	5	10	10	20	33	68	1	2	49	100
University and RSS	499	60	127	15	166	20	43	5	835	100
Total	536	43	242	20	394	32	69	6	1241	100

Source: Jordan National Committee for Culture, Education, and Science, Paper prepared for CASTARAB II, 1983, table 20, p. 53.

Finally, table E gives the most up-to-date information on the manpower in R and D activities in Jordan. The figures in this and the previous table, help to show the development in the human resources involved in R and D in

Jordan since 1980. The total number of persons engaged in R and D increased from 1,241 in 1980-1981, to 1,939, in 1984-1985. The greater part of the increase has been among the Ph.D. holders, and mainly in universities. However, these estimates have to be interpreted with caution. As can be seen in the two tables under consideration, there is a lack of uniformity in the data. Table E for example, does not show the number of technicians nor is there a reference to the "Diploma Holders" mentioned in table 13.

Table E. R and D Personnel: its composition and distribution by institutions during 1984-1985 (Numbers)

Type of qualifications	Jordan University	Yarmouk University	Mauta University	RSS	Other Institutions	Total
Ph.D.	481	371	19	30	30	931
M.Sc.	70	84	2	34	50	190
B.Sc.	88	50	-	100	80	318
Technicians	100	80	20	100	50	300
Total						1939

Source: F. Daghestani, pp. 20-21.

Moreover, at least one informed source argues that that the number of full-time researchers in Jordan universities and RSS is well below the figures just mentioned. Based on a number of assumptions on the percentage of the manpower in universities and RSS who are engaged in R and D full-time, a new set of estimates have been given, and they are shown in table F.

Table F. Full-time equivalent R and D manpower in Jordan during 1984-1985 (Numbers)

Ph.D.	M.Sc.	B.Sc.	Technicians	Ph.D. and M.Sc. students	Total
117	73	80	175	328	773

Source: F. Daghestani, p. 21, table 9.

Thus, excluding the student researchers, the number of (full-time) researchers in the two principal R and D institutions (which accounted for about 90 per cent of the manpower in R and D) drops from 1,599 to 445 only. This estimate, however, is made on the assumption that the time spent on R and D in the universities and RSS has been as follows:

	Universities	RSS
Ph.D.	10 per cent	50 per cent
M.Sc.	20 per cent	50 per cent
B.Sc.	25 per cent	25 per cent
Technicians	50 per cent	50 per cent

Student researchers: 100 per cent and 25 per cent respectively for Ph.D. and M.Sc.

Chapter IV

RESEARCH AND DEVELOPMENT INSTITUTIONS IN KUWAIT

In Kuwait the two main research establishments are the Kuwait Institute for Scientific Research (KISR) and Kuwait University (KU). There are other establishments both in the Government and the private sectors which also carry out R and D activities. They include: the Ministries of Health, Public Work, Electricity and Water and Defence, as well as some of the large manufacturing industries, consulting firms and design offices. Generally, however, the R and D activities of the latter are on a much smaller scale compared with KISR and Kuwait University. In the following, the discussion will be concerned mainly with KISR and Kuwait University. Reference will be made to the other establishments when relevant.

A. Kuwait Institute for Scientific Research

Organizationally, KISR is divided into five scientific divisions, each comprising a number of scientific departments as follows:

1. Division of Food Resources, which includes the following four departments: Agro-production, Aquaculture and Fisheries, Biotechnology, and a Food Technology Group.

2. Division of Environment and Earth Sciences, which includes the following four departments: Environmental Sciences, Earth Sciences, Hydraulics and Coastal Engineering, and a Remote Sensing Group.

3. Division of Engineering, which includes the following three departments: Energy, Civil Engineering and Building and Technology, and Electronics.

4. Division of Petrochemicals and Materials, which includes the department of Petroleum Technology, and Department of Products and Material Applications.

5. Division of Techno-Economics, which includes the Department of Economics and the Department of Applied Systems.

There are also a number of support units. These include: Central Analytical Laboratories, Computer Centre, Electro-Mechanical Workshops and National Scientific Technical Information Centre. The latter provides services to the whole country.

B. Kuwait University

As in any university, the main preoccupation of Kuwait University is with teaching which extends the frontiers of human knowledge without necessarily being of immediate relevance to national development. However, a recent

report by the Kuwait Foundation for the Advancement of Sciences (KFAS), for the calendar year 1985, shows that of the 14 projects funded by KFAS which were completed during that year, 9 were in Kuwait University. They were in the fields of clinical medicine, pharmacology, civil engineering, petrochemical processes, and economics and demography, all with close relevance to problems faced by Kuwait. The University of Kuwait is also carrying out other important research projects relating to civil engineering, corrosion prevention, economics and linguistics. The Environmental Protection Council and KFAS were among the financial contributors to these research activities in Kuwait University.

There is a separate Administrative Unit for Research Management in the University. It is part of the College of Graduate Studies. This Unit, which was set up in 1978-1979, has the responsibility for promoting research in the University. In 1981, the Unit was merged with the newly created Office of the Vice Rector for Research. This Office has been given the specific task of encouraging research in potentially relevant areas to Kuwait. In 1986, and in order to cope with the development in research activities, the Office of the Vice Rector for Research was enlarged to include the University Service Units which are closely connected to research. Currently, the Office of the Vice Rector for Research includes the following six divisions: 1. Research Operations; 2. Research Planning; 3. Science and Technology Policy Studies; 4. Computer Services; 5. Library and Information Services, and 6. Arts and Humanities.

C. R and D Resources in Kuwait

1. Financing R and D in Kuwait

The latest information in the UNESCO statistical yearbook concerning financial resources allocated to R and D in Kuwait dates back to 1977. Therefore, the analysis below depends on a rough estimate made by KISR for R and D expenditures in 1982.

Table 14. Annual expenditure on R and D in Kuwait (Millions $US percentage) (selected years)

Year	(1) Expenditure on R and D	(2) GDP	(3) GNP	(1)/(2)	(1)/(3)
1973	0.7	5,248.0	4,038.0	0.014	0.02
1977	20.1	12,957.0	14,614.0	0.16	0.14
1982	49.6	21,642.0	28,963.0	0.23	0.17

Source: Based on information provided by the Kuwait Institute for Scientific Research (KISR). See O.A. El-Kholy, "R and D in Kuwait" A case-study prepared for the United Nations Economic and Social Commission for Western Asia, 1987 (Unpublished).

Note: Net income from abroad was negative.

It can be seen in table 14 that the percentage of allocation to R and D in Kuwait is very small. In 1982, it amounted to 0.23 per cent of the GDP. This is, for example, smaller than Jordan's (0.4). In absolute terms, however, the size of the fund is relatively quite large for a small country like Kuwait with a total population of around one and a half million. It is, for example, larger than the sum allocated to research in Egypt's current Five-Year Research Plan. Part of the reason for the relative smallness of the share in the GDP is due to the relatively large oil revenues in Kuwait. Significantly, however, the absolute sum allocated to R and D increased from around $US 20.0 million in 1977 to nearly $US 50.0 million in 1982, an increase of 150 per cent over five years.

In 1986-1987, KISR's budget alone amounted to $US 60 million. Around $US 9 million is self-financing. Capital expenditure and maintenance account for 25 per cent; the remaining 75 per cent represent salaries and benefits.

At the same time, Kuwait University earmarks around $US 10 million a year for research. This amounts to about 6 per cent of its total annual budget of $US 165 million.

Kuwait University also gets external funding for its research activities. During the fiscal year 1985-1986, 15 projects were partially funded by KFAS and six by EPC. The total external funding amounted to about $US 2.9 million. This is shown in table 15. However, the table also shows that only about one quarter of the funds were actually utilized. It is, therefore, not clear whether the external research awards were on a yearly basis or covered a period of time.

2. R and D equipment and services

KISR is well-equipped for the applied research in its mandate. It has a central analytical laboratory equipped with computerized testing equipment, a National Scientific and Technical Information Centre (NSTIC) which provides modern information services and works on adapting advanced informatics technologies to the Arabic language. It also has open-line services with major scientific data banks in the world. There has been a high level of demand for these services. NSTIC apparently has been unable to keep pace with the high level of demand for scientific, managerial and administrative services that it has been receiving.

Table 15. External research awards received by Kuwait University and their utilization (Millions $US)

Source	No. of projects	Total awards	Actual expenditure
Kuwait Foundation for Advancement of Sciences	15	1.5	0.6
Environment Protection Council	6	1.3	0.05
Total	21	2.8	0.7

Source: O.A. El-Kholy, R and D in Kuwait, p. 32.

Kuwait University is not a match for KISR in this respect. However, compared with other Arab countries, provision for service is well above the average. The reports of the Vice Rector for Research indicate that nearly 50 per cent of the research budget (amounting to $US 5 million) was spent on procurement over the last five years. Recently, the University Library and Information Services acquired advanced equipment to upgrade the level of their services. The University is also in the process of establishing a national scientific technological information network to include KISR and two regional development funds.

3. R and D manpower in Kuwait

Table 16 shows the number of staff in KISR and the number of researchers among them, as well as the percentage of Kuwaitis in the total and among the researchers. It can be seen in the table that the total number of staff increased from 570 in 1979 to 984 in 1986. However, only around one third of the total staff were Kuwaitis. The number of researchers also increased, from 118 in 1979 to 334 in 1986, an increase of 183 per cent. The number of Kuwaitis among the researchers increased about fourfold, from 48 to 163. The table also shows that in 1986, the ratio of researchers to supporting staff was about 2:1, which is much lower than the ratio 4.8:1 in 1979.

In an attempt to increase the number of native Kuwaitis involved in R and D activities, KISR established a Division of Training with funds amounting to 10 per cent of the KISR annual budget. In 1981, the Graduate Development Programme was initiated to train 20 to 30 Kuwaiti graduates every year. The successful candidates were appointed in KISR. KISR also runs (now for several years) a "Student Summer Training Programme", where secondary school and university students can get training in the Scientific Divisions of KISR, and attend courses on the new developments in various scientific fields. Table 17 shows the courses of training for Kuwaitis and non-Kuwaitis, including the courses organized by KISR. It can be seen that every year during the period 1980-1985, nearly 1,000 Kuwaitis have had training in scientific subjects inside and outside the country. This has been an important factor in the increase in the number of Kuwaitis among KISR staff.

Table 16. Total number of staff in KISR, number engaged in research and the ratio of Kuwaitis among them (1979-1986)

Fiscal year	KISR STAFF			RESEARCH STAFF		
	KT*	TOTAL	KT*%	KT*	TOTAL	KT*%
15 March 86	315	984	32.0	163	334	48.8
1 July 1985	292	974	30.0	157	326	48.0
1 July 1984	286	975	29.3	156	327	47.7
1 July 1983	261	954	27.4	141	300	47.0
1 July 1982	231	915	25.2	117	265	44.2
1 July 1981	198	816	24.3	89	205	43.3
1 July 1980	154	712	21.6	66	162	40.7
1 July 1979	113	570	19.8	48	118	40.6

Source: O.A. El-Kholy, "R and D in Kuwait", p. 31.

KT*: Kuwaitis.

Table 17. Training courses provided by KISR and number of trainees in them (Number and percentage) (1980-1985)

Activity		1980-1981	1981-1982	1982-1983	1983-1984	1984-1985
In-house courses	No. of Trainees	740	1031	773	693	840
	% Kuwaitis	44	33	36	43	34
	%non-KISR Staff	14	19	26	24	15
Local training	KISR Staff	25	166	130	72	91
	Outsiders trained in KISR	-	-	4	14	11
Training abroad	No. of Trainees	61	118	103	86	88
	%Kuwaitis	78	57	70	76	82
Study abroad	B.Sc.	-	1	-	2	3
	M.Sc.	5	12	14	14	13
	Ph.D.	2	3	2	3	3
	Total number	7	16	16	19	19
Graduate development programme	No. enrolled	-	-	29	22	11
Student summer training programme	From secondary schools	40	61	58	70	78
	From Kuwait University	30	17	16	14	25
	Total number	70	78	74	84	103
	%Kuwaitis	51.4	60.2	56.8	66.7	80.5
	From Gulf States	6		2	3	2

Source: O.A. El-Kholy, "R and D in Kuwait", p. 30.

Chapter V

RESEARCH AND DEVELOPMENT INSTITUTIONS IN SAUDI ARABIA

Serious concern with R and D in Saudi Arabia began in 1977, when the National Centre for Science and Technology was established. Setting up the centre was part of the country's Third Development Plan. The centre was given the responsibility for planning science and technology activities in the Kingdom and co-ordinating the work of the various institutions which are in charge of implementing the Kingdom's science and technology programme. The centre was also given the important responsibility of adapting, changing and transferring technology to surmount the problems confronting the country's socio-economic development.

The Fourth Development Plan introduced changes in the Centre's direction of work. Emphasis has been put on developing the Kingdom's own scientific and technological capabilities. The Centre's name was changed to King Abdul Aziz City for Science and Technology (henceforth "the City"). But the changes included more than just the name. The functions and objectives of the Centre have been changed as well. The changes were necessary to cater for the country's social and economic needs. These needs, following three successive and successful development plans, have changed in nature and complexity. The country has left behind the early simple economic structure. A complex infrastructural system has been built, an industrial and agricultural base has been laid down, and the educational system has produced more national capabilities.

In the following, the review will include the major functions of King Abdul Aziz City, its structural composition and R and D activities, the universities in Saudi Arabia and their research activities and, finally, the resources allocated to R and D in the Kingdom.

A. King Abdul Aziz City for Science and Technology (the City)

The City is established to support and promote applied scientific research and co-ordinate between scientific and research institutions to bring their activities into line with the requirements of the country's social and economic development. The City co-operates with concerned government departments and institutions to draw up the development priorities and a national policy in science and technology to establish the country's foundations in agriculture, industry and minerals. It is also responsible for developing national scientific and technological capabilities, and attracting these capabilities to assist in the process of transfer and adaptation of technology to serve the development effort.

In order to serve these purposes the City can propose national science and technology policies and strategies; execute applied research programmes; assist the private sector in conducting research which helps the development of agricultural and industrial products; provide scholarships and support for education for higher degrees and for carrying out applied research; and co-ordinate the activities of national scientific and research institutions.

The structural organization of King Abdul Aziz City

The city is administered by a Board or Directors, headed by a General Director, appointed by the Cabinet for three years, and assisted by a Deputy. The Board is composed, in addition to the Director and the Deputy Director, of eight members: four members from the science and engineering colleges in the universities, and four reputable specialists in the field of science and technology. Structurally, the city is divided into 10 organizations, one for each of the following: scientific research; information and technical services; scientific guidance; transfer of technology; nuclear energy; space science; patents; urban development centre; administration; and public relations.

Each of the substantive organizations mentioned above has its own programme of projects. There are altogether eight programme areas.

B. R and D in Saudi Arabian universities

There are seven universities in Saudi Arabia. Between them, they had a total student population of 71,858 in 1983. Three of these universities are devoted to Islamic, social and humanitarian studies. The student population in these three universities represented about 28 per cent of the total. The remaining universities include science, engineering and medicine colleges. Research activities however, are conducted in both types of universities. Tables 18 and 19 show the number of university teachers involved in scientific research in the Saudi Arabian universities, and the nationality of the university researchers. It can be seen in the first table that more than 62 per cent of all university research is carried out in King Saud University which is the oldest university in the Kingdom. The University of Petroleum and Minerals occupies third place in terms of the ratio of its staff engaged in research.

Table 19 shows the nature of the problem facing Saudi Arabia. Only 32 per cent of the university staff engaged in research were Saudi nationals. The majority of the university researchers were non-Saudi Arabs.

Table 18. University teachers working in research in Saudi Arabia (1983) (Number and percentage)

Universities	No of teachers in research	Percentage
King Saud University	89	62.2
Iman Muhamad Ben Saud University	23	16.1
King Abdul Aziz University	8	5.6
King Faisal University	11	7.7
King Fahad University for petroleum and Minerals	12	8.4
Total	143	100

Table 19. Distribution of university researchers in Saudi Arabian universities by nationality (1983) (Number and percentage)

Nationality/ University	Saudi	Non-Saudi	Foreign	Total
King Saud University	19	65	5	89
Iman Muhamed Ben Saud	9	14	-	23
King Abdul Aziz University	5	2	1	8
King Faisal University	7	4	-	11
King Fahad University	6	6	-	12
Total	46	91	6	143
Percentage	32	64	4	100

Source: Saudi Arabian Annual Statistical Book 1983, pp. 87-96, tables 41/2 - 48/2.

The following are some of the main research centres in the Saudi Arabian universities. In King Saud university, there are eight research centres. They include the Centre for Educational Research, the Centre for Engineering Research, the Centre for Biological Research, the Centre for Agriculture Research, the Centre for Management Research and the Arabic Language Research Centre.

The Petroleum and Mineral University, which was established in 1963, has an Applied Research Centre which specializes in solving technical problems in the field of gas, petroleum and earth sciences. It has the following departments: Petroleum and Gas; Energy Resources; Geology and Minerals, Standards and Measurements; and Industrial and Economic Research. A Marine and Environment Research Centre as well as an oil testing unit are also attached to the Centre.

King Abdul Aziz university has one research centre, the Centre for Development Studies and King Faisal University has an Agriculture Research and Training Centre.

There are also research centres linked to the Ministries of Agriculture and Irrigation and Petroleum and Mineral Wealth.

C. Expenditure on R and D in Saudi Arabia

There are no separate estimates of R and D expenditure in Saudi Arabia. The data for R and D are aggregated with the expenditure on Science and Technology as a whole. There are, nevertheless, clear indications that expenditures on science and technology have increased markedly. Table 21 shows the component elements of expenditure on science and technology in the years 1975 and 1979.

It can be seen in the table that in addition to the allocation for the National Centre for Science and Technology expenditure on research activities that have been distinguished in the table rose by an average annual increase of 6 per cent between 1979 and 1975. Expenditure on education and science and technology in 1979 represented nearly 5 per cent of the GNP. It amounted to $US 5 billion for a population of about 8.5 million in 1979.

Table 20. Expenditure on higher education and science and technology in Saudi Arabia in 1975 and 1979

Items	1975	1979	% Average annual increase
Higher education	235	855	37.0
Educational projects	2,118	2,003	1.6
National Centre for Science and Technology	-	9	-
Vocational Schools	16	146	54.0
Agricultural Research	49	68	6.5
Total	2,418	3,081	27.4

Source: Saudi Arabian National Centre, National Paper on Science and Technology in the Kingdom of Saudi Arabia presented to CASTARAB II, 1983 p. 42, table 9.

Chapter VI

PLANNING RESEARCH AND DEVELOPMENT ACTIVITIES

Introduction

This chapter will deal with how research projects were conceived, formulated, linked with the production sectors, financed, implemented and monitored. These are the aspects of R and D planning which will be discussed here. Interactions between the R and D activities and production activities will be the subject of discussion in another chapter.

Perhaps the research plan which lends itself best to illustrative purposes is the Egyptian research plan for the years 1982/1983-1986/1987. There is adequate information on this plan, particularly for the aspects just referred to. There is also a general similarity between this plan and that of at least one ESCWA country for which detailed data were not available, namely Iraq.

Two points, however, will have to be made clear. First, Egypt's research plan will be considered for the dual purpose of illustration and study of the content. Secondly, Egypt's research plan can at best be used as an illustration model only for Iraq, and to some extent Jordan. For in Jordan, the Royal Scientific Society, which is the centre of R and D activities, follows a path of its own. Moreover, even in the case of Iraq, the similarity extends only to the format of the model. The experience and the details of the research programmes naturally differ. Therefore, this study, in addition to Egypt's research plan, also discuss the experience of Jordan, and Kuwait (for which data were available) to give a picture of R and D planning in the region. The case of Iraq will be discussed to the extent that publication of data permits.

A. Research Planning in Egypt

It is useful to begin by mentioning that the current research plan in Egypt is not the first. Egypt's first attempt at planning scientific research dates to 1959. The second attempt was in 1966. In both cases, technical committees were formed, research priorities were drawn up and research projects were selected. But in both cases lack of funds, shortage of technological capabilities, and organizational bottle-necks vitiated the planning effort.

In 1971 the Academy for Scientific Research and Technology was established to be the authority responsible for supporting scientific research, applying modern technology, and formulating policies linking scientific and technological research to production sectors at the national level.

In 1974 the Academy put into operation a set of research projects. However, these projects, which were supposed to constitute a research programme, lacked the essential requirements of a programme. They did not even share a common objective.[1/] In 1977, the Academy began to take a critical look into its own

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1/ Five-year Plan for the Specialized Councils. Academy for Scientific Research and Technology. December 1982, p. 2.

activities and organizational structure. This internal evaluation process led to significant changes in the Academy's organization and method of operation. Egypt's present research plan therefore, incorporates this long process of learning-by-doing in the field of research planning. Generally, two main problems seem to have characterized the previous research plans in Egypt. They were not co-ordinated and harmonized with the investment projects in the development plans and did not take into consideration the needs of the end-result users.1/ These points will be elaborated in the discussion concerning the linkages between the R and D activities and the production sectors.

1. The organizational structure in charge of the research plan in Egypt

In Egypt, the Academy for Scientific Research and Technology has the overall responsibility for preparing the research plan, and for following up on its implementation. The Academy is also the main, though not the sole, financier of the planned research projects. It co-operates with a large number of national R and D institutions for the implementation of the research projects. While these aspects will be discussed in detail below, the discussion begins first with a brief description of the organizational structure for the preparation of the plan within the Academy.

The bodies within the Academy responsible for formulating the research plan are the Specialized Councils. These Councils, which are organizationally related to the Vice President of the Academy are (since 1981) composed of 11 separate councils, each responsible for one of the 11 major research areas in the research plan. These areas (shown in table 21) include Food and Agriculture, Industry, Petroleum, Energy and Mineral Resources, Health and Medicine, Environment, Transport and Communications, Construction and Housing, New Settlements, Management and Economic Sciences, Social Sciences and Demography, and Basic Sciences. These specialized Councils have a total of 50 commissions and 24 committees. About 851 scientists, experts and former high-ranking officials are engaged in these councils in preparing the research plan. The information available indicates that a large number of qualified people have been consulted in preparing the research plan. A large number of meetings which have lasted for a long period of time have been spent in the process.2/

Table 22 summarizes the composition of the Specialized Research Councils by fields of specialization and sectors of employment. It can be seen that these members came from ministries, universities, scientific research centres and the private sector in that order of importance. The table also shows that the largest group of members were engineers, 34 per cent of the total, followed by scientists, 20 per cent, agricultural scientists, 16 per cent, medicine and pharmacutical scientists, 15 per cent. The smallest group was the economists and social scientists, 7 per cent.

1/ Five-Year Plan for the Specialized Council. Academy for Scientific Research and Technology, December 1982, p.2.

2/ See Five-Year Plan for Research Projects: Preparation and Implementation, Egypt Academy of Scientific Research and Technology, July 1985, p.28 and p.43, tables 1 and 3 respectively.

Table 21. The research structure for the Five-year Research Plan in Egypt (1982/1983 - 1986/1987)

I. Production and Resources				II. Service
Council for Food and Agriculture Research	Industrial Research Council	Council for Research in Petroleum, Energy and Mineral Resources	Council for Research in Health and Medicine	Council for Enviromental Research
Commissions for research in: -Vegetable Products -Animal and Fish Products -Resources -Economic and Social Development -Crop Protection -Food and Food Manufacturing	Commissions for research in: -Food Industrialization includes Committee for Packing and Committee for Utilizing Food Waste -Engineering Industries -Electronic Industries -Metallic Industries -Chemical Industries -Textile and Weaving Industries: Includes Committee for Producing Textile from Mixture of Polyester Natural Yarn; and the Independent Committee for Systems	Commissions for research in: -Petroleum. Includes Committee for Refining and Manufacturing Petroleum Products -Energy -Mineral Resources	Commissions for research in: -Health -Tuberculosis -Bilharzia -Basic Medical Education -Drugs -Sinai Project -Emergency Medical Services -Health Management -Medical Education and Human Development	Commissions for research in: -Pollution and Occupational Hazards. Committee for Protection of Environment and Committee for Occupational Diseases -Protection of Natural Resources -Environmental Education

Table 21 (continued)

III. Infrastructure			IV. Economic and Social Development		V. Basic Sciences
Council for Research in Transport and Communication	Council for Research in Construction and Housing	Council for New Settlements	Council for Research in Management & Economic Sciences	Council for Research in Social Sciences and Population	Council for Research in Basic Sciences
Commissions for Research in: -Internal Transportation -External Transportation -Communication	Commissions for Research in: -Housing, Committee for Urban Housing, Committee for Rural Housing -Building Material -Urban Planning -Drinking Water -Sewage -Economics of Construction	Commission for Research in: -Humanities -Settlements -Management of New Settlements -Resources Committee for Infrastructure Committee for Industry Committee for Manpower -Environment	Commission for Research in: -Management Sciences -Committee for follow-up on Management Research -Research in Economic Sciences Committee for follow-up on Economic Research	Commission for Research in: -Demography -Legal Studies -Education and Psychology -Development & Social Sciences	Commission for Research in: -Environmental Sciences -Biological Sciences -Geological Sciences -Mathematics & Physics -Chemistry

Source: (1) Five-Year Plan for Research Projects: Preparation and Implementation, pp. 31-34.
(2) Five-Year Plan for the Specialized Councils. Ibid, pp.65-242.

Table 22. Composition of specialized research councils members by type of specialization and by sector of employment (1982) (Number and percentage)

Area of specialization	No. of members	%	Sector of employment	No. of members	%
Agricultural Sciences	135	16	Ministries	433	51
Medicine and Pharmacutical Sciences	126	15	Universities	339	40
Engineering	287	34	Scientific Research Centres	62	7
Basic Science	175	20			
Economic, Social and Law	60	7			
Others[a/]	68	8	Private Sector	17	2
Total	851	100		851	100

Source: Five-Year Plan for Research Projects, p. 44.

a/ Including Police and Armed Forces.

Main functions of the composite directorates of the specialized councils

Vice President of the Academy

Specialized Councils

Directorate of Specialized Councils Affairs	Directorate of R and D Links	Directorate of Monitoring and Follow-up	Directorate for R and D Marketing
- Organize workshop and conferences - Follow-up on current projects - Implement results of concluded projects - Survey research activities in the country -Identify fields for foreign co-operation	- This Directorate is composed of three groups each responsible for relations with one of the following - Universities - Local Government - Goods and Services production sectors	- Follow up on financial and administrative aspects of research projects - Prepare budget estimate for the Research Plan - Financial auditing for new projects - Preparing contracts and technical reports - Follow-up on research results	- Identifying research groups - Dissemination of research result and research projects - Compiling information on needs for research

Main areas of scientific research in Egypt's Five-year Research Plan
(1982/1983 - 1986/1987)

I. Production and Resources			II. Service	
Food & Agriculture	Industry	Petroleum, Energy and Mineral Resources	Health and Medicine	Environment
-Plant production -Plant protection -Agricultural natural resources -Fish and animal husbandry -Food and feed industries -Agricultural economics and social development	-Chemical industries -Metallurgical industries -Engineering industries -Electrical industries -Textile industries -Construction materials and ceramics -Food industries	-Completing the geological mapping to cover Sinai peninsula -Petrochemicals -Refining -Exploration of oil, natural gas, coal and uranium	-Health Management Research -Basic Medical Service Research -Drugs -Disease of old age -Nutrition -Sinai Medical Research -Administrative health services	-Research in protecting the environment from pollution. -Technology for treating potable water -Technology for treating liquid industrial wastes -Water recycling for agriculture purposes -Air pollution -Vocational health research -Research on natural resources -Research on environment education -National research plan on sand dunes -Desertification

III. Infrastructure			IV. Social and Economic Development		
Transport and communication	Construction & Building	New Settlements	Management and Economics	Social and Population	Basic Sciences
-Research in problems of implementation of various transport and communication projects -Research in road efficiency and road building materials -Research in methods of improving performance of roads, railways and ports	-Rural housing and rural development planning -Urban planning -Urban housing -Research on various problems relating to drinking water and sewers -Research in rural building materials -Research in building maintenance -Research in traffic problems -Research in the economics of construction	-Research on environment in the new settlements -Research on the optimal size of new settlements in site selection, preservation of culture, application of new and renewable energy, infrastructure designs, selection of building material, and location, of industries -Management of new settlements	-Research in the efficiency of the various public sector activities -Research to identify main public sector problems to find solutions -Research on the prospect of utilizing the capabilities of the armed forces in the government and public sector activities -Evaluation of local government performance -Research on employment and its structure, in wage policy and incentives in management and technological development	- Legal studies - Population studies - Educational research	-Support for research in new sciences -Studies to set up new scientific centres in: - Earthquakes - Laser technology - Infra red radiation - Genetics, etc.

Source: Egypt, Five-Year Plan for Research Projects: Preparation and Implementation, pp. 103-114.

To complete the picture regarding the organizational structure for the Research Plan within the Academy, it should be noted that the Specialized Councils conduct their planning operations through four directorates. These are: Directorate of Specialized Councils; Directorate of Follow-up; Directorate of Marketing; and Directorate of Scientific Agreements. The summary of the main functions of the Directorates is presented in the box above, and they will be treated in more detail below.

2. Stages in preparing the Research Plan

In preparing the Research Plan the following procedure has been used. First, each specialized council would, through its respective commissions and committees, identify the preliminary list of research problems in each of the subsectors over which it presides.

Secondly, to help in this preparation and to ensure harmony with the Development Plan, each specialized council was provided with the relevant section of the Development Plan appropriately summarized to guide the Council members in the process of identifying relevant research problems.

Thirdly, the resulting preliminary list of research areas and problems would then (often) be taken to the research base where the prospective research activity would take place, be it a ministry, university, a local government or a research centre. The box above gives a general picture of the research areas so identified in the plan.

Judging by the number of meetings, the number of participants, the total hours spent in the meetings and the number of members in each specialized council to identify research areas, research problems and research projects, one can say that a very wide participation was secured in the preparation of Egypt's Research Plan.

Fourthly, the councils were given specific guidelines in establishing their selection priority among the suggested list of research projects.

Four important guidelines were observed. The research project should solve a national problem, it should utilize local technological capabilities, it should support the country's scientific and technological infrastructure, and should strengthen the links between the research centres and the production sectors, whether the latter be producers of goods or services, in the public or private sector.

Fifthly, after the discussion at the research base line, the draft of the sectoral research plans would be formulated by the respective specialized councils, and would then, through the Academy, be presented to the concerned ministries, universities and research centres for final comments before finalization and submission to the Academy's Board of Directors and the President's office. Sixthly, before the implementation stage the research projects are advertised for bids. A combination of three methods was applied:

(a) For one category of research projects, with special requirements in terms of expertise and research facilities, the executing agencies would be identified by the Board of the Academy itself.

(b) For a number of other projects which required expertise and research facilities that happened to be available in a small number of national research centres, advertisements for bids were confined to these centres alone.

(c) The majority of the projects were advertised at the national level. Each bidder was also asked to submit a plan of work. Evaluation and selection of bids were made by the Directorate of Marketing within the specialized councils assisted by a large number of committees.1/

Finally, follow-up of implementation, evaluation of results, dissemination and utilization of results, are made on a regular basis by the Directorate of Monitoring and follow-up of projects in the specialized councils. The detailed functions of the directorates which have just been mentioned are presented in the box above.

There is, in addition, a higher body for follow-up of the Plan headed by the President of the Academy, his Deputy in charge of the Specialized Committees, the Directors of the Specialized Committees, and representatives of the Ministries of Planning and Finance

3. Analysis of the projects in the Research Plan

So far the discussion has concentrated on who prepared the Research Plan and how it was formulated. In the following, the analysis will be concerned with the research projects themselves: What they are and who implement them? 2/

Egypt's Five-Year Research Plan for the period 1982/1983-1986/1987 could be considered the most comprehensive in the region. Nearly 1.2 per cent of Egypt's annual national income, is allocated for the implementation of this plan. Three quarters of the Academy's annual work programme stems from the plan, and, nation-wide, there are more than 3,000 researchers and technicians working on the plan.3/ However, not all those working on the Plan's projects are employed by the Academy. Nearly 40 per cent are working in universities; another 40 per cent in the ministries, and only 20 per cent are employed by the research centres which belong to the Academy. Thus, although the Academy has the overall responsibility for the Research Plan, and it is the main financier of the research projects in the Plan, the great part of the research funds in the Plan is allocated to research carried out by the universities and ministries. Between them they use more than 70 per cent of the allocated fund. The Academy received only 28 per cent of the fund.

1/ See Five-Year Plan for Research Projects, table 8, p. 9, 49.

2/ It should be noted that unless otherwise stated "Research Projects" throughout the discussion refer to both continuing and new research projects in the plan.

3/ The remaining one quarter of the Academy's activities is devoted to current work.

Tables 23 - 25 give information on: distribution of research projects by the main institutions which implemented them; share of these agents in the total research fund in the plan; distribution of research projects by sector of activity; and number of research contracts by main implementing institutions and activity sectors. Table 25 shows the functional composition of the research staff engaged in implementing the plan.

It can be seen in table 23 that the greatest share in the implementation of projects went to Universities which received 42.2 per cent (123 projects out of the total 290 projects in the plan), costing nearly $US 8.0 million (35.2 per cent of the fund allocated). The research centres in the Ministries came second in terms of the number of projects implemented (84 projects i.e. 29 per cent of the total), costing nearly $US 8.1 million. The research centres under the Academy implemented 75 projects (25.8 per cent of the total), costing $US 6.2 million (27.6 per cent of the total). The private sector was allocated eight projects only at a cost of $US 300,000.

In table 24 the research projects implemented by each of the main categories of institutions are broken down by the activity sectors. The table shows that within the research projects in universities, research projects in Agriculture were the most numerous, equalled only by Medicine and Environment, each representing 25.3 per cent of the total research projects on universities. Research projects on Economic and Social Problems came third (18.7 per cent), followed by Transport and Construction (12.2 per cent) and Basic Science (7.3 per cent). University research on industrial problems and energy and mineral resources together did not exceeed 11 per cent. It is also interesting to note in the table that the R and D Centres under the Academy also concentrated their research on Agriculture (28 per cent of the total number of projects allocated to these Centres). This was followed by research on Medicine and Environment (18.7 per cent). However, research on Industry, and Energy and Mineral Resources in the Centres under the Academy was proportionately much greater (about 36 per cent of the research projects) than that recorded for the universities. Whether or not this also applies to the cost of the project cannot be ascertained from the information available.

Table 24 indicates the research projects and their sectoral distribution in the Ministries. Here too research projects in Agriculture, and Medicine and Environment, claimed the highest percentage, followed by Energy and Mineral Resources, and Transport and Construction. Industrial research projects represented as little as 9.5 per cent of the total projects allocated to the Ministries.

The few research projects that were allocated to the private sector and scientific societies were more or less equally divided between Economic and Social Problems, Medicine and Environment, Transport and Construction and Basic Sciences.

What would also be important to know is the weight in terms of value attached to each of these projects. It has already been mentioned that the information available does not provide a breakdown of cost of research projects by categories of main institutions and sectors of activities i.e. no cost breakdown is given to correspond with the information in tables 24 and 25. There is, however, a significant breakdown of project costs by main

Table 23. Research projects and funds allocated by main categories of research institutions (Numbers, percentage, million US$)

Implementing institutions	No. of research projects		Funds allocated	
	No.	Percentage	Value $US	Percentage
-Universities	123	42.2	7.9	35.2
-Centres belonging to the Academy	75	25.8	6.2	27.6
-Ministries	84	29.0	8.1	36.0
-Private Sector	8	2.7	0.3	1.2
Total	290	100.0	22.5	100.0

Source: Five-Year Plan for Research Projects, p. 76, table 14.

Table 24. Distribution of research projects in the plan by main categories of implementing institutions and sectors of activity (Percentages)

Implementing Institutions	Total No. of Projects	Agriculture	Industry	Energy and Mineral	Transport and Construction	Medicine and Environment	Economic and Social	Basic Sciences	Percentage
Universities	123	25.3	7.3	3.2	12.2	25.3	18.7	8.9	100
Centres belonging to the Academy	75	28.0	18.7	17.3	0.0	18.7	1.3	16.0	100
Ministries	84	26.2	9.5	16.7	15.5	26.2	5.9	0.0	100
Private Sector	8	0.0	0.0	0.0	25.0	25.0	27.5	12.5	100
Total percentage	290	25.5	10.7	10.7	10.0	23.8	11.0	8.3	100

Source: Five-Year Plan for Research Projects, table 16, p. 82.

Table 25. Distribution of research project contracts in Egypt's Five Year Plan for research projects by research institutions and sectors (Percentage)

Sectors / Institutions	Agriculture	Industry	Energy and Mineral Resources	Transport and Construction	Health and Environment	Economic and Social Sciences	Basic Science
Universities	41.9	29.0	12.9	48.3	45.0	71.9	45.9
Centres belonging to the Academy	28.3	45.2	41.9	0.0	20.3	2.1	50.0
Ministries	29.8	25.8	45.2	44.8	31.9	15.7	0.0
Private Sector	0.0	0.0	0.0	6.8	6.8	9.3	4.1
Total Project contracted	74	31	31	29	69	32	24 = 290
Percentage	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Five-Year Plan for Research Projects. p. 83.

research fields and their components shown in table 26. But before considering this table, it would be useful to extend the analysis regarding the institutional and sectoral compositions of the research projects to the degree of concentration of research (projects) activities within each of the main categories of institutions. This analysis would help to shed some light on the relative importance of the research subjects and the institutions (or agents) in charge of their implementation. This analysis is shown in table 27. It can be seen in the table that 35 per cent of all universities research was concentrated in Cairo University alone. This University got more than a third of the total research funds allocated to universities. Its shares in research projects and funds were about twice as much as those allocated to nine provisional universities put together. Similar concentrations can also be detected in the research centres under the Academy. Here, the National Research Centre alone claimed more than half of the research projects and almost half of the funds.

Within the ministries the greatest share of the research funds was given to the goods-producing ministries ($US 5.3 million, i.e. 65.9 per cent of the total in the ministries). Service-producing ministries received only 10.9 per cent of the funds. This is less than the share of the infrastructure ministries. Nevertheless, within the goods-producing ministries, the greatest concentration is in agriculture, $US 2.6 million (32.0 per cent) as against $US 340,000 (4.2 per cent) allocated to industry.

Table 27 sums up the distribution pattern of research projects in Egypt's Research Plan. Almost half of Egypt's total research funds went to food and agriculture (48.6 per cent), followed by petroleum, energy and mineral resources, and health and medicine (14.5 per cent and 9.0 per cent respectively). The sum allocated to industry, environment and infrastructure together did not exceed $US 4.8 million (i.e., 21 per cent of the total fund) over the Five Year Plan period.

This heavy concentration on agriculture, health and environmental research created a proportionately higher demand for the services of teaching staff and researchers at the universities, table 28 shows, that excluding research supporting staff, who on average had the ratio of two to one researchers, the number of researchers at universities was five times as high as experts and technicians who worked on research. There is, however, no clear definition of the "experts" and "technicians" in the Plan documents.

Three other characteristics of Egypt's Research Plan call for consideration: the size of the research projects; the priorities in the research projects; and inter-connections in research implementation.

The information that is available in the plan on the size of the research projects relates only to new projects. No information in this regard was given for continuing projects. Based on this information, nearly one quarter of the total new projects have cost of less $US 25,000 each, and more than three quarters of the projects have costs less than $US 100,000. Only 10 per cent (i.e., 13 projects) have costs that exceeded $US 200,000, and 3 per cent

Table 26. Distribution of research projects and research funds by main research implementers within each of the main categories of research institutions (Numbers, million $US and percentages)

Main category of institutions	No. of Research Projects	Percentage	Funds Allocated $US	Percentage
Universities	123	100.0	7.9	100.0
- Cairo University	45	35.0	3.0	38.0
- Alexandria University	17	14.1	1.6	20.0
- Ain Shams University	21	17.1	1.3	16.4
- Remaining Nine Universities	40	32.5	1.8	23.0
Centres belonging to the Academy	75	100.0	6.2	100.0
- National Research Centre	42	56.1	3.3	48.7
- Institute for Oceanography and Fishing	11	14.7	1.4	23.4
- Institute for Petroleum	10	13.4	0.9	14.7
- Institute for Geophysics	4	5.3	0.15	2.3
Ministries	84	100.0	8.1	100.0
- Ministries Producing Goods	42	50.1	5.3	65.9
- Ministry of Agriculture	20	23.9	2.6	32.0
- Ministry of Petroleum and Mineral Resources	11	13.1	1.6	20.2
- Ministry of Irrigation	4	4.8	0.76	9.5
- Ministry of Industry	6	7.2	0.34	4.2
Ministries Producing Services	24	28.4	0.88	10.9
- Ministry of Health	14	16.7	0.54	6.7
- Ministry of Interior	2	2.4	0.23	2.8
- Ministry of Social Affairs	5	6.0	0.09	1.1
Infrastructure Ministries	18	21.5	1.9	23.2

Source: Five-Year Plan for Research projects, pp.75 - 81.

Table 27. Research projects by field of research and funds allocated in Egypt's research plan (Number, percentages, millions $US)

Research fields	No. of projects	Percentage	Funds allocated	Percentage
I. Resources and Production				
-Food and Agriculture	53	23.6	11.0	48.6
-Industry	23	10.2	1.4	6.1
-Petroleum, Energy and Mineral Resources	28	12.4	3.3	14.5
II. Services				
-Health and Medicine	38	16.9	2.0	9.0
-Environment	8	3.6	1.3	5.7
III. Infrastructure				
-Transport and Communication	16	7.1	1.1	4.7
-Building and Construction	14	6.2	1.0	4.5
V. Economic and Social				
-Management and Economic Sciences	9	4.1	0.2	0.8
-Social and Population Sciences	17	7.5	0.5	2.3
VI. Basic Sciences	19	8.4	0.9	3.8
Total	225	100.0	22.7	100.0

Source: Five-Year Plan for Research Projects, table 25, p. 99.

Table 28. Composition of researchers working on research plan projects (Numbers and Percentage)

Total number of researchers	Teaching and research staff at universities	Experts and technicians	Associate professors and fellows	Supporting staff
8,024	1,817	552	757	4,898
100	22.6	6.8	9.4	61.2

Source: Five-Year Plan for Research Projects, p. 89.

(7 projects) have costs of more than $US 400,000.[1/] In other words, 132 out of the 152 new projects in the Plan have a cost of less than $US 25,000. This means that 87 per cent of the new projects got only 53 per cent of the budget for new projects and 13 per cent of the projects claimed 47 per cent of the budget.

With regard to priorities among the main research projects, six out of the nine largest research projects were in food and agriculture. This included projects for the improvement of wheat, animal feed, vegetable oil products, fish farming, and medical plants. There was one project which was concerned with environment and one with health. There was also one project which was specifically concerned with technology. But there was no large project concerned with industry.[2/]

It is evident from the analysis of the research projects in the Plan that the great majority of the projects were in the field of applied research and development. The share of basic research projects was relatively very small. But it would be difficult, short of a thorough analysis of the content of the research projects; to ascertain how much technology research there has been, i.e research concerned with the technology and method of production and with products. More detailed information would be needed for this purpose.

Regarding inter-agency involvement in the execution of the research projects, two types of such interrelations are discernable. One type is when a number of agents or institutions co-operate to implement a mono-purpose research project; the other is when a number of institutions are brought together under the umbrella of one large project with a multiple purpose.

Regarding the first type, the coefficient of participation is rather low: 1.38. Confining the analysis to the 152 new projects for which data were available, 123 projects were executed by single agents. The distribution of the remaining 29 projects was as follows: 17 projects were executed by groups of 2 agents; 4 projects by groups of 3 agents; 3 projects by 5 agents; 1 project by 6 agents; and 1 project by 9 agents.

How these agents were co-ordinating their operations is not known. What is known, however, is that most of the shared projects were among the projects with relatively large funds.

In the second category of interrelations referred to, one finds four multi-purpose commissions, on "Sinai Development Project" "Food and Feed Industries", "Rural Development" and "Drinking Water and Sewers". These are entities separated from the Specialized Councils to deal with multi-purpose projects which cross the line of more than one discipline and specialization. Each of the commissions is assisted by a board comprised of representatives of the various concerned research institutions. These boards would, in the light of the multiple objectives of the projects, define the research problems, formulate the projects and supervise their implementation. These categories of projects were all among the high budget group referred to above.

1/ Five-Year Plan for Research Projects, table 22 and pp. 91-93. Total budget allocated to new projects was $US 16.2 million.

2/ Ibid, p. 92.

B. Planning and strategy for R and D in Iraq

Concerning scientific research in Iraq, there were four major developments which marked the period after the Vienna Conference on Science and Technology for Development in August in 1979. The first was the establishment of the Scientific Research Council, the second was the formulation of the Strategy for Scientific Research, the third, the introduction of the first Five-Year Plan for Scientific Research, and the fourth, the formation of the National Committee for Transfer of Technology. Reference had already been made to the Scientific Research Council and the National Committee for Transfer of Technology. In this chapter the two other developments will be considered. However, for reasons explained above, the discussion will be conducted on the basis of attributes and not magnitudes.

The Five-Year Plan Scientific Research Plan (1980-1985)

The Five-Year Scientific Research Plan for 1980-1985 was the first plan of its kind in Iraq. The Plan was prepared by the Scientific Research Council in co-operation with a large number of government departments and science and technology institutions in the country. However, how these consultations were conducted and who were participating in them is not known. The extent to which the research projects were related to the Development Plan Projects is also not clear.

Altogether the Plan seems to have included 357 research projects which were both in the public and private sectors. Each research project contained a comprehensive assessment of at least five aspects: the human and material resources needed for implementation, the institution which would benefit from the research, the institutions which would be involved in the execution of the projects, the type of technical training which would be needed, and the plan of action for implementation. No information is available on how many projects were implemented, how much was invested, how much local and foreign capabilities were utilized and what tangible effects the Plan achieved.

Iraq now has policies and legislation which provide incentives to indigenous enterprises to establish and strengthen their in-house research and development capacities. Among the incentives is the exemption of materials used in the production process from import tax.

Also technology contracts as a matter of rule include provisions for building and developing the enterprises own R and D capacities. But the Government is not generally very keen on foreign enterprises establishing their own R and D capabilities in Iraq. At the same time the Government has introduced legislation to contract or otherwise use the services of local R and D institutes and universities. This is specifically clear regarding testing of building material, civil engineering and other consultancy services which could be provided by the public or the private sectors.

The strategy for scientific research in Iraq was formulated following the introduction of the first Five-Year Research Plan (1981-1985). It is drawn up to direct the research activities and the Plan in the country until the year 2000. Responsibility for co ordinating and following up on the implementation of the strategy is given to the Scientific Research Council. The strategy was

prepared by an extensive committee made up of the Deans of Iraq's six universities, a large number of eminent scientists, and representatives of the ministries involved in research.

The strategy underlines two important problems which characterized the R and D in Iraq: weak mechanisms to link the producers and users of R and D; and the relative ineffectiveness of the R and D in the development process.

The strategy attempts to overcome these two weaknesses by setting up research strategies at a sectoral level with clearly defined objectives by defining suitable methods for conducting R and D in the selected priority areas, and by working out in detail the requirements for implementing R and D in each case.

In each sector the strategy identified the research institutions concerned and assessed their R and D capacities and needs. It grouped research institutions in the country into four groups. The Scientific Research Council, the universities, the R and D units in the industrial establishments, and the scientific societies.

The strategy seems to consider the following eight areas of activities to be of significance for socio-economic development and for attaining a measure of "self-reliance" in technology in Iraq. They include national security; including food security; oil and chemical industries; biology; building and construction; space and astronomy; electronics and information.

In each of these eight areas, the strategy defined the R and D institutions concerned, set up the long-term and short-term aims of the R and D activities, stated the broad research problems to be addressed, described the research methods to be applied and mentioned the physical, human and financial requirements for implementing the R and D. The latter, in a number of cases, refers also to the policy measures which may be needed to realize the stated aims.

While the eight R and D activity areas will be considered in more detail, it is interesting to know that the requirements for the implementation of the strategy are conceived to be of three main types: human resources; infrastructure and facilities and finance. Under each category detailed listing of elements of the requirement have been made. Thus, for example, under "human capital", provision has been made for developing skills and updating knowledge. Scholarships, study leaves, training courses etc. have all been regarded as essential parts of the research requirements. Similar emphasis has been put on induction courses in government technology transfer contracts, and in methods of analysing and discussing contracts. There are also specific directives on how to strengthen linkages between the Scientific Research Council and the R and D units in the ministries and universities. The details concerning financial and infrastructure requirements more or less resemble those for most developing countries which leads to the deduction that more financial allocation is needed and the infrastructural facilities need to be completed.

To give an idea about how the strategy tackles the R and D problems at a sectorial level, the following examples have been selected for which sufficient (indirect) information was available to draw a meaningful picture.

In food security and agriculture, the research activities are to deal with utilization and protection of natural resources; improving land productivity, land reclamation, development and utilization of water resources; mechanization of production processes and development of agro-industries.

In industry and mining the emphasis is on problems which impede the industrialization effort, hinder efficient performance of industries and cause under-utilization of installed capacities. Problems of maintenance and erosion have also been stressed. In energy the emphasis is on alternative sources cf energy as well as on extracting and prospecting oil. Research is carried out on hydrocarbon resources, raw material, material sciences, petrochemicals, cellulose industries, petroleum refining and engineering industries.

In electronics, the strategy aims at keeping the country abreast with the developments in electronic technology and services. It supports the research centre to conduct research in: electronic systems; communications; control systems; computer engineering and programmes; and in materials and methods used in electronic components.

In building and construction, the research is to deal with problems of protecting buildings against natural disasters, human settlements, quality of buildings, communication building, irrigation projects, urban planning and environmental protection.

The general information that is available on the strategy indicate that those responsible for formulating the strategy have worked closely with people working at the base lines. They have succeeded in identifying the country's priority needs and the essential requirements of research activities.

Iraq has already gone a long way in implementing this strategy. It is now in the process of carrying out the second Five-Year Research Plan, which has, as mentioned before, been drawn up in the light of this strategy. Unfortunately, lack of information on the Research Plans and on what they have achieved prevent an appraisal. However, an indirect evaluation of the strategy and the Plans is made in the studies which dealt with Iraq's experience. These studies were presented to the ESCWA Expert Group Meeting organized to review the experience of the ESCWA countries in R and D.[1/]

C. R and D in the development plan in Jordan

Jordan does not have the equivalent of Egypt's Academy of Scientific Research and Technology, i.e. it does not have a central body to identify, at a country level, research problems, formulate research projects, co-ordinate research activities with the development plan and follow up on the implementation of research programmes. The main R and D centre in Jordan is the Royal Scientific Society (RSS). But this is more an R and D service body than an R and D planning institution. The Department of Science and Technology in the Ministry of Planning has some co-ordination responsibilities. But these responsibilities are related to the whole field of science and technology. R and D features is only one of them. Paradoxically, however,

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1/ See annex II.

although there is no central body for R and D in Jordan, the part which concerns science and technology in Jordan's Five-Year Development Plan includes some of the essential ingredients which an R and D plan usually contains. But does it have the prime mover?

Jordan is now in the process of implementing its second Development Plan during this decade. This Plan covers the years 1986-1990. The first Plan covered the years 1981-1985. Both Plans contain development of infrastructure and facilities for R and D activities and policy measures to support the development of local R and D capabilities and utilize existing R and D facilities.

In the following an analysis of R and D activities in Jordan's Development Plans will be conducted through comparing the changes that have occurred regarding R and D in the two Development Plans. The discussion, however, will concentrate more on the second Plan as it presents a more elaborate treatment of the subject. The section will then be concluded by discussing some of the drawbacks in the treatment of R and D in the Plans.

Both science and technology and R and D, as an integral part of it, were included in Jordan's Development Plan for the first time in the 1981-1985 Plan. However, concern with R and D activities in the Plan was confined mainly to the allocation of funds for building R and D infrastructural facilities, laboratories and post graduate education programmes. While more will be said about these below, it must be added that in itself the expenditure pattern regarding R and D does implicitly indicate that the Government was operating according to a priority scheme. But the planned expenditures were for R and D requirements in areas where expansions were anticipated rather than for research flows that were actually planned, as was the case in Egypt, for example. Moreover, the Plan did not include any specific objectives regarding R and D activities per se. It included a number of organizational measures to enhance R and D activities. But these "organizational measures" were more akin to development objectives for creating the necessary requirements for conducting R and D activities than measures concerned with R and D activities per se. The Plan, in fact, did not include goals for R and D activities or any particular R and D programmes to be implemented within the plan period.

The set of organizational measures that were included to support and promote R and D activities included supporting R and D institutions through providing required personnel; supporting university postgraduate studies; encouraging major industries to set up R and D and planning units; and establishing and equipping laboratories in public establishments, universities and the RSS.

Parallel to these general goals there was a set of investment projects to meet the objective stated. These projects will be discussed below when comparing the investment projects in the first and second Development Plan. What is interesting to note, however, is that except for this direct financial support no other policy measures have been indicated in the Plan to facilitate the realization of the objectives stated.

Nevertheless, implementation of the 1981-1985 Development Plan resulted in a marked expansion in research facilities in Jordan. In the universities, for example, the laboratories of the faculties of sciences, agriculture, engineering and medicine were completed. R and D facilities were established in some of the public industries and specialized vocational and training programmes were also introduced.

The plan also contributed to the expansion of the R and D capacities of the RSS. Here again, a number of R and D infrastructure projects were completed which included: a Department for Industrial Chemistry and Centres for Research, Electronic Services, Training in Computers and Solar Energy.

R and D planning received more attention in the 1986-1990 Development Plan. R and D issues in Jordan are better conceived and addressed. Nevertheless, the main preoccupation of the Plan still remains with increasing the supply of R and D activities rather than with planning the components of this supply, interrelating them and co-ordinating them with the development effort.

Table 29 shows the total planned expenditure on R and D activities (including the expenditure on the RSS projects) and the type of projects invested in during the two planned periods. It can be seen that the investment pattern in the second Plan remained mainly the same as in the first Plan, indicating that the second Plan has expanded the same R and D projects which were initiated by the first Plan. This implies that investment priorities in both Plans were not very different. Indeed, only a few new projects are featured in the second Plan. They included: "Support for R and D activities"; "Workshops"; "Technological Information Centre"; and "Manpower Training Centre".

These new projects together represented only $US 2.8 million, i.e. 19 per cent of the total allocation for R and D supporting projects in the Plan.

It can also be noted in the table that the total allocation for R and D supporting projects in the second Plan was less than that in the first Plan: it declined from $US 19.7 million to $US 14.7 million. This, however, may have been caused more by changes in the classification of projects than by actual decreases in the planned allocation.

A significant improvement in the second Plan over the first relates to (a) the specific goals that were set up both for the R and D supporting activities and the R and D activities proper; and (b) the policy measures that were recommended for attaining them.

The Plan recognized that Jordan needed an appropriate central organization to co-ordinate basic and applied research activities in the country and link them with the priorities and objectives of the Development Plan. It also underlined the necessity to harmonize the research activities in universities with national needs and development priorities, and co-ordinate the R and D activities of the scientific institutions in a better way. Moreover, the Plan emphasized the importance of widening the base of R and D activities by generating it in the private sector. It also introduced a number of incentives to expand the demand for R and D activities in the country.

Table 29. R and D expenditure and projects in Jordan's development plans, 1981-1985 and 1986-1987 (millions $US)

Allocation for R and D projects and type of R and D projects in 1981-1985 Development Plan		Allocation for R and D projects and type of R and D projects in 1986-1989 Development Plan	
1. Expanding laboratories for:			
(a) Building Research Centre	4.5	1. Research and Development	
(b) Mechanical Engineering	3.2	priorities in various sectors	0.6
(c) Industrial Chemistry Depts	6.2	2. Workshops	0.5
2. Equipment of the Electronic		3. Laboratory Equipment	
Services and Training Centre	2.5	(a) Building Research Centre	1.1
3. Expanding the Computer Centre	2.9	(b) Mechanical Engineering	1.1
		(c) Industrial Chemistry Dept	4.8
		(d) Solar and Wind Energy	1.1
		4. Equipment for Electronic	
		Services and Training Centre	2.2
		5. Technological Information	
		Centre	0.6
		6. Training Building	1.6
		7. Manpower Training	1.1
Total	19.8	Total	14.7
Total expenditure on Science and Technology activities	n.a.		26.2

Source: Five-Year Plan for Economic and Social Development in Jordan 1986-1990, p. 139.

To attain these goals a set of policy measures was recommended. They included fiscal, monetary, legislative, institutional, organizationl, managerial and technical measures.[1/]

1/ Five-Year Plan for Economic and Social Development 1986-1990. pp.129-131.

Thus the annual government allocation to RSS will be increased to $US 3.2 million in the current plan; in addition, the universities' allocation for scientific research will be increased to 5 per cent of their annual budget. The "main financial" source for these increases will be the revenues which will be collected from levying a "scientific research tax per litre of petroleum products.1/

Moreover, a "greater percentage" of external technical assistance will also be directed to building local R and D capabilities. The private sector too will be encouraged to conduct R and D activities in national research institutions through tax exemptions on their R and D expenditure.

In addition to supporting the RSS to expand its technological and industrial extension services to industry and to conduct applied research relating to development, the Plan also aims at financially supporting the graduate studies programmes of Jordanian universities. Equally significant, the Plan concerns itself with the development of vital R and D supporting activities of local consultancy, design and engineering services (CEDS). There will be legislation to reorganize small CEDS into appropriate sizes. The Plan will support local CEDS financially and with qualified personnel so that they can execute investment projects and be partners with foreign CED organizations in the implementation of local projects, sharing not less than 25 per cent of the value of the projects.

Finally, the Plan also attends to two other important aspects of R and D activities: the link between local R and D capabilities and the process of transfer of technology, and specification of a strategy for the development of R and D and R and D linked institutions. Under the former, "unpackaged" forms of technology transfer have been stressed to make possible local technological participation in the process of selection, absorption, adaptation, operation, maintenance and development. Under the latter, the Plan includes development of information and computer centres, and a manpower training centre. It makes standard and quality control mandatory. All goods including those locally produced will be subject to quality control and standardization. Local scientific research laboratories will be accredited for testing and certification. The Plan also includes development of "centres of excellence" for research in new and advanced scientific fields such as biotechnology, material sciences and telecommunication. Jordan's universities will be provided with assistance to establish these centres.

Moreover, research activities will be intentionally directed towards food production, water, energy (alternative and renewable energy), mining and mineral resources. But which institutions will be accountable for these actions and activities and how?

The Plan includes eight investment projects to meet some of the objectives just mentioned. These projects and the funds allocated to them are shown in table 29. Two of these projects relate directly to proper R and D activities, namely the project entitled "Research and development priorities in various sectors" and the project on "Workshops". The first project will be concerned

1/ Ibid, pp. 131-133.

with determining priorities in applied and basic research. It will also identify potential and basic research projects in agriculture, industry, energy, water and other strategically important resources. The Department of Science and Technology in the Ministry of Planning will be in charge of this project.

The Workshop project will conduct periodic workshops for qualified personnel to identify scientific and technological problems whose solution calls for R and D activity. RSS and Jordanian universities will jointly organize the workshops.

The Plan also allocates funds for the development of two new projects in RSS and the expansion of six others. The latter are expansions of projects which the RSS had already established during the first Plan. The science and technology project should be classified among R and D supporting projects. It aims to establish links with international scientific data banks to be used by internal researchers, whereas the manpower training project aims at upgrading relevant skills and qualifications at RSS through scholarships for higher university degrees. What is interesting to note is that all RSS projects are to be financed externally, while the two projects referred to above "Research and development priorities in various sectors" and, the "Workshop" project were both financed from the central budget.1/

But who would be supervising the application of the policy measures that are included in the Plan? These measures include several directives to harmonize the R and D activities with the Development Plan projects, direct them towards strategically important sectors, increase their efficiency and widen their base by encouraging R and D in the private sector.

The planners in Jordan's case have been well aware of what a successful science and technology policy requires and what measures are needed to enhance the R and D activities in Jordan. Two important steps, however, are still needed to make the system work as planned. First, a central authority or organization to orchestrate the operation of the various concerned R and D institutions, and secondly, a mechanism to regulate the operation of the various measures that have been recommended to attain the objectives stated. Two years of the plan period have already passed and these essential measures have not yet been implemented.

D. Research planning in Kuwait

The concept of research planning in Kuwait is different from that discussed for Egypt and Jordan. In the case of Kuwait, planning is confined to the micro aspect of R and D activity, i.e., it is at the programme and project level and not at the national level as it is in Egypt for example.

Recently, there has been a move towards comprehensive planning. But this, as will be seen, is still in the embryonic stage.

The following will deal with the selection of research projects in KISR, followed by a review of the process in Kuwait University.

1/ Five-year Plan for Economic and Social Development, 1986-1990, pp. 131-134.

Selection of research projects in KISR is done within the framework of a "Five-Year Strategic Research Programme". Before proceeding to a discussion of how this strategic research programme is formulated, it would be useful to bear in mind a number of points.

First, as has been mentioned above, while KISR does provide technical services for the market, it is also mandated to carry out base-line studies and research in areas of special long-term interest to the nation; these kinds of studies and research could continue for several years before bearing fruit.

Secondly, as has also been mentioned above, KISR conducts its applied research in five main areas; food, environment, engineering, petroleum and techno-economic studies.

But what and who determines these research areas? Who decides what Kuwait need in terms of applied research in those areas? How are research projects selected among alternatives? What are the priority norms that have been applied? And, finally, what are the research projects selected?

1. Formulation of research strategy in KISR and selection of R and D projects

To begin with, KISR as an R and D institute has its defined goals. These goals, which are briefly mentioned below, have been the guidelines in formulating the strategy. The goals included: relevance of the R and D projects to national needs; cost-effectiveness; enhancing existing R and D capabilities; and encouraging contract research. The three parties which acted as the main agents in formulating the strategy were the Scientific Research Divisions in KISR; a core group within KISR (including the Director of the Division for Policy and Planning and the Senior Advisors); and finally the Board of Trustees, particularly the Committee for Programme Planning (CPP), which was entrusted with the responsibility for preparing the strategy. There have also been external consultative bodies which will be referred to below.

The procedure for formulating the strategy begins by the Scientific Division preparing draft programme proposals in their respective fields of competence within the framework of directives from top management. These proposals would be submitted to the core group. Prior to drawing up the programme proposals, a thorough review of problems and difficulties in implementing the previous and ongoing programmes would be carried out. The review would be conducted on the basis of criteria suggested by the core group and approved by the top management. The review covered causes of changes in programme orientation; implementation difficulties; problems of contract research; recruitment and human resources development problems; and shortcomings of research facilities. In addition to this review, the divisions also conduct widespread consultations with concerned authorities in the private and public sector, and take note of the relevant sections of the Government Development Programme and the research needs in it.

The first draft of the programme proposals so prepared would be submitted to a Review Panel of Eminent Scientists from a wide spectrum of specializations. The Panel discusses the proposed programmes with the

Scientific Division concerned and with a large number of concerned personalities before making its report on the draft programme proposals.[1/]

This report would be submitted to CPP and the Board of Trustees. The latter would study the report and make recommendations. These recommendations would be considered by the Scientific Division in making the revised draft of the research programme.

This draft programme would also be circulated by KISR to all concerned governments and private organizations (20 in all) to solicit their comments.

The final version of the programme incorporates these comments as directed by the CPP. The Five-Year Strategic Research Programme for the period 1979-1984 which was prepared in the manner just described, identified six areas which needed research activities. Before referring to these areas, it is useful to note that, under the strategic programme, KISR activities fall into the following three categories:

- Baseline Studies and Research. They include activities of special long-term interest to the country and are financed from the State annual budget.

- Contract Studies, Research and Consultations. They include made-to-order research to meet specific needs with costs, at least partly, covered by clients.

- Support for Development Work. Here KISR either participates as requested or offers advice on transferring research results to semi-industrial units.

The following are the six areas in which the country's needs for applied research were identified:

(1) Maximize ecologically-sound and socially-justifiable local food production; (2) Relax the constraints of limited water resources; (3) Support the needs and long-term strategy of the oil sector; (4) Upgrade current practices in justified production and utility services; (5) Adapt Kuwait's harsh natural environment and modern habitat to meet the expanding social needs while protecting the environment and the cultural identify; (6) Anticipate short-term and long-term technical changes to ensure appropriate applications in the social and economic development of the country.

In order to meet these needs, seven main research programmes were formulated. These programmes constituted the "Five-Year Strategic Research Programme". Each of the programmes contained a number of components. They were characterized by their inter-disciplinary nature and required an inter-departmental approach. These research programmes and their respective components are shown in the box below.

1/ This included eminent persons from Kuwait, the Arab region and the world at large. Inside Kuwait a large number of persons in Government, Parliament, public and private enterprises, educational establishments, professional societies and business associations were consulted.

2. Planning of research process

Implementation of research is carried out through a series of research projects and was selected under each of the major programme areas just referred to. For each project, the objectives, methodology, phases, output, time schedule and allocation of human and material resources are worked out. The annual plan for the projects is tailored to the financial resources allocated and based on a review of the research work during the previous year, as well as changes in priority needs of the organization concerned with the research results.

Recently, there has been an increasing realization that assessing individual projects, whether at different times or within a long-time interval, is not conducive to the overall sucess of the projects within the scope of the main strategic programmes. For this to be achieved, there would have to be detailed programme planning. This would cut across divisional barriers to achieve programme interaction between the several divisions that may be involved in a programme area. Thus, the approach in KISR now is to review all the projects within a main programme together, the idea being that, once the mix of projects in a programme and the optimum balance between the different programmes have been decided, the detailed project proposals could then be reviewed on technical grounds.[1/] This process has just been initiated; therefore, it is too early to evaluate its impact on establishing priorities in the operational plans.

Another interesting change that has recently taken place in KISR has been in relation to setting up priorities.[2/] All of the six areas under the Strategic Programme (referred to above) were given specific weights in implementation. Recently, following the decline of oil revenues, and the prospect of stagnation in research allocation on the one hand, and its mandated long-term research responsibilities on the other, KISR has begun to operate on a system of priorities in its research implementation. Factors affecting demand for and supply of its activities are now carefully considered. The priorities are set up within the context of the national needs and the state of the art in technology. Both of these factors are clearly subject to continuous changes.

The current priority scale in the KISR research programme is shown below:

(a) High priority programmes and elements (short- and long-term)

Aquaculture - Water Resources - Corrosion - Environmental Protection and Management - Hydraulic and Coastal Engineering - Microprocessor and Computer Applications - Solar Energy Applications - Economic Studies.

1/ O.A. El-Kholy "R and D in Kuwait" A case study prepared for the United Nations Economic and Social Commission for Western Asia, 1987, p. 9, (unpublished).

2/ Priorities defined simply to mean establishing a rational approach to resource allocation when the demand for resources exceeds the supply and a choice has to be made over a given period keeping to the objective of the strategic programme (see El-Kholy, "R and D in Kuwait", p. 11).

(b) Medium priority elements (short and long-term)

Fisheries and Marine Biology - Agro-production and Livestock - Industrial Fermentation and Food Technology - Crude and Product Evaluation - Building Materials and Technology - Industrial Operations - Service Facilities Planning and Operation - Chemical Processes (and Products)

(c) Medium priority elements (long-term)

(d) Low priority elements

Geological Survey - Electronics and Laser Applications.

Programmes of programme components included in Kuwait's Five-Year Strategic Research Programme 1979-1984

(a) Development of Food Resources
- Fisheries and marine biology
- Aquaculture
- Agro-production and livestock
- Industrial fermentation and food technology

(b) Development of Water Resources
- Resource base (desalination and hydrological investigation)
- Efficient utilization (agricultural, industrial and urban)
- Water management

(c) Support of Petroleum and petrochemical Sector
- Crude and product evaluation
- Catalysis
- Polymer technology
- Corrosion

(d) Environment and Habitat (Man-Made Environment)
- Environmental protection
- Hydraulic and coastal investigations
- Geological surveys
- Building materials and technology

(e) Industrial Production and Service Facilities
- Industrial operations
- Service facilities planning and operation

(f) Monitoring, Assessment and Development of Technological Advances of Potential Value
- Solar energy applications
- Microprocessor, control and robotics applications
- Electronics and laser applications
- Computer applications and decision support systems
- Chemical processes
- Biological studies

(g) Economic Programme
- Energy economics
- Industrial and environmental economics
- Human resources and public resource allocation

Source: See El-Kholy study entitled "R and D in Kuwait". A case study prepared for the United Nations Economic and Social Commission for Western Asia, 1987 (Unpublished).

3. Analysis of research projects in KISR

In 1985-1986, nearly half of the KISR annual budget was allocated to its research divisions; 35 per cent went for administration, construction and other non-scientific support services, 9 per cent for training and 8 per cent for technical support.

Table 30 gives the breakdown of the R and D projects between the seven programme areas for the fiscal year 1985-1986. Tables 31 and 32, give the cost of the completed and ongoing research projects respectively for the same year. It was not possible to make a retrospective analysis as data for these variables were not available regarding the year preceeding 1985.

Based on the data in the three tables just referred to, R and D in KISR has been concentrated on food resources; environment; and petroleum, petrochemicals and materials. Engineering comes fourth. Techno-economic studies were accorded the lowest priority. The picture will become clear when the completed and ongoing activities are summed up together.

Tables 32 and 33 also reveal interesting information on the contribution of contractual research to KISR activities. Revenues from contractual research (see table 31) amounted to $US 5.6 million. This is a substantial increase over $US 1.2 million in 1979. But it apparently barely covered 30 to 40 per cent of the actual cost of the contractual work. KISR efforts to increase the percentage contribution of clients have not, evidently, been very successful (more on this below). KISR did not achieve its target of 50 per cent contract research. Moreover, contract research created problems.

One point which is worth making here is that so far there is no systematic procedure for evaluating completed projects in KISR. One KISR-sponsored study suggested the method of evaluation at different levels.1/

Nevertheless, contract research has been effective in inter-relating research activities to national development problems and needs, and they will be considered in more detail below.

4. Selection of research projects in Kuwait University

The University has a handbook which contains the regulations and procedures for getting research support.

A mechanism for soliciting project applications was established in 1986. Two areas of research are: (a) research announced for competitive proposals through nominations by the University faculty members and considered of special significance to Kuwait; and (b) research subjects identified by studies, surveys, and analyses carried out by the office of the Vice Rector. The mechanism also provides for suggesting new areas of research, including suggestions by non-researchers.

Awards are made in the form of contracts to produce a deliverable product within a specific deadline.

1/ According to this method, the evaluation will be made at the level of the research project, the research programmes, or a group of projects carried out for the same client. See El-Kholy "R and D in Kuwait", p. 12.

Table 30. Distribution of R and D projects by main programme areas (1985-86) (Numbers)

Programme area / Projects		Food and water	Environment	Petroleum	Industry services	New technologies	Economic
Completed	1984-1985	4	11	6	6	8	3
	1985-1986	15	22	9	14	13	4
Ongoing	1984-1985	16	6	5	2	8	1
	1985-1986	10	10	9	4	6	3
Approved	1984-1985	7	2	6	4	3	1
	1985-1986	6	3	2	2	1	-
Under consideration	1984-85	2	8	6	6	5	-
	1985-86	11	6	9	10	5	4

Source: El-Kholy, "R and D in Kuwait", p. 13.

Table 31. Breakdown of completed R and D projects in KISR by programme areas (million $US and percentages) (1985-1986)

Division	Completed projects		Total funding		Client contribution	
	Number	% of Total number	$US	% of Grand total	$US	% of Project funding
Food Resources	13	33.3	6.3	48.1	1.3	20.8
Environmental and Earth Sciences	10	25.6	4.5	34.7	3.4	75.1
Petroleum, Petro-chemical & Materials	3	7.8	0.4	2.8	0.1	25.5
Engineering	8	20.5	1.1	8.6	0.5	45.4
Techno-Economics	5	12.8	0.8	5.8	0.3	37.5
Totals	39	100.0	13.1	100.0	5.6	42.7

Source: El-Kholy, "R and D in Kuwait", p. 55.

Table 32. Breakdown of ongoing R and D projects in KISR by programme areas (millions $US and percentages) (1985-1986)

Division	Ongoing Projects		Total funding		Client contribution	
	Number	% of Total Number	$US	% of Grand Total	$US	% of Project Funding
Food Resources	12	29.3	11.2	24.7	4.6	41.1
Environmental and Earth Sciences	7	17.1	1.7	3.8	1.3	76.4
Petroleum, Petro-chemicals & Materials	11	26.8	5.8	0.0	0.0	0.0
Engineering	7	17.1	1.4	5.4	1.2	85.7
Techno-Economics	4	9.7	0.2	0.4	0.1	50.0
Total	41	100.0	17.9	100.0	7.1	39.7

Note: A sum of $US 24.0 million has been allocated from outside sources for a reverse osmosis plant. This sum has been subtracted from the total in making the analysis in the text.

Most of the topics accepted for research have been of an interdisciplinary nature. A review of the research activities for the years shows that the main areas of research has been science and medicine. This is matched by their share of publications in internationally recognized scientific publications. Of a total of 1,329 papers published by Kuwait University faculties during 1970-1984, nearly 59.0 per cent were on medicine, biochemistry, microbiology, botany and zoology. The shares of chemistry, physics, mathematics and engineering amounted to 16.0 per cent, 6.2 per cent, 9.6 per cent, and 9.6 per cent respectively.

As pointed out above, external funding plays an important role in supporting Kuwait University research activities. Nearly 75 per cent of the total research funds emanated from external sources in 1985-1986. The Kuwait Fund for Advancement of Sciences and the Environmental Protection Council have been the largest contributors.

E. Research and development programmes in Saudi Arabia

In Saudi Arabia universities and the ministries all have their approved research programmes prepared and implemented on an annual basis. In the following review of research programmes in Saudi Arabia the research programmes in King Abdul Aziz City will be analysed as an example.

There are differet types of research programmes in the City. These are: the programme for supporting applied research; national research projects; solar energy research; fish farming projects; the National Observatory Project; lunar observation; remote sensing; and international co-operation projects.

In each of these programmes there are ongoing activities, and the programmes already have a network of interlinks with the users. All these programmes are government-financed. But the users and those benefiting from the projects could be a government department, a public enterprise, or the private sector. The projects also could be serving a short-term scientific and technological goal.

Three of these programmes would be considered for purposes of illustration.

1. Programme for supporting applied research

Every year, the city announces the applied research projects to be contracted. These projects would be selected within the framework of the City research objectives which have already been referred to. Scientists and researchers inside the country are encouraged either individually or through their institutions, to apply for the projects. During the last six years nearly 178 applied research projects (costing nearly $US 58 million) in various scientific fields have been so contracted.

2. National research projects

These are research projects which the City implements upon request from government departments concerned with the National Development plan. The

research projects in this category are often formulated to deal with specific developmental problems. The total cost of research projects in this programme has amounted to nearly $US 14 million since 1979. They included projects in the field of medicine, health, traffic, construction and electronic computers.

3. International co-operation

The City has a ministerial committee for science and technology to co-ordinate with the Organization of Islamic Conference, with the Federation of Arab Scientific Research Councils and with the countries of the Gulf Co-operation Council. The City has also co-operation agreements with the United States, China, Canada, the Republic of Korea, the Federal Republic of Germany and France. The co-operation agreements cover the programme areas just mentioned, and aim at enabling the country to keep abreast with the developments in the fields concerned.

Chapter VII

LINKAGES BETWEEN R AND D AND PRODUCTION SECTORS

Introduction

In an ideal R and D world, there would not be a need to examine the existence or effectiveness of the linkages between R and D and production sectors. Ideally also when there are central research organizations outside the firm and the farm, the results of the research would be swiftly transformed into products, processes and technical devices, and would immediately be channelled into production by farmers and industrial enterprises. Unfortunately, there is no ideal R and D world in the Arab countries.

To begin with the state under which the production factors (labour, capital and entrepreneur) operate leaves a lot to be desired. There are also other constraints. The countries covered suffer from a relative scarcity of technological capabilities. They have shortages of R and D capabilities in managerial talents, infrastructure and facilities. These shortages have become more acute because of the multiplicity of research problems that have to be dealt with. Most of these research problems have a direct bearing on the welfare and well-being of the community at large. They include problems in the fields of health, environment and energy as well as agriculture and industry. Often, these research problems had to be dealt with a relatively small allocation for R and D. It was therefore, expected that policy-makers move cautiously, invest in central R and D organizations and move gradually to production units. The countries under consideration are still in a development stage where emphasis is on central research organizations, but a decentralization process is under way, although slowly.

Formal and effective R and D linkages

In the previous chapters, there were ample indications of the linkages that existed between R and D and the production sectors. Indeed, these linkages existed not only at the final stage of the R and D activities, but at all stages: from the stage of identifying and conceiving the research problems to formulating the research projects and utilizing their results. Below these linkages aspects will be dealt with in detail.

The aspects of linkages which are of relevance to this study would be the extent to which the problems of concern to R and D are generated at the base - production - line, and the extent to which they correspond to the real needs of the development effort. An equally important aspect is the contribution of R and D activities to solving these problems, and what effect they created, whether in increasing production or opening new potentials for further expansion. In other words, two aspects of the linkages would be studied: the formal aspect, which will be concerned with the form of the linkages; and the effective linkages, which would be concerned with the results they generate.

This is by no means a narrow approach to R and D linkages. It recognizes the significant demand R and D activities create for local technological capabilities and the important contributions they make to establish scientific and technological facilities, infrastructure and extension services. But for the purpose of this study these aspects could be regarded as concomitants and not the prime objective of R and D activities.

A. Linkages between R and D and production sectors in Egypt

There has been ample reference to the formal R and D linkages in Egypt (see section A of the preceding chapter), wherein the methods of identifying and formulating research projects in the Five-Year Research Plan were discussed. The organizational set-up and composition of R and D institutions also revealed strong linkages with the production sectors. They indicated awareness on the part of the policy-makers of the significance of close interactions between the supply and demand for R and D services. Another clear indication of concern in forging strong linkages between R and D and production sectors is the tendency in Egypt to change the organizational structure and functions to cope better with the changing needs.

The following text first examines the linkages between R and D activities in the agricultural sector, as this sector polarized most of the R and D activities; it then studies the linkage aspects in R and D activities of the three most important R and D institutions in Egypt, namely the National Research Centre (NRC); the Academy for Scientific Research and Technology; and the Universities.

1. R and D linkages in agriculture

In the agricultural sector, in order to deal with Egypt's perennial problems of scarcity of cultivable land in the face of an ever-growing population and the increasing demand for food, research activities have been directed to maximizing land and water use and improving agricultural production. As shown above, agricultural research included research in plant production, plant protection, development of natural agricultural resources, soil improvement, development of fish and animal husbandry, research in food and feed industries, and research on the economic and social aspect of agricultural development. The details of the research projects reveal concern with the following: developing vertical cultivation; intensifying use of hybrids, high-yielding and fast-growing seeds; expanding production of "strategic" agricultural products; controlling plant diseases; and integrating plant production and plant protection processes. There are also research projects on how to increase production of local animals, of non-conventional sources of food, and how to improve the nutritional quality of Egyptian bread.

The results of these research activities in agriculture have no doubt been valuable. There is, however, still a long way to go. In recent years, Egypt's food production has fallen well behind its food consumption. How much more Egypt would have had to import had there not been all these related R and D activities which raised land and labour productivity is not known. What is known, however, is that in comparative terms, Egypt's performance in agriculture has not matched that of other highly populated developing countries. For example, India, in 1981, was a net importer of 17 million tons

of grain. In 1986, it was exporting grains. The same is true for some other Far Eastern countries which have now turned to exporting rice. These countries, just like Egypt, applied intensive agricultural research programmes to update their technology, and followed effective policies to utilize the results. They seem to have succeeded where Egypt has not.

One major reason behind this has been, as shown in the previous chapter, inadequate allocations for agricultural research. This inadequacy applies despite the fact that agriculture has a relatively high share in the total research allocation. But there have been other reasons too.

The utilization and development of the research results in many instances have not been satisfactory; there have been problems in harmonizing and integrating inter-related research activities and the priority areas have not been very clearly defined.

The policy measures that were introduced to deal with these problems included setting up research teams from the Ministry of Agriculture, Ministry of Irrigation and universities to co-ordinate the research work. The policy measures also emphasized research in fewer priority areas. To give just a few examples, corn and rice were selected as priority research areas. Production of the former was doubled, and production of the latter increased threefold within a span of two years. A fast-growing high-yielding cultivator of rice was introduced, which through adequate extension services, helped the farmers to harvest two cycles of rice in a period of 160 days, the length of one cycle with the locally cultivated rice.

2. R and D linkages in industry

One of the main reasons for setting up the National Research Centre (NRC) in the mid-1950s as a central research institute to cater for the need of the growing Egyptian industries was the lack of funds and technological capabilities to establish R and D units at a wider industrial enterprise level. NRC therefore was established to conduct both basic and applied research mainly in industry, agriculture, medicine and areas closely related to the national economy.

Scarce local technical and technological capabilities remained as constraints in the operation of NRC at the early stages. The Centre was forced to devote a considerable amount of effort and resources to developing its own manpower. A combination of methods was used which included granting scholarships, involving university faculty members in the work and inviting foreign researchers to supervise applied research activities in laboratories. By the end of the 1960s, a core research staff was formed and a number of R and D units for industrial research were operated which included: units for glass technology; ceramics and building materials; pulp and paper; leather tanning, metallurgy; polymers and pigments; insecticides; textile dyeing and finishing; textile spinning and weaving; food industries; fats and oils; pharmaceuticals; electronics; chemical pilot plant and mechanical engineering.

Nevertheless, it seems that at this stage the NRC was more successful in building up its research capabilities than using these capabilities to serve the needs of the production sectors. Indeed, a serious criticisim of NRC was

that it became an extension of universities, where the primary concern of the staff was publication of scientific papers. Industries grew reluctant to send their problems to NRC. This image had to change, and change it did in the late 1960s. Research activities were confined to five major areas: food and agriculture; industrial research; energy; health and environment; and natural resources. Researchers were allowed to use the NRC fund only when the research they worked on was in the priority areas just mentioned. A formal internal contracting system was also operated between researchers and management.

A number of other measures were introduced to encourage the production sectors to bring their research problems to NRC, especially in areas related to raw materials, processing, productivity and quality control. These measures included: establishing a marketing office to promote sale of NRC services; co-sponsorship operations with a number of national funding agencies and international organizations; forming joint committees between NRC departments and corresponding industrial firms to include R and D staff members from both parties; and organizing training courses and seminars.

These measures have succeeded in cementing NRC linkages with the production sectors. A total of 152 contracts was signed in the period 1975-1980, which covered public and private industries, the Academy and foreign and international funding agencies. But the main thrust of the contract research, nearly 60 per cent, was directed to local production sectors. Analysis of some of these contracts is in order.

Below are a few examples of different types of linkages NRC has forged with the production sectors.1/

3. Phosphate ore project

Egypt's supply of high quality phosphate ore is being depleted. There was a need to evaluate the characteristics of the large reserve of low-grade ores (which have impurities that are not easily removed), and study the technical and economic problems in converting the ore to fertilizers end-products.

NRC assembled a team of experienced chemists and chemical engineers in the phosphate industry which managed to solve the problem. The R and D activities which were conducted in the process included: pilot plant studies of ore beneficiation; development of production flow sheets; laboratory and pilot studies of chemical conversion of ore to phosphoric acid and to phosphate fertilizer end-products; techno-economic evaluation; and agronomic studies on the products.

4. Bentonite clays

Initially, Egypt imported specialized bentonite products at an annual cost of $15 to $20 million. Bentonite clays are used for soil conditioning for land reclamation, as binders in metal casting to decolorize vegetable and mineral oils, in deep drilling, in oil exploration, and many other industrial

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1/ For more detailed case-studies on linkages between R and D and production sectors in Egypt, see the following documents listed in annex II to this study: E/ESCWA/NR/87/WG.1/WP.6; E/ESCWA/NR/87/WG.1/WP.3; and E/ESCWA/NR/87/WG.1/WP.5.

uses. The NRC was contracted to evaluate local bentonite clays and study the technical and economic feasibility of using local bentonite for industrial needs. This it has done using a local research team as mentioned above.

5. Wool scouring and wax recovery

Misr Beida Dyers Company brought the following problem to the Textile Division of NRC. The problem was how to improve the economic efficiency of wool scouring by reducing the consumption of heat water process, and chemicals, improving the quality of wool tops; recovering the high quality wool wax by-product for local and export markets, and reducing process wastes by removing the pollutants before the wash was discharged into the environment. The R and D process here involved setting up a wool wax recovery unit on site with full-scale testing facilities. Implementation of the result of this research is yielding a profit of three quarters of a million dollars annually.

6. More and better food programme project

This project is another example of linkages between NRC and the production sectors. This time, it is in the field of agriculture. The project basically demonstrates how application of science and technology led to increasing food production. Three villages were chosen for the experiment which aimed at increasing the output of cash crops for the rural population. The project, which was one of the largest undertaken by NRC, involved nearly 300 scientists in 13 lines of specialization and 100 scientists from ministries and universities. It helped NRC staff and management to gain experience in dealing with large multi-disciplinary and multi-institutional projects.

The project produced very satisfactory results in animal and crop production; increases ranging between 25 per cent to 200 per cent have been recorded. What is equally important is that NRC carried on with this project after the foreign support stopped. Thus, in 1982, the NRC researchers were working with tens of thousands of farmers, helping them to increase their yield of corn and tomatoes, except this time instead of foreign funds, the project was supported by the Organization for Rural Development.

There are other equally interesting examples of interactions between NRC activities and the production sectors. They include discovering methods for dealing with industrial corrosion which it accomplished for the Academy and selecting, adapting and testing processes up to the pre-production stage for a number of selected chemicals for the pharmaceutical industries.

Imported pharmaceutical chemicals in Egypt amount to nearly $400 million every year. The Government is aiming to manufacture 50 per cent of the country's needs locally. NRC has been given a leading role in this process. The contract signed between NRC and a leading drug manufacturing company in Egypt has specified technology packages for 13 important pharmaceutical products. NRC has successfully produced the technology packages for the preparation of these products.

7. Linkages between the Academy, R and D and production sectors

The Academy funds projects which are requested either by production sectors themselves or R and D institutions serving the production sectors. Funding is usually provided on the basis of a contract between the Academy and the institution or firm concerned. The list of projects which were funded by the Academy during 1974-1981 included: prospection for Nile silt substitute in brick industry; improving specifications of petroleum additives; use of petroleum materials for soil amelioration; location of new raw materials for road, railway and airport construction; studies on the iron ores in Bahareya Oasis; use of hydrochloric acid for phosphoric acid production; production of paper pulp from the desert plant Thymelaea - histua L; food industries waste as a source of fodder; and the potentialities of developing vitamin production from micro-organisms.

Recently, in an attempt to secure implementation of research results, the Academy has laid down the condition that requests for funds by industrial companies must be partially funded by them. Agricultural research projects, however, were exempted from this condition. The entire research would be funded by the Academy on the basis that farmers who are the final users of the results cannot afford research expenses.

8. Linkages between universities R and D and production sectors

Universities research activities are concentrated, as shown in the previous chapters, in basic research for M.Sc. and Ph.D. degrees and publication of scientific papers for career development. During the 1970s, the system of sponsor or contract research was introduced into universities research work. This encouraged university faculty members to work in production sectors and especially in agriculture, where the share of universities in research is very high. University research contracts are funded mainly by production sectors themselves, the Academy and international funding agencies. For example, the Academy funded all the agricultural national projects. This included projects for rice, corn and wheat, which were carried out by university faculty members, the staff of the Agricultural Research Centre and the National Research Centre.

There is also the University Linkage Programme, which is in charge of mobilizing foreign fund for university research. Several of the research projects of this Programme were orientated to solve problems in industrial production. The list includes: Research for extraction of aluminium oxide from Egyptian ore; a study for measuring and improving productivity in a basic industrial sector in Egypt; development of the iron and steel industry using process computer control; development of packaging and canning technologies for basic food industries in Egypt; application of micro computers in spinning and weaving process control; design and development of agricultural equipment for small-scale farms in Egypt; development and design optimization of welding transformers produced by El-Maco company; melting, casting, rolling, cold drawing and heat treating of some special steels at Delta Mills; and investigating the degradation of polyvinyl chloride (PVC) pipes used in subsoil agricultural drainage.

B. Linkages between R and D and production sectors in Iraq

As mentioned in the previous chapters, the Scientific Research Council in Iraq is entrusted with the task of formulating the national scientific research strategy in relation with the country's national development plans. The Council has already produced a strategy to direct the countries' R and D activities until the year 2000. The strategy dealt with the national priorities in scientific research and the goals and the directions of research activities. Based on this strategy the Council also formulated the Scientific Research Plan for the years 1984-1990. Similarly, the Ministry of Higher Education and Scientific Research formulated the research plan for the Iraqi universities for the years 1986-1990. The Ministry of Industry and the Ministry of Heavy Industry each issued their respective R and D plans for the same years. Public sector enterprises also have their own, albeit limited R and D programmes in their fields of operations.1/

Iraq has also a State organization for Design and Industrial Construction (SODIC), now renamed the General Engineering Company for Design and Industrial Construction (GECDIC). As the name indicates, it carries out consulting and engineering design work for the public investment projects in the industrial sector. Its recent reorganization gives it greater independence in offering its services, and widens the scope of its operation.

There is also the specialized Institute for Engineering Industries (SIEI), which deals with design and detailed engineering related to products and process. This Institute is designed to carry out projects from the stage of R and D to prototype at the factory level.

There are officaial links between the Scientific Research Council and other research centres on the one hand, and universities, ministries and other concerned government departments on the other. In the Council itself, for example, there was, until recently, the Scientific Board which was responsible for channelling interactions. This Board was headed by the President of the Council as the Chairman and 12 members, among them university presidents, under-secretaries, director-generals representing the Ministries of Industry, Petroleum and Agriculture, and distinguished scientists. The specialized research centre too had administrative boards composed of representatives of concerned ministries. But how effective these bodies have been in establishing strong linkages between R and D activities and the production sectors is still not clear.

Generally speaking, the country is now going through a reconsideration of a number of its institutional set-ups. The field of R and D has not been excluded. There is now a realization that there is a much greater prospect for forging stronger links between the operations of the Scientific Research Council and the universities on the one hand and the production sectors on the other. Even within the production sectors themselves, the relationship between the research units and the production activities need to be reconsidered and strengthened.

1/ See Ghasi Derwish, "Strengthening Research and Development Capacity and Linkages with the production Sectors in Iraq". Paper prepared for ESCWA Expert Group Meeting in Amman 15-19 November 1987 (E/ESCWA/NR/87/WG.1/WP.7), p. 3.

A number of reasons have been given for the present unsatisfactory linkages between the R and D and the production sectors. But before discussing these suggestions, it should be noted that the picture is not entirely gloomy. There are some good examples of success in the field of R and D both by the research centres in the ministries, by the Scientific Research Council and by the universities. The examples include mineral upgrading, industrial waste utilization, plant seeds selection, and development of refinery products.

In a study of the experience of the Ministry of Industry and Minerals in transfer and adaptation of technology in Iraq between 1973 and 1983[1/], it was found that during this period a total of 250 industrial projects were established in the country, costing nearly eleven billion dollars. They included projects in six main industrial branches; engineering, chemicals, construction, food, textiles and electricity. But it was found out that only 2 per cent of these projects were actually carried out by local capabilities. In terms of money this represented $US 21.4 million, i.e. 0.6 per cent of the total cost of the projects. Whereas, 93.2 per cent of the project, costing nearly ten billion dollars, was executed by foreign companies. Nearly 12 per cent ($US 770.4 million) of the latter were projects which were executed directly by the Government in co-operation with foreign companies. Even here the share of the local input was very small. What is equally interesting to note is that some of the projects which were established, especially electric plants, were of a recurring type.

The Institute for Engineering Industries offers some encouraging examples of successful interactions. The Institute is now well established. It has carried out a number of projects in engineering industries in the public sector. The United Nations Industrial Development Organization executed a number of United Nations Development Programme projects in support of the Institute. During the 1980s the Institute made useful contributions in reverse-engineering and trouble-shooting. It has now to its credit a number of patents, especially one on the protection of sponge-iron against re-oxidative, which enjoys the protection not only of the national patent law, but also the patent law in the United Kingdom and the United States.

A number of suggestions have been made to further strengthen the existing linkages betweeen the R and D (in the research centres, universities and the ministries) and the production sectors. Some of these suggestions are mentioned below:

1. There seems to be a lack of clarity at the industrial management level regarding the concept and purpose of R and D in the industrial enterprises. As a result result R and D activities have been confused with ordinary production activities and this has often resulted in hindering the operation of the latter.

1/ See A. Al-Khafagi (et al) "The experience of the Ministry of Industry and Mining in the Field of Transfer and Adaptation of Technology in Iraq". Working paper Ministry of Industry and Minerals, Baghdad 1984, p. 8.

2. Industrial enterprises generally have not been very successful in developing R and D units capable of leading the production process. In most cases the existing units suffered from a shortage of qualified and experienced personnel and adequate R and D facilities. In many instances R and D units have been made to compete with production services in using the same facilities. This has created frictions and conflicts which did not help the R and D work.

3. In an attempt to remedy the scarcity of qualified and experienced R and D personnel, policy makers have encouraged participation by university teachers in the industrial R and D. This was also a method to increase the interest and awareness of university students with regard to industrial problems. This attempt has met with little success. One day a week involvement by university teachers in industrial R and D was hardly sufficient to maintain continuity in research work, or to create the expected feedback in the university. Often, it seems, this arrangement has resulted in burdening the R and D personnel in production with additional problems. At the same time the solution of increasing the working research time for university teachers was requiring far-reaching changes in the university time allocation system.

4. There seems to have been resistance on the part of industrial management to come to terms with the fact that it may not be possible always to remunerate R and D work on the basis of visible or measurable output.

5. Relatively speaking, the contribution of consultancy, engineering and design offices in the universities has been minimal, especially in product and process design. There were better linkages between the universities and the production sectors in surveying industrial and agricultural activities, in evaluation and feasibility studies as well as in participating in boards of factories.

6. The industrial strategy with its heavy emphasis on advanced technology and packaged mode of technology transfer has played an important role in creating the present gap between the local scientific and technical know-how and the requirement of the industrial sector. A science and technology policy which closely links the process of transfer of technology to the process of utilizing and developing local technological capabilities would help to narrow this gap.

There are a number of other problems concerning Iraq's experience in establishing linkages between R and D activities and the production sectors. These have been presented in the papers relating to Iraq in the Expert Group Meeting.

C. Linkages between R and D and production sectors in Jordan

The annex to this chapter shows the type of R and D activities that take place in various concerned institutions in Jordan. The table clearly shows

that almost all the industrial R and D are carried out in the RSS. Those activities cover a fairly wide range of industries. Moreover RSS also provides technical services in industry and engineering activities. In the following, owing to lack of data, the review of the linkages between R and D institutions and the production sectors will be confined to the activities of the RSS.

Perhaps the best way to discuss the type of linkages and interactions RSS has established with the production sector would be to discuss what strategy of work RSS followed and why.

RSS, as mentioned above, is a non-governmental organization. It was established to conduct industrial research and provide scientific and technological services including material testing, trouble-shooting, standards and other extension services.

What situations were the decision-makers of RSS facing? There were no explicit science and technology policies in the country. Until very recently there was no central institution to co-ordinate the science and technology actions in the various government departments. As a result, the little demand for R and D services which emerged from the private and public sectors was not fully exploited. This was impeding the process of accumulation of knowledge and financial resources. Equally important, it was perpetuating the reliance on foreign supply of technology. At the same time, most of the industrial firms in Jordan were new and they were based on imported technology. This has created more of a need for services than a demand for R and D to develop new processes and products.

Moreover, the managers were discovering that the research personnel were not adequately familiar with the technology used, and the technologies used were often not fully suitable for the environment in which they were operating. There was therefore a need to acquaint the skilled manpower, who were often trained abroad, with the problems of technology and production in the home market. There was also an urgent need to meet the demand of the production sectors for technical services to handle the imported technology. This resulted in placing more emphasis on the supply of technical services at the early stages.

This gradual approach helped RSS researchers to know more about local technology problems and later on to identify critical areas where the scarce resources could be effectively utilized in relevant R and D activities. The strategy was also favoured because it was generating revenues for RSS and this in turn gave it more freedom and flexibility in designing its operations. Concurrently with this strategy, the RSS was also developing the technical skill of its staff through training courses abroad and at home. It was enforcing national standards on locally produced goods and imported goods and materials which required extensive scientific equipment and knowledge. These facilities were available in the RSS. The society therefore was turning into a source for technical change and improvement. It was attracting more and more clients. This in turn was enhancing the chances for the application of the R and D results in the production sectors.

The extent of linkages between the RSS and the production sectors is indicated by the RSS self-generated income. In 1978, this income amounted to 10 per cent of its revenues. In 1984, it reached 80 per cent. In 1976, the number of laboratory tests and technical services provided by RSS to individual clients amounted to $18,000. In 1986, this number increased to $ 2,850,000. Individual contracts were signed with a number of local firms to provide them with technical service according to specific programmes. In terms of contribution to the national standards, RSS has formulated about 50 per cent of the current national standards in its laboratories. It has prepared the national Building Codes in 23 volumes which were approved by the Government. It has built the maintenance capacity for electronic medical equipment and has a contract with the Ministry of Health to maintain its medical equipment. The saving for the Government through this operation alone far exceeded the annual budget of RSS in that year. Most of the non-destructive testing for metal structures of major development projects is carried out at RSS and at a fraction of the cost requested by foreign companies.

As mentioned above, gradually more R and D activities were conducted at RSS. In 1980, R and D activities counted for only 10 per cent of RSS work; R and D activities in 1986 represented nearly 40 per cent of the work. This increase has been the direct result of improvement in RSS capabilities to conduct technical research tailored to the needs of the users.

The impact of RSS work in the economy is being gradually recognized. Several of its staff members were included in the committees set up for drawing up the last Five-Year Development Plan. Many of the studies prepared by the Economic Department of RSS led to changes in government laws and regulations. There are examples also in the field of solar energy. The solar water heaters that were developed by the RSS led to the establishment of the national standards and the setting up of about 35 manufacturing firms that produce solar water heaters. Nearly 20 per cent of the households in the country now use these heaters.

There are a large number of other examples which show how dynamic linkages have been forged with the production sectors and the consumer sectors. They also show how the RSS has utilized research skills in the universities and the ministries. But the example also indicates that there is still a long way to go for the future and more productive utilization of the R and D capacities and opportunities that exist in Jordan.

D. Linkages between R and D and production sectors in Kuwait

1. KISR internal organizations for linkages

At an internal organizational level, KISR has the "Office of Business Development" (OBD), which is in charge of foreign relations with various sectors in the country to promote KISR services. Among the tasks assigned to OBD is identifying potential beneficiaries, introducing them to KISR research activities, cultivating potential and active users in areas of mutual interest as well as providing feedbacks on ongoing contract research to the management.

In each of the composite Research Divisions, there is a "Research Advisory Council", which studies the "nitty-gritty" of the research projects. These councils also evaluate the result of the research and assess their possible application. Still in this category of formal links, there is in KISR what is known as the "Reverse" type of linkages. This includes KISR representation (at a senior staff level) on the boards of other bodies. At present, KISR is represented on the senate of Kuwait University, the Environmental Protection Council, the Food and Nutrition council, the Bubyan Fisheries Corporation, the Kuwait Corporation for Consultations and Investment (formerly the Technology Investment Corporation). In almost all these cases, the representation has led to concluding research contracts with the institutions concerned and created useful feedback for the Scientific Division concerned in KISR. Recently, however, a conflict of interest is raising doubt about the continuity of this representation arrangement.

Also in the way of formal links, one may mention the volume of scientific and technical information that has been published and the training courses and seminars which have all, in no little way, contributed to increasing social awareness of the importance of R and D activities. But it is in the area of effective linkages that KISR experiment deserves some special consideration.

2. Technology Investment Company (TIC)

Aware of the importance of a "transmission belt" where the results of its successful research could be transformed, through a production or service unit, into a feasible cost-effective market-scale technology, a mixed sector company, the Technology Investment Company (TIC) was set up in 1981. The shareholders of this mixed company included the Ministry of Finance, the Industrial Bank of Kuwait, the Social Insurance Corporation, Kuwait Foreign Trade, Contracting and Investment Corporation, and Kuwait Investment Corporation. (KISR could not legally be a shareholder). The objective of the Company was defined to develop the innovations, inventions patents and trademarks of Kuwaiti scientific bodies; assist in registering patents and industrial and commercial trademarks; and explore the prospects for investment opportunities in regard to these. In other words, TIC was destined to be the agency for commercializing Kuwaiti-developed technologies. Occasionally, it has also worked with the technology proprietors in preparing and presenting the developed technology as an investment opportunity to Kuwaiti and other investors. i.e. TIC acted both as an investment banker and as a direct investor in a new venture.

As mentioned above, TIC began operations in June 1982. Since then, one venture placement has been completed and there are others under consideration. The first venture involved raising funds for the commercialization of a technology which was developed by KISR. The technology concerned related to the domestic culture of Sobaiti Fish (Silvery Black Seabream) in sea cages or ponds. TIC studied the viability of commercializing the technology, on the basis of which it entered into a "Joint Venture" agreement with KISR and took the responsibility for: (a) raising the investment capital required for commercializing the technology; and (b) identifying potential investors in return for a fixed front end fee and a share of the royalties once the successful commercialization of the technique had been launched.

Two out of eleven prospectors were short-listed and eventually the contract was concluded with United Fisheries of Kuwait (UFK) for a sum of $1.5 million investment in return for the commercialization rights to the Sobaiti technology.[1/] The contract, however, had a provision permitting within a certain time limit other Kuwaiti investors to join UFK as co-investors with the same rights and obligations.

TIC terms of reference were later expanded to include not only "Kuwaiti-developed" technologies but also "Kuwaiti-owned" technologies. Certain technologies developed abroad, it was decided, could benefit Kuwait. Two illustrative examples would make this clear.

The first is the application of photovoltaic technology in shaving off peak loads in electricity generating plants. It was found out that, for several hours during daytime in the summer months, nearly one third of the total load was consumed in domestic air conditioning. This period happened to concide with the period of maximum insolation. Thus, the solution found dealt with the basic problem of storage which often hampers solar electricity generation. With the remarkable developments that have taken place in the efficiency and production techniques of amorphous silica cells, TIC analysis demonstrated that the above application is technologically and economically viable. Negotiations have been initiated with the Ministry of Electricity and Water to set up a pilot plant using locally produced panels, the idea being that once field testing and satisfactory development have been carried out, larger production facilities would be established for a wider application and marketing of the panels in the Gulf region and the Arab countries. However, no firm commitment has been so far forthcoming from the Ministry.

The other project relates to the use of biosurfactants. This material has been developed abroad and it is used for cleaning oil storage tanks. TIC presented it to the Kuwaiti Oil Company (KOC) after carrying out field trials on its applicability in the anticipation that KOC may use the technology.

Recently, however TIC has undergone some drastic changes which included altering its name. It has now become the "Kuwait Company for Consultatation and Investment". New shareholders joined the Company and its capital has been raised to $ 15.6 million. Its function, however, has been widened and diluted. It has now become the technical investment advisor of the Kuwait Fund responsible for studying investment projects in developing countries, promoting projects among Kuwaiti investors, implementing projects and concluding agreement with host countries. Thus the Company has deviated from its original concept which concentrated on investing in technologies leading to the production of goods and services. Interestingly enough, under-capitalization and the need for an advisory-consulting-investment body were among the reasons for this change.

Finally, another area of interactions and linkages between R and D and the production sectors is exemplified by the scale and diversity of the contract research which has been conducted by KISR. As table 33 shows, the linkages covered a large number of government departments, public companies and private

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1/ KISR invested nearly $3.2 million in developing the technology of Sobaiti and Telapia culture in the Kuwaiti environment.

enterprises in various goods and services-producing sectors. For example, table 34 shows that in 1985-1986, a total investment of $ 5.7 million was made in research projects in KISR. Out of this KISR contributed nearly $ 3.36 million (59 per cent, the rest paid by the research contractors themselves). This in itself represented an increased contribution by KISR of nearly 6 per cent over the previous year. Table 35 shows the activity areas of KISR research programme. It can be seen that these activities correspond to the six areas in which the country's need for applied research were defined (as shown above).

However, contract research has not been without problems. The list of the problems includes: resentment on behalf of the scientific staff members at being involved in promoting and soliciting research contracts; organizational problems relating to implementing and monitoring multi-disciplinary projects of a relatively wide scope and long duration; arbitrary definition of income targets; and clients, over-sensitive to changing economic conditions in the country, deciding on engaging local capabilities to solve their production problems; tendency to accept contracts indiscriminately to boost high self-financing figures. Finally, some managerial problems have also been encountered, especially in the mechanics of contract research, and which are caused mainly by lack of experience.

Nevertheless, judging from the development and the demand that have been sustained and increased through the years, contract research has been effective in inter-relating research activities to national development problems and needs.

In addition to the activities just referred to, KISR also executed a number of important techno-economic projects. To give just a few examples, it carried out a major municipal project for planning national desert parks and a plantation for the water front. This project involved conducting ecological studies which led to identifying a location and designing implementation plans. A 10-year project on developing acquaculture of local fish under the harsh local environment involved studies in physiology, life cycle, breeding habits, nutrition, diseases and climatic aspects of fish culture. (The commercial exploitation of this project has already been referred to). An energy conservation code was drafted which was applied by the Ministry of Electricity and Water, and produced a substantial saving for the nation. Other projects included building an econometric model for the economy and for the production sectors, and developing a computer model of patterns of air pollution around power stations and industrial zones. This last project was included by the Ministry of Planning in the Country's Five-Year Development Plan. Numerical and physical models were constructed to combat thermal pollution in the Shuaiba industrial area together with suggestions to solve problems. Regular monitoring of the marine environment in Kuwait was conducted. Thus when in 1982 the Nurze Oil spill occurred, against the generally held view, it was concluded that the spill would have a marginal effect on the rate of pollution in the area. Although severely criticized at the time, this conclusion was proved right and the country saved millions of dollars which would have gone to multi-national companies. KISR was also instrumental in localizing the process of crude oil assaying and oil well-logging techniques. At the moment three KISR patents relating to the use of polymer products are being negotiated with multi-national chemical

companies and Gulf Petrochemical Industry. The patents relate to concrete super plastics and fertilizer - releasing, much for agriculture. KISR is also engaged in a long-term contract with the Oil Ministry to study the chronic and acute problems of corrision, particularly in the oil sector. It is carrying out an extensive multi-disciplinary study into the causes of problems of asbestos cement pipes used in the municipal water distribution network. KISR work in the Battery Factory in Kuwait on design changes in the products and materials used, quality control and market research helped to put the factory back in the black. These are just a few of the long list of results which KISR was able to achieve through its R and D activities.

Table 33. Major KISR clients for 1984/1985 and 1985/1986

Client	Client contribution (thousands $US)	Client contribution Percentage
- Kuwait Foundation for the Advancement of Science	2,120	36.3
- Ministry of Oil	587.2	10.1
- Environmental Protection Council	442.5	7.6
- Kuwait National Petroleum Company	387.5	6.6
- Ministry of Electricity and Water	371.8	6.4
- Regional Organization for the Protection of the Marine Environment	333.0	5.7
- Other	1,591.0	27.3
Total	5,833	100

Source: El-Kholy, "R and D in Kuwait" p. 41.

Table 34. Total volume of KISR research contracts and share of contract research (Thousands $US and percentage) (1984-1986)

Year	Volume	KISR	CLIENT	KISR/Volume Percentage
1984/1985	3,811	2,470	1,341	65
1985/1986	5,660	3,363	2,297	59

Source: El-Kholy, "R and D in Kuwait", pp. 14-15.

Table 35. Composition of KISR research programmes for 1985/1986

Programme	Volume	Client (Thousands of US dollars)	KISR	Client/Volume Percentage
Food	1,719.7	627.2	1,092.2	36
Water	64.0	41.6	22.4	65
Oil	767.7	451.5	316.5	59
Environment and Habitat	1,620.8	1,209.3	411.8	75
Industry and Services	1,036.8	695.7	340.8	67
Technical Development	371.5	257.9	113.6	69
Economy	---	---	---	---
Services	80	80	---	100

Source: See table 34.

E. Linkages between R and D and production sectors in Saudi Arabia

As a new and fast developing country Saudi Arabia has a need for R and D in various strategically important fields of development. The current development plan distinguishes three main areas of concern: development of human resources, the production sectors and the infrastructure. The development objectives in each of these areas are specified, as are policy measures and financial and other resources needed to achieve the stated objectives. Within the production sector, several strategically important activities have been underlined. These include water resources, agriculture, oil, transportation of oil, oil refining, mineral resources, electricity and solar energy. Within the manufacturing sector hydrocarbon and non-hydrocarbon industries have been emphasized. In all these areas, there are important research problems which have been addressed under the different research programme areas in the city, the universities and the research centres in the ministries.

Several methods have been applied to strengthen the linkages between the R and D activities and the production sectors in Saudi Arabia. Among them is the regional distribution of research centres. For example, agricultural research centres are located in King Faisal University and King Saud University, both in agricultural areas, whereas research centres relating to oil and oil products are located in the Al-Thahran area. Medical research centres have been located in a balanced manner in all three main regions of the Kingdom. The application of the contractual method in granting research projects has not only helped to select the most efficient executors but it also emphasized the presence of strong local content in the problem-solving. The method helped to develop a group of competent researchers in many fields. These in turn, helped to define future R and D activity more accurately. The

city also applies the method of direct contact with base-line operators in defining research problems.[1/] The last such meeting was in February 1986 when representatives of all ministries and industrial organizations in the public and private sectors participated in an open discussion forum in the city evaluating, over three days, the results of several research projects and formulating recommendations for policy-makers. The city also publishes a directory on the research activities it is supporting. This contains a summary of the research projects and the results achieved or aimed at. The city also publishes the results and findings of research activities in separate booklets. Several of the research projects supported by the city have produced effective results. This, for example, includes production of animal feed from date palms, treatment of the skin disease Lashmania, and a project on traffic safety. The city is also actively contributing to the national effort to develop national capabilities in various science and technology fields. This is being done through application of a policy of including national researchers in the implementation of contractual research projects. As a result, the 1983 low ratio of Saudi nationals involved in R and D activities is now rising. One estimate puts the proportion of Saudis at nearly 60 per cent.[2/]

1/ See paper prepared by Sulaiman El-Ogaily, "Application of Research Results for the Development of the Society" (E/ESCWA/NR/87/WG.1/WP.9) (in Arabic), pp. 6-7.

2/ United Nations Economic and Social Commission for Western Asia, "Strengthening and Applying Scientific Research for Development of Society" (E/ESCWA/NR/WG.1/WP.9/Rev.1).

Annex to chapter VII

THE GENERAL FIELDS OF R AND D ACTIVITIES AT THE MAJOR R AND D INSTITUTIONS IN JORDAN

Field of activity	Jordan Univ.	Mauta Univ.	S and T Univ.	Yarmouk Univ.	The Royal Scientific	Ministry of Agriculture
1. Science						
- Mathematics	x	x	x	x		
- Statistics	x			x		
- Computers	x	x	x	x	x	
- Physics	x	x	x	x		
- Chemistry	x	x	x	x	x	
- Biology	x			x		
- Geology and Mining	x			x		
- Environment	x			x	x	
- Marine Science	x			x		
2. Engineering						
- Civil Engineering	x		x		x	
- Architecture	x		x		x	
- Mechanical Eng.	x	x	x		x	
- Electrical Eng.	x	x	x		x	
- Electronics	x		x		x	
- Chemical Eng.	x		x		x	
- Industrial Eng.	x					
3. Agriculture						
- Plant Production	x		x			x
- Animal Production	x		x			x
- Nutrition	x		x			x
- Soils	x		x			x
- Agric. Economics	x		x			x
- Plant Protection	x		x			x
4. Economics						
- Economics	x			x	x	
- Statistics	x			x	x	
- Accounting	x			x		
- political Science	x					
- Banking	x			x		
- Management	x	x		x		
5. Medical Sciences						
- Medicine	x		x			
- Nursing	x		x			
- Pharmacy	x		x			
- Dentistry	x		x			

Annex (continued)

Field of activity	Jordan Univ.	Mauta Univ.	S and T Univ.	Yarmouk Univ.	The Royal Scientific	Ministry of Agriculture
6. Other area						
- Arabic Language	x	x				
- English Language	x	x				
- History	x					
- Geography	x					
- Philosophy	x					
- Sociology	x					
- Population	x					
- Islamic Studies	x				x	
- Physical Education	x				x	
- Journalism	x				x	
- Law	x					
- Fine Arts	x	x			x	
- Education	x				x	
- Military Science		x				
- Police Science		x				
- Science Education		x			x	
7. Industrial Research						
- Glass					x	
- Ceramics					x	
- Paints					x	
- Fuels					x	
- Lubricants					x	
- Detergents					x	
- Water Pollution	x				x	
- Air Pollution					x	
- Plastics					x	
- Paper					x	
- Textile					x	
- Metals					x	
- Cement					x	
- Concrete					x	
- Asphalt					x	
- Soils					x	
- Electronic Design					x	
- Insulation, thermal					x	
- Solar Energy					x	
- Wind Energy					x	

Source: See F. Daghestani (E/ESCWA/NR/WG.1/WP.1), p. 15.

Chapter VIII

SUMMARY AND CONCLUSIONS

A common denominator which characterizes the R and D scene in the countries concerned is the weakness of their intermediate technologies. These are the capacities which transform research results into products. They are also known as the "technology package". They include engineering design of products and process, capabilities to carry out techno-economic studies, sample products, prototypes and pilot projects. Generally, these capacities were either weak or missing in the countries reviewed. As a consequence in a number of cases, the results of industrial R and D either have not been utilized or have been exploited by foreign companies.

The policy, therefore, should be to develop a nucleus of an intermediate chain of technologies which could be further expanded. Such a policy, however, would have deeper implications. It would require involvement of R and D institutions in the process of technology transfer, an unpackaged mode of technology transfer, localization of parts of the technology required through utilizing locally available know-how, involving science and technology institutions in technology transfer and strengthening the negotiating position of the country.

The weak link in the agricultural R and D chain was in the extension services. The success or failure of infusing the new ideas, and technological packages depends to a great extent on the role of the extension service which corresponds to intermediate technology in industry.

The policy action suggested in this regard also concentrates on the R aspect. The personnel should be well trained to be able to transfer the required technical change to the farmers, to supervise and follow up the extension activities and provide the feedback of the experimentation to the research institutions.

Regarding R and D in services, there is a need to concentrate on unpackaging of the imported technology. More R and D should be conducted in how to unpackage the equipment, machinery and maintenance requirement as a first stage for more gradual manufacturing.

Thus government legislation, priorities, fundings, education systems and training should be directed towards strengthening these areas in the technological capacity building.

A. Egypt

1. The research network in Egypt is one of the most extensive in the region. It deals with a wide range of R and D problems in the country and engages a large number of researchers and R and D institutions.

2. R and D policy-makers are well aware of the importance of strong linkages between the R and D activities and the production sectors. There have been

frequent changes in the R and D organizational structures and functions to strengthen these linkages. Relevant policy measures have also been introduced to utilize research results.

3. The Five-Year Research Plan in Egypt is well prepared. This applies to the problems identified, the method of identifying them, the formulation of the research projects and the selection of project implementors. The research projects selected are also well co-ordinated with the investment projects in the Five-Year Development Plan.

4. The extensive coverage of the Research Plan is not confined to the wide variety of research subjects it covers; it extends also geographically on a country-wide basis and involves all the counties in R and D activities.

5. The Plan keeps a fair balance between recurrent and continuous research projects and new and emerging research problems. This is indicated by the number of projects in each category and by the distribution of resources.

6. The organizational set-up, within the Academy, in charge of preparing the Plan, has ensured effective identification, selection and implementation of research projects.

7. Emphasis on competitive bidding in contracting research projects secured high quality of inputs and stimulated researchers to keep abreast of new advances in their fields.

8. The Plan has also correctly included a number of multi-disciplinary, multi-institution research projects which required various team approaches to deal with them. An example in this regard would be the Sinai Development project which included potable water supply, sewers, environment studies, housing, urban development, medical care, sand and dunes, pollution control and energy research. This approach has been applied in a number of strategically important research areas. It has yielded significant experience for the management and the researchers. There are, however, a number of observations to be made regarding R and D in Egypt.

9. As there is no explicit technology policy in Egypt, neither the Research Plan is co-ordinated with the process of transfer of technology to the country, nor is there an entity within the existing R and D (or Science and Technology) institutions which is concerned with exacting this co-ordination. As a result, the important issue of linking transfer of technology to the development of local R and D capabilities is, at the the moment, left to the vagaries of separate R and D institutions. There are, however, plans being made to remedy this drawback.

10. Although there is ample information in the Research Plan on various aspects of the variables concerned, some vital information was still missing: for example, qualification of researchers and the time spent on research projects; breakdown of expenditure items by variable costs and fixed capital investment in infrastructure, R and D facilities, equipment, etc which were involved in the research project. There is, in fact, no information at all in the Research Plan on investment in R and D infrastructure.

11. Still on the subject of data on R and D expenditure, although the research funds of some of the R and D institutions have been augumented from foreign sources, there is very little information on the magnitude and significance of this funding.

12. The Academy is the principal financier of research activity in Egypt, and the main source of its funds is the Central Government. No attempt has been made to supplement the Academy's budget from non-governmental sources inside the country. Therefore, R and D activities in Egypt remain by and large a government affair. Not only almost all the funds are provided by the Central Government but also almost all the R and D activities are conducted by government departments.

13. The participation of the private sector in R and D activities has been dismal and no policy measure has been introduced to stimulate private sector participation or demand for R and D.

14. The wide and extensive coverage of research activities in Egypt is in fact both a strong and a weak point of the system. It is strong, because it reflects serious concern on the part of R and D policy-makers that R and D activities should be linked to development problems on a wide basis. But for this concern to be more effective more funds need to be allocated than at present. Therefore, R and D resources in Egypt remain thinly stretched. There are, nevertheless, indications that some institutions are scaling down their research priority areas. There are also attempts to augment resources from foreign sources.

15. The need for larger R and D funds is indicated in yet another way. An examination of distribution of research projects by: scientific fields; production sectors; implementing institutions; and size of projects reveals a skewed distribution. A much larger fund would be needed to bring the curve to a normal distribution form.

B. Iraq

Iraq has made great strides in developing its R and D capacities and infrastructure. There has also been marked development in human capabilities in the field of science and technology. Iraq R and D centres are making a useful contribution to the development process. However, the prospects for stronger linkages between the R and D activities in the research centres and universities, and the productin sectors have not been fully exploited. There is a need to reconsider some of the existing mechanisms in this regard. There is also a need to give more support to the R and D units in the ministries to play their crucial role.

C. Jordan

1. R and D programmes in Jordan are also mostly government financed. However, unlike Egypt, there is no centrally planned research programme. Nor is there an institution in the country which is responsible for harmonizing the various research activities and co-ordinating them with the National Development Plan.

2. Although institutions conduct their own problem-oriented R and D programmes, they do, nonetheless, abide by the general directives provided in the Plan regarding the strategically important research areas.

3. The development plans' concerns with R and D have been in two areas. One involved allocation for the development of the required R and D infrastructure and facilities, and the other a set of policy measures to stimulate the development of R and D activities. There is, as yet, no plan of action concerning R and D activities themselves and their interrelation with the technology transfer process.

4. The present Development Plan identifies the missing elements in the existing R and D system in Jordan. It recommends a number of suitable policy measures to remedy the situation. Yet the essential and central missing element, namely, the body to implement this policy, has not yet been established, although two years of the plan period have elapsed.

5. The co-ordination responsibilities given to the Science and Technology Department in the Ministry of Planning are well in excess of the limited resources made available to this Department.

6. Total planned allocations for building R and D requirements have remained stagnant over the last decade. There are even signs that they have declined.

7. The current Five-Year Development Plan contains a number of ambiguities regarding R and D. For example, R and D activities are supposed to be co-ordinated with the development plan, linked with the technology transfer process, and directed to strategically important research areas. But there is no indication as to whom or which department, and how all these objectives will be attained.

D. Kuwait

1. The main R and D institutions in Kuwait are well established. They have also been well catered for in terms of physical, financial and manpower resources.

2. KISR, which is the principal R and D institution in Kuwait, has developed clearly defined research programmes, formulated in close co-operation with concerned parties in the public and private sectors.

3. Research activities in KISR are carried out mainly on a contract research basis. But there are a number of long-term research projects and the contract research remains heavily subsidized from the government budget.

4. Kuwait University concentrates on research. A well established system for granting research projects is being operated. The bulk of its research, however, remains in basic sciences.

5. KISR, which is mainly concerned with applied research, has produced a number of useful research results which have been commercially exploited.

6. Kuwait has also witnessed the development of the pioneering "Technology Investment Company", the first venture capital company in the Arab region. The Company initiated a successful commercialization of local research results. The original aim of the company has lately been diluted.

7. For an institution like KISR which has been conducting research along the same programme lines now for over a decade there is remarkably little documentation about the economic impact of its research programmes.

E. Saudi Arabia

In Saudi Arabia, more detailed data would be needed to make an accurate assessment of the R and D performance in the country. The indications however, are that the country has successfully completed the phase of establishing its basic R and D infrastructure and facilities. The R and D institutions are also making an effective contribution to the development process. While Saudi Arabia suffers from the general characteristics which have been described above, it is also facing the difficult task of developing its national capabilities in science and technology.

There are also some common observations regarding R and D activities in the countries reviewed.

(a) There is a general lack of well-defined and classified data concerning R and D. There are also wide conceptual differences in the uses of the term R and D itself. This study has not dwelt too much on this point, but rather has used whatever relevant information happened to be available to draw a picture of the situation regarding R and D in the countries concerned. Nevertheless, lack of accurately defined data made it impossible to make comparative analyses. There is, therefore, a serious need to prepare R and D data in a uniform manner and according to concepts and definitions which have already been defined and applied world-wide.

(b) Parallel to this lack of uniformity in reporting R and D statistics, there is abundant uniformity in not publishing R and D data. This is especially true regarding documentation of the impact the results of the R and D activities created. One almost suspects that the R and D community in the Arab countries is partly the cause of its own demise.

Chapter IX

RECOMMENDATIONS OF PARTICIPANTS IN THE EXPERT GROUP MEETING ON STRENGTHENING RESEARCH AND DEVELOPMENT CAPACITY AND LINKAGES WITH PRODUCTION SECTORS IN COUNTRIES OF THE ESCWA REGION

Introduction

The past two decades have been marked by the leading role of science and technology in meeting the needs of the individual and society. The rivalry among the industrially advanced countries in their attempts at military and economic domination has entered the field of high technology. As a result, many countries have put their ideological and political differences aside and have begun to seek co-operation, even with countries of different economic and social systems, with the aim of enhancing the social and economic return on scientific and technological applications.

The Arab countries have not neglected the importance of economic and social development nor have they shown any lack of interest in establishing universities and scientific research centres. However, in comparison with the industrially advanced countries and a number of developing countries, what they have achieved in increasing their scientific and technological capabilities is extemely modest. This is true despite the differences in the level of advancement and development between the countries in question. This is highlighted by the fact that the science and technology gap between the Arab countries and the industrially advanced countries is growing at a startling pace and that the former are becoming increasingly dependent on the technology imported not only from the advanced countries but also from some developing countries. This is so despite the diversified industrial base that has been established in many of the countries of the region. This is because the base itself has been built on imported advance technology. If this state of affairs is allowed to continue, the gap between those countries and the industrialized countries will reach a critical stage.

It must be emphasized that the remedy to this state of affairs is not in the increased imports of technology alone. It lies chiefly in developing and strengthening local technological capabilities, and in increasing the share of locally developed technologies among those used.

There has been marked development in the scientific capabilities in universities and research centres in the past decades. There is, however, a general conviction among all concerned (government officials, researchers and managers in the economic sectors) that there is a seriously growing gap between the academic research centres and the production sectors. This gap has reduced the importance of the technological base in the countries concerned. Although this base is essential for linking the activities of the research centres to the production sectors and despite the substantial investment that has been made in building it and the efforts made, over the last two decades, to strengthe its ties with the production sectors, the impact of the technological base on the development process remained marginal. This is a significant indicator that urgent consideration should be given to dealing with this internal technological gap.

This shows the importance of the programme of the Economic and Social Commission for Western Asia, and those of the Arab organizations and federations, for strengthening research and development capacities and their linkages with the production sectors.

Although the ESCWA programme is concerned with the Western Asia region, its importance extends to all of the Arab countries. Greater co-operation and co-ordination between the Commission and other regional and international organizations is therefore required.

The draft report for the Expert Group Meeting prepared by the secretariat of the Commission (see annex II) reflected the general framework in which the problem is experienced by the institutions of scientific research and technological development in their relations with the end-users in the production sectors. This has been shown by a number of case-studies in selected countries of the region which were presented at the Meeting. They reflect the overall state of affairs in the region as a whole.

The picture was completed through the contributions made by the experts during the Meeting. They all reflected the views that the present unsatisfactory relations between the production sectors and the research institutions call for urgent consideration. Workable methods must be found to establish effective links between science and technology institutions and the production sectors.

The deliberations of the Meeting have also shown that, despite the disparities in social and economic aspects and in the levels of scientific and technological advancement among the countries of the region, the general features of the problem and its components are similar. Thus, all the countries concerned will benefit from the methods that will be devised to deal with the existing problems. They can adapt the methods to their particular circumstances. The discussion during the Meeting showed that there are a number of axes around which the solutions for the existing gap can be developed.

A. Linkage of science and technology and development policies and related strategies and priorities

National efforts in the field of science and technology, and particularly in research and development, continue to have a marginal impact in the absence of adequate and effective technology policies in the countries of the ESCWA region and the Arab countries in general. This has affected the standard of achievement in scientific and technological research. Necessary measures should therefore be taken in order to achieve the following:

1. The formulation of an effective technology policy aimed at improving national technological capabilities, increasing the share of local technologies in the various production sectors, and reinforcing potential in the high technology fields;

2. The establishment of goals for development policy and modalities for its implementation in line with the requirements for achieving the goals of technology policy, particularly those relating to national technological advancement;

3. Co-ordination between science and technology and development policies to achieve the following objectives:

(a) Development of human capabilities in science and technology in order to meet the needs of the various sectors as required by development objectives;

(b) Optimum utilization of locally available natural resources;

(c) Increasing the efficient utilization of the technologies used in the production and service sectors;

(d) Co-ordinating the development of science and technology institutions, to enable them to meet the requirements of the production sectors for growth and advancement.

4. The formulation of a technology strategy which will achieve the goals through application of plans and programmes and measures to secure their implementation. These measures should underline the significance of self-reliance;

5. Establishment of priorities for plans and programmes in the field of science and technology on a scientific basis and in accordance with sound scientific methods;

6. Establishment, in the countries where such bodies are still lacking, of a national agency responsible for planning and co-ordination of science and technology at the country level, and provision of physical and human resources necessary for implementation of national programmes;

7. Development of all aspects of bilateral and regional inter-Arab co-operation in order to establish an effective link between scientific and technological institutions on the one hand and the production sectors on the other. Also promoting utilization of local technology in the Arab countries;

8. Regional, interregional and international co-operation in the acquisition, adaptation and utilization of technological know-how in a manner suited to the needs of the Arab countries and helping to strengthen the role of relevant inter-Arab institutions;

9. Emphasis on the importance of proceeding with the establishment of the Arab centre for the transfer and development of technology which has been considered by Arab experts and inter-Arab and regional organizations. One of the functions of this centre should be to study the experience of other countries in technology transfer in order to assist the countries of the region in drafting laws and leglislation to regulate contractual arrangements for the transfer of technology.

B. Strengthening the capacities of research and development institutions

It was recommended that the following measures be carried out:

1. Establishment of research and development centres at the level of specific sector and of research and development units, no matter how modest,

at the establishment level within the sector. Support for those already in existence, and provision of development requirements, including pilot plants, as a major step towards a sound and fruitful operation.

2. Strengthening of human resources for research and development in the following manner:

(a) Provision of staff required for research and development activities. Also provision of training and upgrading in such a way that research workers spend periods of time in the field and specialists engaged in production or services spend periods of time at research centres. This could be arranged in the framework of joint research teams set up for particular projects;

(b) Training of research and development workers in the use of computers and advanced technology and equipment which benefit the research and development projects;

(c) Development of human resources highly specialized in research and development by attracting qualified nationals residing abroad or by sending candidates to acquire expertise and know-how at advanced research institutions;

(d) Selection of supervisory personnel for research and development centres and projects and training in modern management methods;

(e) Upgrading the skill of research workers and their assistants through training courses at specialized research institutions at home or abroad;

(f) Payment of financial incentives to national research personnel equivalent to that paid to foreign staff.

3. Provision of necessary funding to support the operation of research and development centres to enable them to achieve their objectives and perform the tasks entrusted to them. The funds should also be increased in line with the growth of capabilities in these centres.

4. In connection with physical resources:

(a) Establishment of specialized information centres and strengthening of those already in existence;

(b) Provision of the necessary physical facilities in terms of buildings, laboratories, equipment, experimental stations, pilot plants, maintenence workshops and tool shops.

C. Institutional linkages at the level of economic, research and technological establishments and specific sectors at the national, regional and interregional levels

The following were recommended:

1. Direct participation by the production sectors in the research plans of research centres and universities;

2. Use by production sectors of expertise available to research centres and universities in solving problems and developing production;

3. Participation from the outset of beneficiaries in the production field, in the research process together with the research staff. Participation by research workers in research centres in the application of research results;

4. Emphasis on contractual arrangements in the implementation of research and development projects, with the assurance of compensation for the research team in keeping with the effort expended and returns achieved, as in the world marketplace;

5. Establishment of specific research and development centres in co-ordination with research and development units within the same sector and with outside research bodies (research centres and universities);

6. Holding of seminars and specialized scientific meetings in order to promote a stronger linkage between research bodies and the production sectors;

7. Organization of carefully planned visits by research workers in research centres and universities to the field, the partial release of experts from research centres for work in production, and participation by specialists from the production sectors in the research conducted at research centres and universities;

8. Formation of joint research and development committees made up of specialists from the field and from research centres and universities to consider the needs of production for research and development projects;

9. Investigation by the research centres of areas of future demand to be prepared to provide consultation and research services for which there may be a need.

D. Establishment, strengthening and development of technology units specializing in the transmission and application of research results to the production sectors

The following measures were recommended:

1. Preparation of specialists in technical and economic feasibility studies on the recasting of research results;

2. Provision of engineering capabilities for the design and consultancy services necessary for the recasting of research results;

3. Provision of workshops for the production of pilot plants preparatory to the conducting of tests. The technological and economic results would then be analysed and, in the event of success, designs perfected and the necessary capabilities provided for technical consultation on mass production, where required, as a step towards actual manufacture.

E. An effective mechanism to promote implementation and application of research and development projects oriented towards meeting the needs of the economic sectors and the requirements for their development

The following were recommended:

1. Elaboration of frameworks and model contracts for co-operation between the production sectors and universities, university staff and consultancy houses;

2. Utilization of the technical assistance provided by inter-Arab and international organizations;

3. Establishment of information centres and their linkage with existing international information centres;

4. Elaboration of systems for the training of research and development workers, and strengthening of existing systems;

5. Progressive development of patent and industrial proprietary law so as to encourage invention and innovation at the national level and more effective exploitation of discoveries and inventions and their applications;

6. Establishment of specialized financial institutions to provide the funds for the necessary investment in the practical application of the results of the discoveries and innovations made in the Arab countries;

7. Linkage of the funding of industrial research and development institutions in an appropriate manner with the return on the projects undertaken by them which are of benefit to the production sectors.

F. Statistics and information relating to science and technology

The lack of data and accurate statistics on scientific and technological capabilities in the Arab countries impedes the carrying out of analytical studies on research and development and assessing the progress which has been made.

The reason for this lack is the deficiency in the organizations and staff necessary to collect and classify data relating to science and technology and research and development in accordance with the international classifications presently in use in many countries. Therefore, it is necessary for the regional organizations concerned to assist the countries of the region in developing their statistical organizations and training their staff.

The participants in the Meeting agreed on the importance of the ESCWA science and technology programme and its three subsidiary elements, relating as they do to the strengthening of research and development capabilities and their relationship with the production sector, exploration of the possibility of the specialized financial institutions contributing to the strengthening of research and development institutions, and the encouragement of invention, innovation and the commercialization of research results. The participants recommended that the Commission should lend greater support to the science and technology programme in the coming years.

Annex I

PARTICIPANTS IN THE EXPERT GROUP MEETING

A. United Nations Organizations

1. Executive Director
   United Nations Centre for Science and
   Technology for Development (UNCSTD)
   New York, U.S.A.

2. Programme Specialist in Basic Sciences
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B. ESCWA Member States

3. Mr. Mohammed Kamel
   Former President, Academy of Scientific Research and Technology
   Cairo, Egypt.

4. Mr. Hamdi Abu El-Naga
   Manager of Sales and Research Centre
   MISR Petroleum House
   Cairo, Egypt.

5. Mr. Ahmad Aboulenein
   President
   South Egypt Drug Industries Company, SEDICO
   Cairo, Egypt.

6. Mr. Ahmad Abdul Azim
   Director
   Central Metallurgical Research and Development Institute
   El-Tibbin, Helwan
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7. Mr. Ghazi Darwish
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8. Mr. Kamil Al-Mashta
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9. Mr. Muthana Akram
   Expert, Ministry of Industry
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10. Mr. Mohammed Elizzi
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12. Mr. Jawad Anani
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13. Mr. Fakhruddin Daghestani
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14. Mr. Mohammed Smadi
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15. Mr. Sami Zreigat,
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16. Mr. Omar Al-Asfar
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18. Mr. Subhi Qasem
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19. Mr. Farouk Razzo
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20. Mr. Hussein Shafa' Amri
Engineer, Ministry of Planning
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21. Mr. Ahmad Bishara
Vice Rector for Academic Affairs
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22. Mr. Mohammed Meraikib
Expert of Metallurgical Research
Industrial Development Technical Centre
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23. Mr. Soliman M. Al-Agaili
Director, Department of Scientific Research
King Abdul Aziz City for Science and Technology
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C. Arab Organizations

24. Mr. Nouriddin Al-Rubayi,
Head Department of Industry and Energy Research
Federation of Arab Scientific Research Councils
Baghdad, Iraq.

25. Mr. Abdulilah Muslih Al-Tikriti
Expert, Technical Department
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D. ESCWA secretariat

26. Chief
Natural Resources, Science and Technology Division
Economic and Social Commission for Western Asia
Baghdad, Iraq.

27. Senior Economic Affairs Officer
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28. Regional Advisor in Science and Technology
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Annex II

LIST OF DOCUMENTS SUBMITTED TO THE EXPERT GROUP MEETING

Symbol	Title	
E/ESCWA/NR/87/WG.1/L.1	Agenda	
E/ESCWA/NR/87/WG.1/L.2	Draft report	
E/ESCWA/NR/87/WG.1/3/Rev.1	Organization of work	
E/ESCWA/NR/87/WG.1/WP.1	The Experience of Industrial Research and Development in Iraq (Arabic only)	Mr. Kamil Al-Mashtah, Expert, Electric Energy Commission, Ministry of Heavy Industries, Baghdad, Iraq
E/ESCWA/NR/87/WG.1/WP.2	Scientific Research and the Importance of Applying its results in Iraq (Arabic only)	Mr. Mohammed Elizzi, Director-General, Building Research Centre, Scientific Research Council, Baghdad, Iraq
E/ESCWA/NR/87/WG.1/WP.3	The Experience of the Central Metallurgical Research and Development Institute in Egypt.	Mr. Ahmad Abdul azim, Director, Central Metallurgical Research and Development Institute, Cairo, Egypt
E/ESCWA/NR/87/WG.1/WP.4	Working Paper on Research and Development in Jordan	Mr. Fakhruddin Daghestani, Advisor, Royal Scientific Society, Amman, Jordan
E/ESCWA/NR/87/WG.1/WP.5	Working paper on Research and Development Capacity and Linkages with the Production Concerning Finished Petroleum Products in Egypt	Mr. Hamdi Abu El-Naga, Manager of Sales and Research Centre, MISR Petroleum House, Cairo, Egypt
E/ESCWA/NR/87/WG.1/WP.6	Working Paper on Research and Development in the Pharmaceutical Sector in Egypt	Mr. Ahmad Aboulenein, President, South Egypt Drug Industries Company, SEDICO, Cairo, Egypt
E/ESCWA/NR/87/WG.1/WP.7	Strengthening Research and Development Capacity and Linkages with the Production Sectors in Iraq	Mr. Ghazi Darwish, Professor, College of Science University of Baghdad, Baghdad, Iraq
E/ESCWA/NR/87/WG.1/WP.8	Research and Development in Kuwait.	Mr. Usama El-Kholy, Senior Advisor, Kuwait Institute for Science Research and Technology, Kuwait
E/ESCWA/NR/87/WG.1/WP.9/Rev.1	Strengthening and Applying Scientific Research for the Development of Society (Arabic only)	Mr. Soliman Al-Agaili, Director, Department of Scientific Research, King Abdul Aziz City for Science and Technology, Riyadh, Saudi Arabia
E/ESCWA/NR/87/WG.1/WP.10	The need for National Research and Development Policy in Jordan	Mr. Naji Abuirmeileh, Professor of Nutrition, Jordan University of Science and Technology, Irbid, Jordan
E/ESCWA/NR/87/WG.1/WP.11	The Role of Government, Universities and Industry in Promoting Research and Development in Developing Countries	Mr. Omar Al-Asfar, Dean of Graduate Studies, Jordan University for Science and Technology, Irbid, Jordan
E/ESCWA/NR/87/WG.1/INF.1/Rev.1	List of participants	