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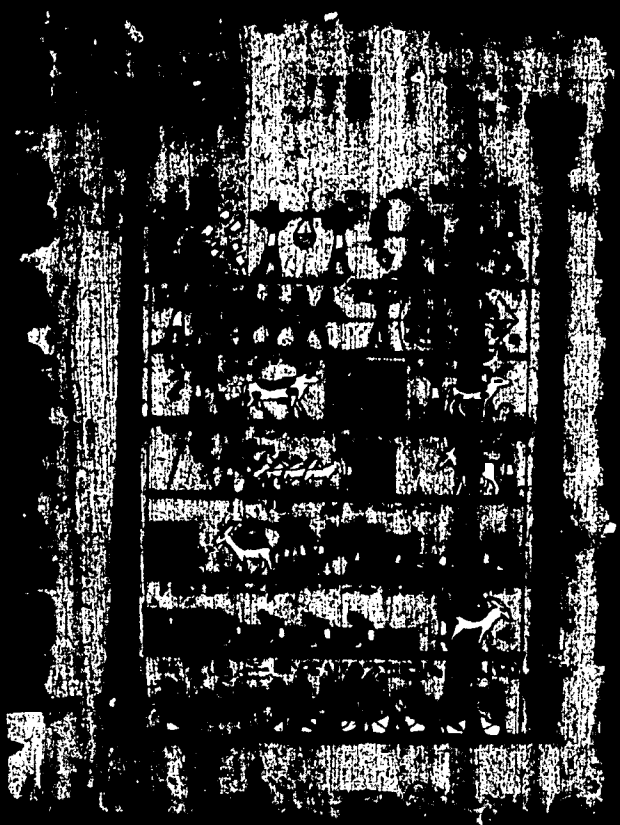
Applied Science and Technology



Applied Science and Technology

AN EGYPTIAN-AMERICAN COOPERATIVE PROGRAM

by

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NOTICE: The Applied Science and Technology Research Program in Egypt, which is the subject of this report, is a product of collaboration among the Academy of Scientific Research and Technology of Egypt, the National Research Centre in Cairo, and the following U.S. institutions: National Academy of Sciences/National Research Council, National Bureau of Standards, National Institutes of Health, National Science Foundation, the Catholic University of America, the Georgia Institute of Technology, and the University of Wisconsin-Madison.

The program came under the general oversight of a Joint Consultative Committee made up of five Egyptians and five Americans under the chairmanship of the President of the Academy of Scientific Research and Technology. The Joint Consultative Committee requested a final summary report. The report, however, is a product of the authors and does not necessarily represent the opinions of the Joint Consultative Committee or the participating institutions cited above. It was written to inform an interested audience of development specialists, administrators, and others concerned with the role of science and technology in socioeconomic development.

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PREFACE

The Applied Science and Technology Program was designed to reorient Egypt's science and technology community towards issues that have a positive impact on national development. Egypt's Academy of Scientific Research and Technology (ASRT) and National Research Centre were responsible for implementing the program. The United States Agency for International Development (USAID) provided financial support and participated in the overall management and follow-up of the program that extended from March 1977 to September 1986. More than 700 scientists and engineers from Egyptian R&D institutes participated in the activities, which took place in 14 governorates (administrative regions) of Egypt. U.S. organizations that provided assistance were the National Academy of Sciences/National Research Council (NAS/NRC), the National Science Foundation, the National Institutes of Health, the National Bureau of Standards, the University of Wisconsin-Madison, the Catholic University of America, and the Georgia Institute of Technology.

The authors wish to thank all the scientists involved, for it was they who helped the Applied Science and Technology Program achieve its objectives. Special thanks are due to Dr. M. Kamel, the President of the ASRT; Dr. I. Badran, Dr. H. Ismail, and Dr. A. Aboul Azm, former Presidents of ASRT; Dr. G. White, Chairman of the U.S. Panel of the Joint Consultative Committee (JCC), the binational oversight body for the program; Dr. H.G. Stever, former Chairman of the U.S. Panel; all Egyptian and U.S. members of the JCC; and Dr. M.B.E. Fayez, the Director of the National Research Centre. It is also appropriate to thank Drs. L. Packer and H. Weldes for their efforts as resident managers for the program.

The authors are grateful to the organizations and personnel that made this report possible: USAID, for providing support and for its coordinative efforts with ASRT; the NAS/NRC, for assisting with technical aspects of the training, consultancy, and documentation as well

as staff support; and the other U.S. institutions mentioned above for assisting projects related to S&T facilities development.

It is impossible to note all of the U.S. universities, research institutes, and scientific laboratories that collaborated with Egyptian scientists, but their assistance is most gratefully acknowledged. The editorial assistance of Mr. T. Winston, Mrs. M. Risdon, and Miss I. Martinez, and the major contribution of Miss F.R. Ruskin, who coordinated and prepared the manuscript for publication, are acknowledged with thanks. Special thanks are due to Mr. J. Riley, Dr. S. Arif, and Ms. C. Coleman of USAID, and Mr. A. Nasmith of NAS/NRC for their contributions to the program's management.

EXECUTIVE SUMMARY

The continuing development of any society must rely heavily on the contributions of its scientific and technological community. The availability of resources, the traditions of the society, and the nature and extent of external forces upon that society are also important; but without the scientific and technical capacity--as well as the parallel capability in managerial skills--the benefits of development will remain, at best, marginal.

Over the past 35 years, Egypt's scientific and technological community has grown significantly, and now comprises more than 50,000 professionally trained Egyptians and more than 150 research and development institutes. For a variety of reasons, however, there is serious underutilization of the R&D community and its resources in problem solving for agriculture, health, industry, and other key sectors of the economy.

The Applied Science and Technology Research Program, launched in 1977 and concluded in 1986, was a cooperative effort between the Government of Egypt, represented by the Academy of Scientific Research and Technology (ASRT), and the U.S. Government, represented by the U.S. Agency for International Development (USAID). The goals of the program were:

- To effect attitudinal and institutional changes in the S&T community, so that scientists and technologists could contribute more dynamically to problem-solving R&D
- To establish new links between R&D providers and users in agriculture, industry, and services
- To upgrade the facilities and equipment of Egyptian R&D institutions.

The program design included three main elements. The first was concerned with S&T policy planning and strengthening R&D program and project management. It focused on personnel performance and institutional

systems, and on formulating a draft national technology policy statement for Egypt that would promote indigenous socioeconomic development. The second element involved designing and implementing model, multidisciplinary, and, where possible, multi-institutional R&D activities directed at industrial applications and problems of agriculture, nutrition, and energy.

The third sought to strengthen S&T infrastructure in research institutions, including universities, by providing equipment, instrumentation, and facilities; by building an information system and network; and by promoting the wider adoption of international standards, measurements, and quality control methods in Egyptian industry.

This report is a case study of an Egyptian-U.S. partnership created to demonstrate that Egypt's S&T community could be more effectively utilized to solve critical problems of national development. Throughout the entire eight-year life of the Applied S&T Program, emphasis was placed on linking researchers and end users of research in agriculture, industry, and the service sector. The report is not intended to give the reader technical details of individual elements of the program. (Comprehensive individual reports are available on policy planning, specific R&D projects, field demonstration activities, and the S&T information network; many are cited in the reference section of this document.) Rather, it is designed to show to development planners, particularly in Egypt, the rationale for the inclusion of each element and to describe the program's achievements in the areas of personnel motivation, institutional change, and interdisciplinary cooperation.

The authors have set the context for the program by providing a historical summary of the evolution of S&T institutions in Egypt. The major participants are the ASRT and its affiliated National Research Centre (NRC). The concept of a "functional gap" between Egyptian S&T institutions and services is explained in an early section of the report along with a description of benefits that can be expected from the closing of this "gap."

The next section of the report highlights the objectives and program design of the Applied Science and Technology Research Program. The program management system is outlined to illustrate its multidisciplinary and multi-institutional approach. This management approach differs somewhat from past experiences of the ASRT and NRC. The experience was a mix of success and failure, and provides lessons for future program design.

Another section describes a variety of individual projects, again with a design-for-development approach rather than a strictly scientific or technical

presentation: collaboration with end users in food and nutrition; renewable energy (biogas technology for rural applications); land reclamation and water use technologies; use of natural resources (bentonite clays, phosphate ores, and fishery resources in the Red Sea); and services to industry that included corrosion monitoring in petroleum refining, wool scouring in textiles, and in local production of pharmaceutical chemicals for the Egyptian market. Other projects were designed to strengthen S&T information resources for research and industrial use, to enhance the local capability to maintain and repair scientific equipment, and to institute greater reliance upon quality control methods and international standards.

The program's achievements are cited. The criteria are not strictly cost versus benefits, because the goals of the program had to do with improving a process rather than generating a product. The outcomes sought were to effect attitudinal changes toward R&D, to incorporate users into all phases of the work, and to make R&D institutions more responsive to national development priorities. Examples of both "process" and "end-result" achievements are:

- R&D Management Fifty-eight senior administrators and researchers were initially given R&D management training opportunities in the United States. From this cadre came a Core Management Group (CMG) that has offered training in R&D management principles to more than 700 persons in the ASRT and its affiliated research institutes, and in universities and research institutions of the ministries. The CMG holds regular R&D management training sessions at the NRC and will schedule such training at other locations.

  The CMG provides management consultant and program evaluation services to other institutions. Seven of the 10 key positions in the NRC's new management structure are filled by individuals who were trained under the auspices of the program.

- Technology Policy The ASRT has taken the lead in mobilizing the nation's specialists from universities, ministries, and government and non-government agencies to collaborate in an ongoing process of national technology policy planning. A policy document was presented for consideration by a ministerial-level policy committee. The ASRT also assists the ministries of agriculture, irrigation, and industry in their policy analysis process and annual reviews.

- Demonstration and R&D Projects Three demonstration and 6 R&D projects involved more than 700 researchers from 11 Egyptian organizations. The largest project, More and Better Food (MBF), included more than 400 researchers and research assistants from 9 organizations and 11 specialties. The MBF project included 31 subsidiary projects, carried out in 7 governorates, over an area of 130,000 feddans (one feddan = 1.038 acres) owned by more than 90,000 farmers. The annual extra income from 3 crops (maize, peanuts, and tomatoes), grown in 5 governorates on an area of about 91,000 feddans, is estimated at LE 35 million--more than 175 percent of the overall expenditure on the Applied S&T Program.

- S&T Facilities Development Facilities support included supply of equipment, investments in training and support services, and improvement of standards, measurements, and quality control. Centers for maintenance and repair of scientific equipment were established and are functioning at the Scientific Instrumentation Centre (affiliated with the ASRT), the NRC, and 8 universities. A new national S&T Information (STI) network links the ministries of agriculture, health, industry, energy, and the National Information and Documentation Centre (also affiliated with the ASRT).

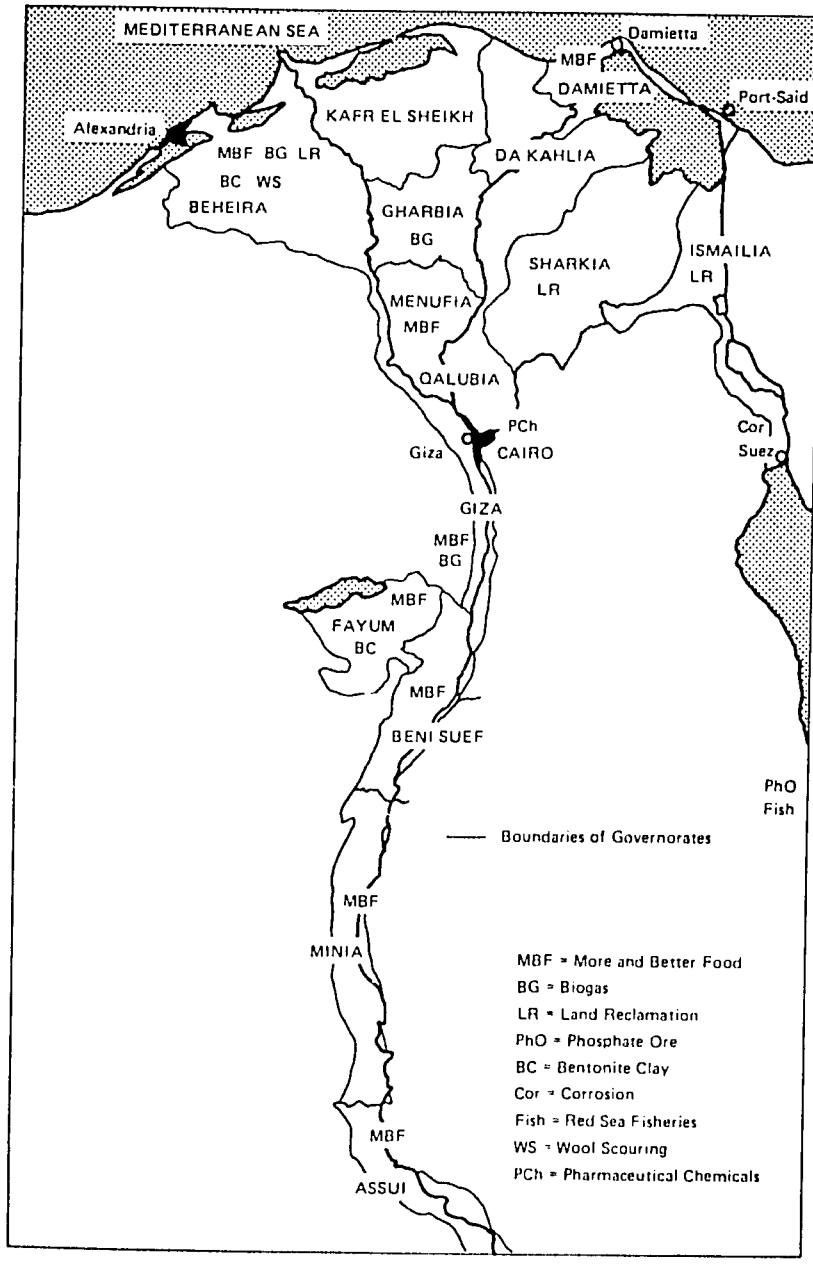
  Facilities development also required training --in the operation of the STI network and in maintenance and repair for scientific equipment. In STI, the core group of 12 were trained in the United States and more than 1,000 Egyptians were then given in-country training and orientation on modern information retrieval methods, systems, and resources. In maintenance and repair, 26 were trained in the United States and 220 in Egypt. Thus, the capacity to utilize, maintain, and repair the S&T facilities has been transferred to Egypt.

A final section deals with lessons learned from the Applied S&T Program. These may be summarized as follows:

- S&T for Egyptian national development can be effectively mobilized through the multidisciplinary team approach to problem solving.
- The socioeconomic aspects of the design and implementation of S&T for development are as important, if not more important, than the technical factors.

- Attention to R&D management skills at all project and program levels pays big dividends.
- There is a growing role for a modern, strong, and well-coordinated S&T information system in Egypt that is linked to worldwide networks.
- A comprehensive and versatile system for equipment maintenance and repair is an essential underpinning for science and technology.
- Solutions to problems in the agricultural and industrial sectors are best achieved when the end users and R&D institutes form strong active partnerships.
- S&T capacity building and problem solving can be complementary objectives of a single program.

Clearly, the Applied Science and Technology Research Project demonstrated the dynamic potential of the ASRT and NRC in addressing R&D directed toward solving national needs.



Sites of demonstration and R&D projects.

I

INTRODUCTION

As the twentieth century draws to a close, it becomes increasingly clear that the continuing development of any society must rely heavily on that society's scientific and technological community. The availability of resources, the traditions of the society, and the nature and extent of external forces upon that society are also influential; but without the scientific and technical capacity--as well as the parallel capability in managerial skills--the benefits of development will remain, at best, marginal.

Egypt is committed to development and is fortunate to have a large community of well-trained scientists and engineers who are eager to enhance the nation's scientific contribution to development. Unfortunately, this community has been on the periphery of the development process, although it recognizes the necessity to bridge the gap between academic research and its applications to agriculture, industry, health, and other sectors of the economy.

Institutional and individual research has contributed to development applications, but there nonetheless are serious constraints to achieving a more dynamic role for science and technology.[1-4] Institutions have not been oriented to systematic applications of research for social and economic development, and the S&T community too often concentrates on academic values and rewards. Moreover, motivation for applied S&T is often low because there are few incentives to encourage high-quality, problem-solving R&D. There are weak linkages between researchers and potential users of S&T, and cooperation is limited in the exchange of data and in joint or multidisciplinary research efforts. Further, Egyptian industry prefers to use foreign technology and R&D expertise.

Rigid administrative procedures in the public sector result in inefficiencies, and low salaries force civil servants to take second (and even third) jobs. Competent individuals often supplement their incomes with part-time

consulting, and there is a constant flow of trained persons to other Arab countries.

These constraints continue to hinder the effective participation of the Egyptian scientific and technological community in development. Yet the need for S&T increases: Egypt's population keeps growing, and there are limited opportunities for further major gains from the traditional sources of production. Egypt must therefore seek new directions for economic growth. The urgency of this situation is just being realized. There is still a widespread belief that the application of technology to current production problems is sufficient. However, it is equally important that S&T resources be used to develop new products that will stimulate economic growth.

This report summarizes a major program of the Academy of Scientific Research and Technology to motivate and reorient Egypt's scientific and technical institutions and personnel toward problem-solving R&D in agriculture, manufacturing, health, energy, and natural resource utilization. It was specifically designed by ASRT and AID to address some of the factors that constrain the application of science and technology to Egypt's development efforts:

- The management element was concerned with enhancement of personnel performance and of institutional systems in addressing national problems of production and services.
- Policy planning was directed toward the choice of national technologies for creating and adapting local skills and resources for socio-economic development.
- Demonstration and R&D project support sought wider use of multidisciplinary and multi-institutional approaches for high-priority problems in plant and animal productivity; child health and nutrition; renewable energy resources for rural application; and industrial problem solving in specific situations in production of textiles, clay minerals, and pharmaceuticals.
- The element of facilities development, or support services, was concerned with updating scientific equipment, instituting a modern system of S&T information retrieval and dissemination, strengthening metrology in industrial applications, and creating an enhanced capacity for the maintenance and repair of scientific equipment.

Although the Applied Science and Technology Research Program formally ends in September 1986, it is hoped that new activities will follow from the achievements described here.

II

SCIENCE AND TECHNOLOGY IN EGYPT

This chapter describes the human and institutional setting of the S&T system in Egypt with emphasis on the Academy of Scientific Research and Technology (ASRT). It also analyzes some of the strengths and weaknesses of that system in applying S&T to Egyptian development problems.

RESOURCES AND THE S&T SYSTEM

The Academy of Scientific Research and Technology is the principal body for national S&T policy planning programs, coordination, and mobilization of S&T resources. The ASRT's assessments of Egypt's scientific and technological resources are available in four Arabic language documents.[5-8]

S&T Manpower

In 1979, according to ASRT estimates, about 26,000 Egyptians were active in S&T research. Of the total, some 22,000 held doctoral and master's degrees from Egyptian and foreign universities. In addition, research institutes and universities employed about 8,700 skilled technicians.[6,8]

Those with D.Sc. and Ph.D. degrees--about half the total engaged in research--are classified as research professors, associate research professors, or researchers in research institutes; and as professors, associate professors, and teachers in universities. Those with M.Sc. degrees--36 percent of the total--are classified as teaching assistants in institutes and universities. Those holding B.Sc. degrees are appointed as research assistants. Technicians are graduates of technical schools (two years of education after high school).

According to 1979 data, about 84 percent of the scientific personnel were male and 16 percent were female.

The dominant field of effort was applied science, which accounted for 64 percent of the total; basic and social sciences accounted for about 18 percent each. Of the roughly 20,000 scientists working in the applied sciences, the principal disciplines were medicine and pharmacy, which accounted for 8,000 (40 percent); agriculture, for 6,000 (30 percent); and engineering, for nearly 3,000 (14 percent). At a lower level of representation, chemistry and chemical engineering accounted for about 1,400 (7 percent), statistics for 1,200 (6 percent), and industry and construction for about 400 each (2 percent each). Of the advanced degree candidates, mainly Ph.D., 26 percent received their degrees from foreign institutions. Forth-three percent of the foreign-trained graduates were educated in Western Europe, and 21 percent in the United States or Canada.

More recent records on S&T manpower are available for some sectors, notably manpower in agricultural research. Data for 1979-81,[9] given in Table 1, includes the institutional affiliations.

TABLE 1 Manpower in Agricultural Research

Affiliation	1979		1980		1981	
	Ph.D.	M.Sc.	Ph.D.	M.Sc.	Ph.D.	M.Sc.
Faculties of Agriculture	1,401	1,576	1,606	1,661	1,838	1,731
Faculties of Veterinary Medicine	262	257	318	253	377	312
Ministry of Agriculture	758	2,215	778	2,267	712	1,962
ASRT	197	229	213	232	250	260
Others	57	78	66	90	90	148
Total	2,675	4,355	2,981	4,503	3,267	4,413
Combined Total	7,030		7,484		7,680	

The Institutional Setting

Scientific and technical research takes place in more than 150 institutes and faculties affiliated with minis-

tries and the 13 Egyptian universities. Details (including the R&D manpower in each facility) are given in Table 2. About 60 percent of the manpower is attached to universities, the rest to scientific and technical institutes affiliated with ministries. Agricultural and medical research rank first, both in terms of the number of institutes and staff. The ASRT, with seven affiliated R&D institutes, employs about 8 percent of the national S&T manpower.

TABLE 2 Research Faculties, Institutes, and R&D Manpower

	Number of Faculties/ Institutes	Researchers		Technicians	
		No.	%	No.	%
Faculties					
Medicine	21	4,187	16	943	11
Science	13	3,633	14	703	8
Engineering	15	3,508	14	1,073	12
Agriculture	13	2,946	11	485	6
Pharmacology	6	685	3	188	2
Veterinary Medicine	4	506	2	72	1
Total	72	15,465	60	3,464	40
Ministries and ASRT					
Agriculture	15	4,167	16	1,370	16
ASRT	7	2,043	8	492	6
Industry	16	1,790	7	1,664	19
Health	14	1,000	4	582	7
Electricity & Energy	3	720	3	413	5
Planning	4	284	1	201	2
Construction	3	252	1	155	2
Irrigation	10	174	1	200	2
Transportation and Commerce	3	74	--	25	--
Culture	3	70	--	35	--
Manpower and Training	1	54	--	10	--
Tourism and Navigation	1	38	--	95	1
Total	80	10,666	40	5,242	60
Combined Total	152	26,131		8,706	

Note: Percentages are rounded.

The main institutions have been in place for at least 15 years. Historically, there were several significant developments. The first government-sponsored body for organizing scientific research was the National Research Council, established in 1948. It concentrated on completing the research "infrastructure" by establishing the laboratories of the National Research Centre (NRC), which began operations in 1955. The original council was replaced in 1956 by the Supreme Science Council, whose membership included a number of ministers and prominent scientists. With the help of many scientists, the Supreme Council drew up Egypt's first scientific research plan, which posed an ambitious agenda of research projects to be carried out, on a national basis, in the various scientific institutions.

In 1961, the council was superseded by the Ministry of Scientific Research.

In 1965, the Supreme Council of Scientific Research came into existence; it was abolished in 1968 and replaced once again by the Ministry of Scientific Research.(10)

In 1971, the ASRT was established. It remains the responsible body for S&T policy and planning in Egypt.

Academy of Scientific Research and Technology(11)

The ASRT has the following functions:

- To support scientific research directed towards solving problems of national priority
- To encourage the application of modern technology in national programs of socioeconomic development
- To formulate policies that ensure strong linkages between scientific and technological organizations in order to serve national development plans
- To participate in the study of the S&T aspects of major development projects
- To encourage basic research, develop human resources, and recommend establishment of new research institutes and centers of excellence
- To support scientific societies
- To develop international relations.

The organization of the ASRT is diagrammed below.

The President

The ASRT is headed by a president, appointed by presidential decree, who has the rank of minister. The

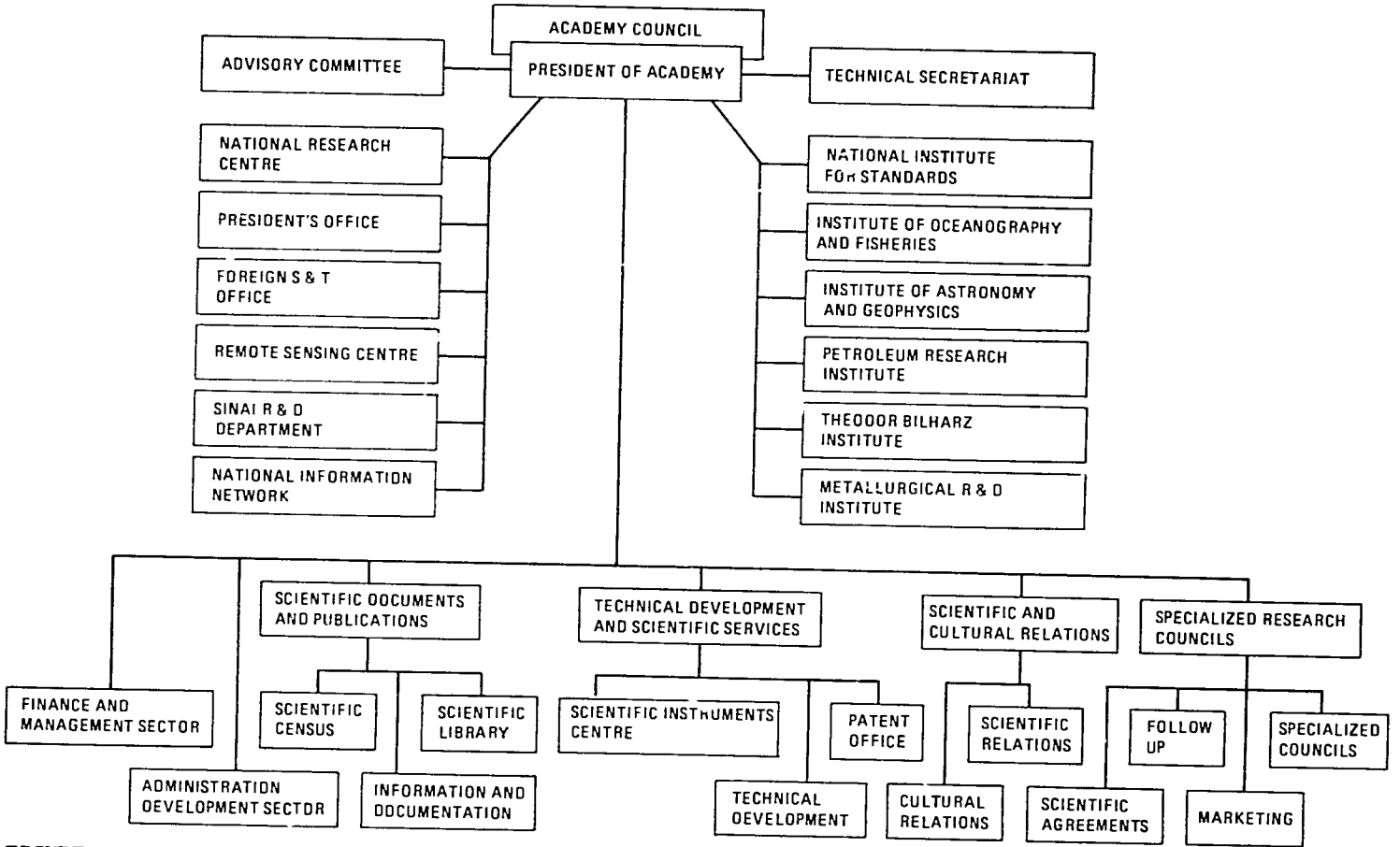


FIGURE 1 Organization chart: Academy of Scientific Research and Technology.

president serves as chairman of the ASRT council and is chief administrator of ASRT. The president's responsibilities include approval of the activities of the following institutes and centers: The National Research Centre, the Institute of Oceanography and Fisheries, National Institute of Standards, Institute of Oceanography and Geophysics, Petroleum Research Institute, Central Metallurgical Research and Development Institute, Scientific Instrumentation Centre, National Information and Documentation Centre, Remote Sensing Institute, Technology Development and Scientific Services Division, and The Foreign S&T Office.

The ASRT Council

As the policymaking body of the ASRT, the ASRT council sets policies that aim at mobilizing national S&T institutes in support of the priority problems of socioeconomic development. Its resolutions are based on recommendations submitted by the specialized research councils. It approves budgets and expenditure. It gives state awards and considers issues assigned to the council by the ministerial cabinet or ASRT's president.

The council is headed by ASRT's president. Its members include the presidents of national universities, the directors of NRC, the atomic energy establishment, and the National Research Centre for Sociological and Criminological Research, and the ASRT vice presidents and undersecretaries responsible for S&T. The president of the ASRT appoints 10 members selected on the basis of personal merit.

The Specialized Councils

Specialized councils are established to carry out ASRT functions in sectoral planning and coordinating of scientific research at the national level. In this endeavor, they can mobilize S&T manpower to serve national development priorities.

The ASRT has established 11 sectoral councils in the following fields of research: food and agriculture; industry; petroleum, energy, and mineral resources; medicine and drugs; transportation and communication; environment; construction and housing, new settlements; economics and administration; society and population; and basic sciences.

Each council encompasses a good representation of leading research workers, technologists, and users of research. The aim is to create interaction of interested

parties at a high level of planning and coordination. Each council includes a number of specialized committees, which make recommendations to the parent council.

The Five-Year S&T Plan

The ASRT's first Five-Year S&T Plan, for 1982-87, covers programs and projects that serve the national Five-Year Plan prepared by the government. A management system, also established by the ASRT, ensures the monitoring and evaluation of projects.

In 1981, as preparation for the plan, the ASRT council passed a resolution that assigns to the specialized councils the planning of programs to support the National Five-Year Plan (1982-87), prepared by the Ministry of Planning and approved by the Cabinet, the Peoples Assembly, and the President.

ASRT's technical secretariat summarized the eight documents of the national plan, emphasizing elements that required scientific and technical involvement. The summary was distributed to the 11 specialized councils, with a request that they come up with a plan of action, including priorities. Draft documents of a Five-Year S&T Plan were prepared and submitted to concerned ministries and sectors for comment and discussion. The final document was submitted to the President of the Republic, who supported the plan and approved the budget.

In December 1985, 152 ongoing projects had been approved by the ASRT, involving more than 1,500 scientists and technologists. About 75 percent came from the universities and ministries, in equal proportions, and the remaining 25 percent from the ASRT and its affiliated institutes.

The National Research Centre[12]

The National Research Centre is by far the largest R&D institute in Egypt, and the only multidisciplinary center that employs a full range of professional scientists (Figure 2). The NRC's manpower resources are shown in Table 3.

The NRC's 14 divisions are subdivided into 41 specialized laboratories. The organizational structure is diagrammed in Figure 3.

The NRC is governed by a board of directors headed by the director of the NRC. Other board members are the two assistant directors, the vice-president of the ASRT, and heads of the 14 divisions.

TABLE 3 NRC Manpower Resources (1980)

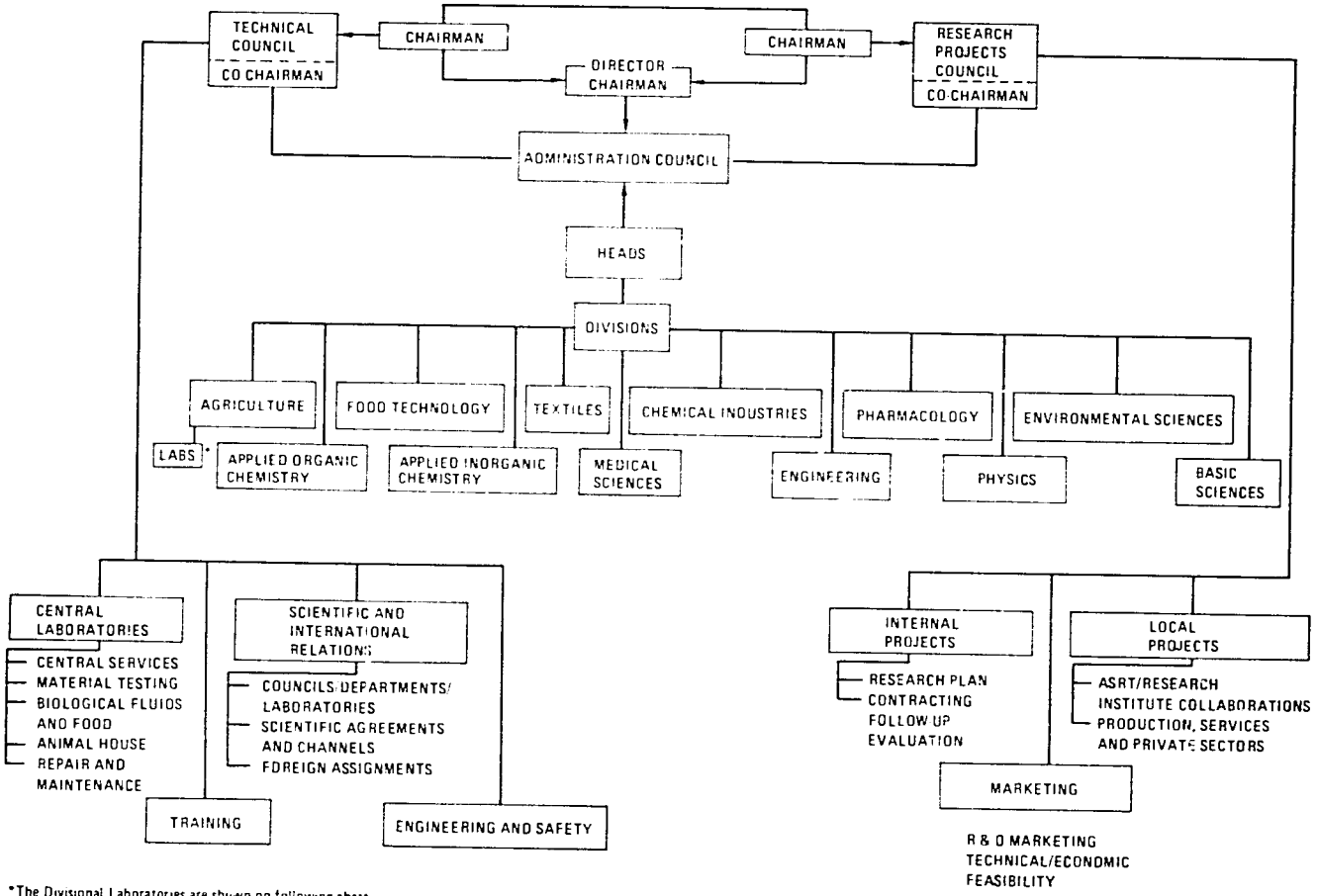
Post	Degree	Number
Research Professor	Ph.D.	160
Associate Research Professor	Ph.D.	225
Researcher	Ph.D.	318
Teaching Assistant	M.Sc.	321
Research Assistant	B.Sc.	369
Total Research Staff		1,393
Specialized Technician	Diploma	634
Assistant Technician	Diploma	347
		2,374
Administration & Management		1,102
Total NRC Manpower		3,476

The NRC started operating in 1955 and has since passed through three evolutionary stages. The initiation stage, extending to 1968, concentrated on basic sciences and staff development. The orientation stage, 1968-1973, was marked by a growing interaction with the production and services sectors. The customer-oriented research stage, 1973 to the present, features plans for research activity that serve the specific needs of end users. This latter stage required the establishment of specialized offices--in marketing, contracting, R&D management--and the development of managerial capabilities through training.

The Agricultural Research Centre(12)

The primary authority for agricultural research and extension belongs to the Agricultural Research Centre (ARC) in the Ministry of Agriculture (MOA). In addition, research of direct or indirect interest to agriculture is conducted within the Ministry of Irrigation, the ASRT, and the universities.

The ARC operates 13 research institutes, all located in Cairo. They cover the following areas: economics; mechanization; animal health, production, and reproduction; cotton, field crops and horticulture; plant pathology and protection; serums and vaccines; soils and water; and sugar. The staffs of these institutes include nearly



*The Divisional Laboratories are shown on following chart.

FIGURE 2 Organization of the National Research Centre.

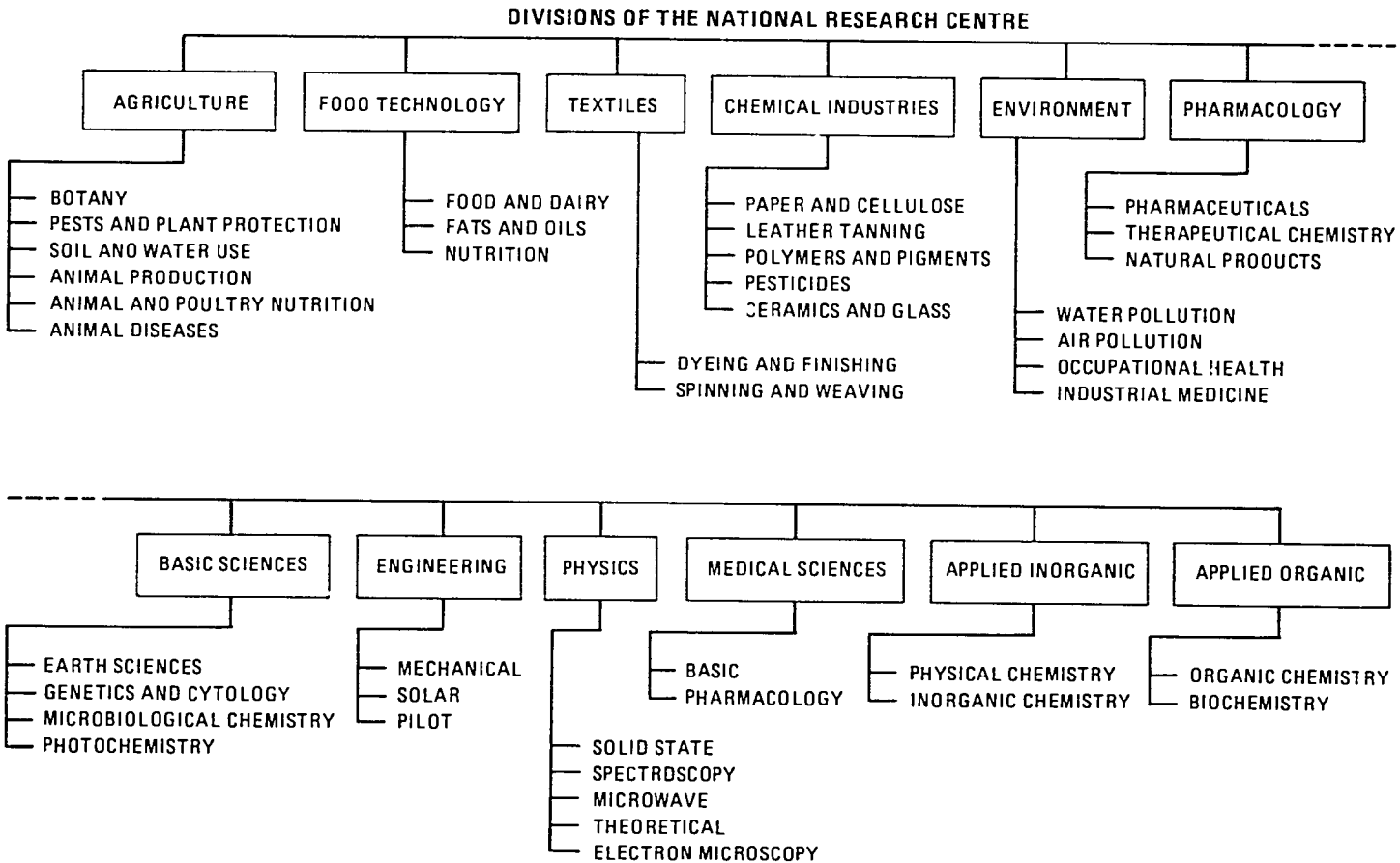


FIGURE 3 Organization of NRC Divisions and Laboratories.

400 Ph.D.s, more than 1,100 M.S.s, and nearly 1,300 B.S. graduates.

Thirty-one commodity-oriented research stations are located in various ecological and agricultural zones. Total staffing of these stations include 125 Ph.D.s, 361 M.S.s, and 236 B.S.s. Staff members belong to the various research institutes in Cairo. Strong liaison is maintained between the research stations and the institutes.

Health and Industrial Research

Health(13)

Science and technology in Egypt's health sector are supported by resources provided by numerous national and international sources. These resources are primarily channeled through the Ministry of Health (MOH) and the ASRT. Subsequently, funds are allocated for projects conducted by MOH, NRC, and universities.

The MOH conducts research mainly through 15 affiliated research institutes. They cover a broad range of health topics, including biological products and vaccines, epidemiology, vector control, drug control, environmental health, medical equipment, public health, nutrition, health statistics, diabetes, heart and chest surgery, polio, ophthalmology, and dentistry.

Industrial Research(14)

Eighty of 117 public sector industries in the Ministry of Industry (MOIND) have established R&D units, which deal primarily with daily operational problems rather than basic or applied R&D. In the private sector, industrial companies generally do not have the resources to fund R&D, other than routine technology adaptation.

The General Organization for Industrialization (GOFI) is a unit of the MOIND with a staff of 1,300. GOFI formulates policies and plans, collects industrial data, examines technologies and industrial opportunities, reviews licenses, carries out feasibility studies, studies investment applications, and follows up project implementation.

Sixteen other ministry assistance units and centres include facilities devoted to engineering and industrial design, chemistry organization, standards, metallurgy (two units), food (seven units), and textiles (three units).

The ASRT has active programs with local industries including: metallurgy (aluminum, steel), food, chemicals, pesticides, construction materials, and electrical supplies. The NRC and the Central Metallurgical Research and Development Institute, affiliated with ASRT, are involved with local industrial problems through contracts.

The universities, which are the major source of scientific and technical manpower, are currently strengthening their links with industry. The main linkage is via industry-related proposals funded by ASRT and the USAID's University Linkages Project.

THE FUNCTIONAL GAP(15)

The Government of Egypt has a strong interest in science. And Egypt's scientific leadership has a strong desire to enhance the scientific community's contribution to development. However, a functional gap has always existed between the research community and the needs of industry, agriculture, health, and other vital sectors of production and services. Although excellent examples of institutional and individual achievement can be cited, the overall system lacks the effective dynamism that could transfer the existing S&T potential into quantum jumps in socioeconomic development. The strengths and weaknesses of Egypt's S&T efforts are outlined below.

Strengths of Egyptian Science and Technology

The five key features of Egyptian S&T are:

- A sizable S&T community--There are more than 50,000 professionally trained Egyptians--a major resource for the adaptation and development of new technologies.

- Existing institutions--More than 150 research centers/institutes/faculties conduct S&T activities, and the facilities can absorb additional tasks.

- Motivated S&T personnel--Professional S&T personnel are generally open to change and are strongly motivated to have a positive impact on development.

- Fertile environment for research--Specific development needs and the existence of experienced scientists and technologists make Egypt a natural laboratory for the development of work on certain problem

areas, especially water management, schistosomiasis, cotton breeding, and textiles.

- Capacity to transfer technology--Egypt is a regional leader in S&T matters, and is thus in a position to transfer technology to other Arab and African countries.

Weaknesses of Egyptian Science and Technology

There are four major weaknesses of Egyptian S&T:

- Bureaucratic inadequacies--Many S&T institutions are not now capable of meeting future development requirements. Symptoms include low salaries, short working hours, lack of productivity, and lack of management services. A more basic problem is that organizational policies constrain managerial flexibility and discourage delegation of authority.

- Inadequate S&T linkages--Future development challenges may not be met because of the lack of coordination between R&D institutes, and between them and the user community.

- Lack of basic support services--S&T efforts are hampered by inadequate scientific supplies, equipment, pilot facilities, data bases, libraries, and S&T literature--in part due to financial constraints on acquiring such materials.

- Lack of self-sufficiency--There is a continuing tendency to rely on imported technology and expertise.

Interaction Between Doer and User(1)

If Egypt is to be more effectively committed to development, stronger links are needed between S&T doers and users. The demand for R&D from the productive and service sectors needs stimulation. Problem solving in the Egyptian S&T community requires further motivation and strengthening.

Stronger linkages between the user and the S&T community are critical to these objectives. Such linkages would sharpen the focus of S&T work on problems, improve the formulation of tasks by both users and researchers, and more clearly identify the technical gaps in Egypt's S&T establishment that must be bridged. An efficient and dynamic management system for S&T functions is also a basic requirement.

Potential Research Users

An analytical approach to the community of potential research users in Egypt provides useful groupings for R&D planning--both to improve the utility of end uses and the efficiency of R&D marketing. Three major groups of users can be identified:

- Initial users are those in research who interact with each other and with other users (see below) to identify the problem, design a research program, and carry it to completion. The initial user's aim is to meet specified needs and wants of target markets.

- Intermediate users are those who adopt the new knowledge, develop it further, and put it to work.

- Final users (ultimate end users) are those whose lives and socioeconomic welfare are affected by the impact of the new knowledge.

The three types of intermediate users need an appropriate approach that meets their particular requirements:

- The commercial user includes organizations willing to finance a research project on a contractual basis, assuming cost effectiveness. This user is seeking to improve his product(s), develop new products, investigate raw material inputs, or overcome managerial problems.

- The potential-investor user responds to economic opportunities that have been identified ' research. The research problem does not originate with these users, and they enter the picture only after a solution is in sight.

- The public-domain user includes individuals and organizations that use knowledge developed deliberately for exploitation within or by the public domain. Most agricultural research is in this category.

In considering these different types of users, several features of Egypt's S&T effort are relevant. First, more than 75 percent of the research carried out by S&T organizations is applied research. This percentage reaches 90 percent or more for the NRC, ASRT, and the Agriculture Research Centre. While university research is devoted mainly to the basic sciences, the past decade has witnessed major involvement by universities in

applied research projects financed by local (ASRT, MOA) or foreign sources (USAID's University Linkages Program).

Second, despite the emphasis on applied research, only a very small percentage of the output finds its way to real use. The major defect is the lack of participation by a client in the research process--problem identification, research design, and finance. The researcher, therefore, can only hope that his research will have meaningful results. In response to this defect, some Egyptian institutes have begun to realize the importance of R&D marketing as a means of tailoring professional services to specific clients and benefactors. But the best advertisement for well-planned research is success.

The value of realistic planning is emphasized by a recent assessment of 120 research projects financed by the ASRT in 1974-75, in agriculture, industry, health, housing, and remote sensing. Of these projects, having a total budget of LE 4 million, it was found that five projects alone gave a real return of LE 10 million, as estimated by the users.(16) The successful projects involved fish farming, combatting cotton boll worms using natural enemies, metallurgy, the use of natural clay in brick manufacture, and a remote sensing project in the Suez Canal Zone. Another example of successful targeting was the collaborative research management system devised by the metallurgy research institute and industry, which led to a major sharing of research finance and a high degree of coordination between research and local metallurgical industrial firms.

Third, among the different types of intermediate user, the potential investor hardly exists, since Egypt does not have a strong private sector. The public-domain user depends on Egypt's research budget, which does not exceed one percent of the gross national product. This is low by world standards, especially in the early stages of developmental research.

Finally, in many cases, R&D projects require a multidisciplinary approach. The majority of the institutes in Egypt lack experience in designing and managing this kind of project. Also, Egyptian institutes dealing with related areas of research but belonging to different sectors do not cooperate in joint programs. As Table 4 shows, there are 46 institutes, affiliated with 6 agencies, that deal with problems of food, agriculture, and nutrition.

TABLE 4 Egyptian Agencies and Institutes Engaged in Food, Agriculture, and Nutrition

Responsible Agency	Affiliated R&D Institutes
Ministry of riculture	15
Universities	13
Ministry of Irrigation	10
Ministry of Industry	5
Academy of Scientific Research and Technology	2
Ministry of Health	1
Total	46

III

MANAGEMENT OF THE COOPERATIVE PROGRAM

This chapter presents an overview of the three major elements of the Applied Science and Technology Research Program emphasizing the system created by the Academy of Scientific Research and Technology (ASRT) for program management.

OBJECTIVES

The Applied Science and Technology Program, begun in 1977, has been a cooperative effort between the Government of Egypt, represented by ASRT, and the U.S. Government, represented by the U.S. Agency for International Development (USAID). The program addressed three major issues:

- The marginal impact of the scientific and technical community on the socioeconomic development of Egypt
- The lack of coordination between S&T institutes, and between them and the production and service sectors
- The need to support S&T facilities (managerially and technically) and to direct S&T resources towards national development priorities.

The ultimate goals were: (1) to bring about attitudinal and institutional changes, so as to engage scientists and technologists in problem-solving R&D; (2) to establish new links between R&D institutes and user groups in agriculture, industry, and service sectors; and (3) to upgrade the facilities of R&D institutes.

Phase I (1977-80) and Phase II (1980-86) had an overall budget of $24.1 million. The funding was distributed

among four major items: equipment and supplies, 59 percent; consultancies, 18 percent; training, 15 percent; and salaries and services, 9 percent.

PROGRAM DESIGN

The programs were geared to specific objectives that would fulfill the ultimate goals of the Applied S&T Program. Projects and activities were selected as vehicles that would facilitate and demonstrate the impact of S&T on socioeconomic development. The three principal elements of the program design are outlined below.

R&D Management and Policy Planning

This element had two major objectives: (1) to develop personnel performance and institutional systems that would respond effectively to national problems of production and services, and (2) to develop a national technology policy that would promote Egypt's capability to adapt and develop appropriate technologies and thus minimize reliance on imports.

Demonstration Programs and R&D Projects

This element was aimed at designing and implementing multidisciplinary programs and projects selected according to five criteria: (1) priority in terms of national needs; (2) participation of end users; (3) simple, inexpensive, and appropriate technologies; (4) modern methods of management; and (5) demonstration of the S&T potential. The demonstration and R&D projects related to food, energy, land reclamation, natural resource utilization and industrial applications.

Facilities Development

This element aimed at providing facilities for equipment and institutionalizing the maintenance and repair function in R&D institutes; establishing an S&T information system network to support the R&D role in development; and supporting standards, measurements, and quality control in S&T institutes and industry.

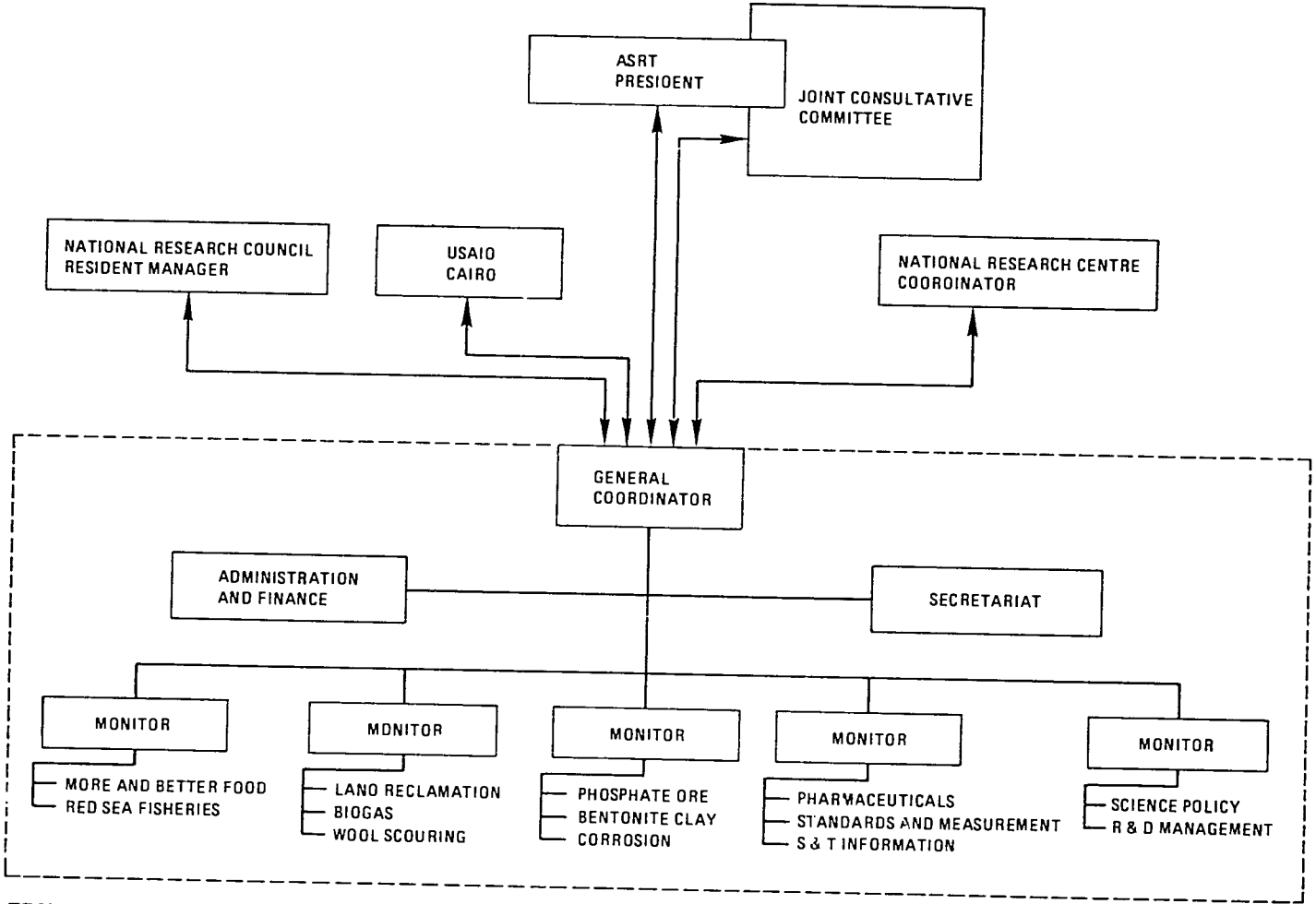


FIGURE 4 Management of Applied Science and Technology Program.

THE MANAGEMENT SYSTEM

The system for managing the Applied S&T Program is illustrated below. A general program coordinator, appointed by ASRT's president, was charged with supervising staff headed by program monitors. A binational Joint Consultative Committee served in an advisory role to the president.

The Joint Consultative Committee

The Joint Consultative Committee (JCC), whose role was to advise the ASRT president, had five members from Egypt and five from the United States, and was chaired by the ASRT president. The Egyptian members were scientists, engineers, or economists who had served at the highest level of the political system. For example, the Egyptian side included, at various times, a former prime minister, two former ministers of planning, and former ministers of agriculture, health, and higher education. All the American members had served on national advisory commissions and boards of the U.S. National Research Council and were thoroughly familiar with S&T planning, policy, and program evaluation and research assessment at the national level. One American member had served as a presidential science advisor and another was president of a major university; all had extensive experience in research management at the university, state, or national levels, or in industry.

The JCC held semiannual meetings, alternately in Cairo and Washington, for two or three days. The Cairo meetings were generally supplemented with field visits.

The JCC advised the ASRT president on program policy and planning and on policy questions relating to the role of S&T in Egyptian development. It helped the president establish criteria consistent with overall program policies and goals, it advised on project selection and follow-up achievements, and it recommended future courses of action.

Program Coordination and Monitoring Office

The Program Coordination and Monitoring Office is attached to the Office of the ASRT President. The office acts as the technical secretariat for the JCC. It monitors progress and performance of projects and facilitates links with end users; it studies project achievements and prepares progress, financial, and administrative reports on the overall program and evaluates the usefulness of

results to the potential users; and it coordinates and communicates information to and from the ASRT president, JCC, USAID, NAS/NRC and other United States contractors, steering committees, principal investigators, and the Ministry of Investment and Foreign Cooperation (MOIFC).

The General Program Coordinator

The general program coordinator serves ex-officio from his post as executive director of foreign S&T programs in the ASRT. He is the link between the ASRT programs and foreign agencies. His responsibilities include overall management, control, and coordination of activities. He develops comprehensive policies and plans to accomplish the objectives recommended by the JCC and approved by ASRT's president, and to that end establishes guidelines, procedures, and regulations. He projects budgets and prepares the biannual administrative report to the JCC, the biannual achievement and impact report to the MOIFC, and the quarterly report to the ASRT president; and he recommends incentives and honoraria to ASRT's president. He also serves on project steering committees.

The Program Monitors

The program monitors, appointed by the ASRT president, maintain a continuous follow-up of projects or programs to assess progress and to provide whatever assistance is needed, but they do not interfere with the responsibility of the implementing agency. The monitors hold doctoral degrees in science, and have special training in R&D management. They serve as members of the steering committees of demonstration programs, and take a special interest in the dissemination and utilization of the results by potential users. The monitors also assist and follow up on report preparation, training, budget, and finance.

Steering Committees and Program Managers

After demonstration programs and R&D projects were selected on the basis of proposals submitted to the ASRT, the Program Coordination and Management Office and project leaders put the proposal into final form for review and acceptance by the JCC.

The parent institution, depending on the size of the activity, assigned the management function to a steering

committee, a program manager, or a principal investigator. Management was responsible for follow-up on technical matters. The ultimate goal was an expanded market for the services offered by the responsible organization and for the products of R&D.

U.S. Organizations

The USAID provided financial support for the Applied Science and Technology Program and participated in the overall responsibility for program management and follow-up under USAID contracts. Other U.S. organizations provided assistance to particular aspects of the cooperative program.

The National Academy of Sciences/National Research Council (NAS/NRC) participated in policy planning, technical assistance for training, providing advisors and consultants, staff support for the JCC, documentation, and other services linking the scientific and technical participants from Egypt with those in the United States and in other appropriate countries. The NAS/NRC resident manager in Cairo coordinated all these activities with the ASRT Program Coordination and Monitoring Office.

The University of Wisconsin-Madison and the National Institutes of Health assisted with equipment purchases and development of an institutional capacity for maintenance and repair of equipment.

The National Science Foundation, Georgia Institute of Technology, and Catholic University collaborated in the establishment of a National Scientific and Technical Information System Network.

The National Bureau of Standards provided assistance to Egyptian institutions in its specialties--standards, measurements, and quality control.

IV

PROJECTS

This chapter describes each of the projects undertaken in the Applied Science and Technology Program under the three major categories of management and policy, demonstration and R&D activities, and facilities (or support systems) development.

MANAGEMENT AND POLICY

R&D Management[17,18]

It was clear at the outset that the Applied S&T Program would require proper R&D management. In turn, it was expected that good management would lead to improved personnel performance and much-needed institutional changes.

The R&D management project encompassed four elements:

1. Training for senior Academy for Scientific Research and Technology (ASRT) and National Research Centre (NRC) personnel in principles of R&D management
2. The institutionalization of management training within Egyptian institutions
3. The application of management practices to R&D projects
4. The development of a management system in the ASRT and affiliated institutes.

Fifty-eight selected Egyptian personnel were sent to the United States for eight workshops, each lasting three weeks, at institutes and universities. The subjects covered R&D management and marketing, technical/economic assessment, technology-based innovation, and contracts management. In Egypt, Egyptian trainers conducted 21 workshops of 1 to 3 weeks each, attended by over 700 personnel from more than 40 public and private agencies.

Under the project, NRC's organization and operation systems were analyzed. A management system for the ASRT's Five-Year S&T Plan was developed. Two model systems were established: one was for management of multidisciplinary, multi-institutional projects in the NRC, the other was the program coordination mechanism in the ASRT. A core group of R&D management specialists was set up in the NRC and ASRT to coordinate and organize activities and to provide training in R&D management. Also, a mechanism for providing R&D management services to other government agencies was created.

National Technology Policy[2,19-21]

At the invitation of the Egyptian Government, a team of U.S. specialists, led by Dr. Princeton Lyman from the Department of State, visited Egypt in April 1980 to review U.S. cooperation with Egypt in S&T. The team emphasized the importance of technology policy analysis and planning within the ASRT, so as to link S&T resources with national planning bodies. The creation of the National Technology Policy Project was catalyzed by this visit.

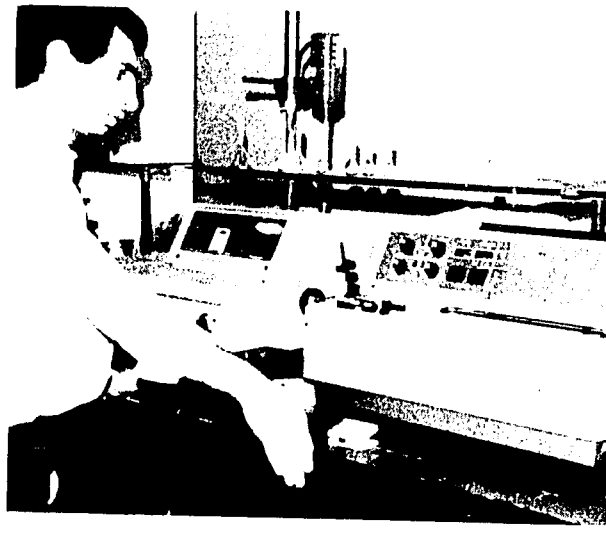
The scope of the project was as follows:

- To mobilize S&T manpower, independent of sectoral affiliation
- To carry out thorough analyses
- To provide policy guidelines at the ministry, industry, or farm level
- To draft a national S&T policy statement for Egypt.

A main element of the project was the establishment of an S&T policy committee within the ASRT. The purpose was to develop a methodology for carrying out an evaluation of the status of technology in Egypt and of the potential impact of S&T resources, and to devise a program that would lead to a national document on technology policies. A three-year program (1981-1983) was developed, and three seminars were organized to discuss issues raised. More than 700 S&T personnel were involved. A technology policy document was completed and submitted to a cabinet council for review.

The content of the three seminars reflected the concern that led to the technology policy project being included in the Applied S&T Program.

FIGURE 5 As elements of the More and Better Food Project, tomatoes are grown on wires at a farm in Omar Makram, Beheira (left); research equipment is used at the MBF laboratory, Cairo (below).



DEMONSTRATION AND R&D

The More and Better Food Project[12]

The More and Better Food Project (MBF) arose from the nationwide recognition that food production had to be increased to meet an ever-growing demand. Egypt has arable land of only about 6 million acres, which is equivalent to about 11 million acres using crop rotation. The total population is about 48 million, with an annual increase of about 2.9 percent; per capita consumption is increasing, and the government subsidizes food prices. With a severe limitation on cultivable area, the gap between production and consumption is widening. The value of food imports grew from $150 million in 1960 to $184 million in 1970, then by 1980, escalated to $1.9 billion.

The MBF's activities included: fostering the use of appropriate practices and simple, inexpensive technologies to increase agricultural productivity; developing an effective interaction between the Egyptian scientist and the farmer; strengthening the managerial capability of the NRC to deal with multidisciplinary, multi-institutional programs; and studying the impact of increased productivity on the nutritional, health, and socioeconomic status of the target population.

A steering committee was established to manage the food program. Three villages were selected for field trials: one represented a traditional Nile Valley village (Kafr Al-Khadra, Menufia Governorate), the second, new settlements (Omar Makram, Tahrir Province), and the third was chosen because of its proximity to the central government (Beni-Magdoul, Giza Governorate). Collection of baseline data was followed by preparation and implementation of more than 30 food projects in the 3 villages.

Some MBF projects were aimed at plant and animal production, others at health and nutrition. Plant production projects were directed at increasing productivity of peanuts, maize, wheat, onions, cucumbers, tomatoes, grapes, and mangoes; at improving soil fertility and insect and weed control; and increasing family income through activities such as silkworm raising and beekeeping. Animal production projects addressed poultry production, dairy production, animal health and productivity, and the raising of rabbits. Health and nutrition projects included the study of nutrition and health among young children (1-12 years), child growth patterns, child anemia, and the testing of food programs for preschool and school-age children.

Several R&D projects were carried out in collaboration with local food industries: improvement of the refining process for cottonseed oil; introduction of a process for making soft cheese from powdered milk; production of a highly nutritious cake made from local products for school lunch programs; and the formulation and production of prototype nutritious beverages from local products.

The food program was expanded to cover seven governorates--Menufia, Beheira, Giza, El-Fayum, Beni Souef, El-Menia, and Assuit. The total area exceeded 130,000 acres, owned by more than 90,000 farmers. Several national campaigns were based on MBF demonstrations, including one on maize, one on peanuts, and another on school lunches.

Biogas[22]

The biogas project resulted from a growing interest by the NRC in directing its efforts towards integrated rural development. The project sought to demonstrate the technical feasibility, social acceptability, and economic viability of biogas applications in rural areas, and to lay the foundation for wider implementation on a national scale.

Its scope encompassed surveys and analysis of the factors involved in biogas production and use; field demonstrations, including evaluation of digestor designs and selection of appropriate, inexpensive, socially viable types; and research and development, including scientific, technical, engineering, and socioeconomic aspects.

The project was conducted by a team of natural and social scientists and engineers, and included an advisory panel from the United States. The team reviewed the worldwide status of biogas technology, and fact-finding visits were made to China, India, Thailand, the Philippines, and Brazil. Following a socioeconomic survey, three Egyptian villages were selected to participate in the project: Al-Manawat (traditional), Omar Makram (new settlement), and Shubra Kass (poultry-growing area). Laboratory and pilot work tested such variables as digestibility of wastes, gas formation rates, toxicity, pathogens, and effective use of digester effluent. Then came the engineering and development work--design, construction, testing and operation of prototype digesters, and development of gas devices for household and other use. Finally, an international conference was held on the State of the Art on Biogas Technology, Transfer, and Diffusion, in Cairo, November 1984. The conference was attended by more than 135 scientists from 38 countries.

Land Reclamation[23]

Of Egypt's total area of 1 million square kilometers, only a very small portion is cultivable. The increase in population and the limitations of "vertical" expansion--increases in yield--make "horizontal" expansion of agricultural land a social and economic necessity. Therefore, a more explicit understanding of the economic, technical, and social aspects of land reclamation is an S&T priority.

The land reclamation program is an ongoing, major element of ASRT's Five-Year S&T Plan. It has received funds from the Egyptian Government (LE 385,000) as well as from the Applied S&T Program ($136,000). The latter amount financed analytical and field equipment, vehicles, and technical assistance. The program is managed by the Water Distribution and Irrigation System Research Institute, attached to the Ministry of Irrigation.

The basic objective is to collect and interpret data from operating land reclamation projects. The data include vital cost figures for establishing various irrigation systems on specific sites, for operations and system maintenance, for energy, and for production and marketing aspects--cropping patterns, rotation, agricultural practices, yields, soil types. Also of interest are the stated goals of the government in settling the farmers in the new land, perceptions of farmers regarding the land reclamation, and the goals of the farmers themselves in settling on the new land.

The project began in May 1984, and is scheduled to end by 1988. The project began with a design phase, the selection of staff and field sites, and the determination of measurement and study criteria. Three sites were selected to represent a spectrum of technical and socioeconomic variables:

- Salhia Project: a large-scale sprinkler and drip irrigation scheme operated by a state-owned company

- El-Nubariya Project: surface, sprinkler, and drip irrigation, on sandy and calcareous soils, involving state-owned and private companies

- Inshass Site: a research station owned by the Ministry of Agriculture, offering facilities to test surface, drip, and sprinkler systems.

A U.S. consultant collaborated in the planning of socioeconomic aspects of the evaluation. Six staff scientists were sent to the United States on special fact-finding missions.

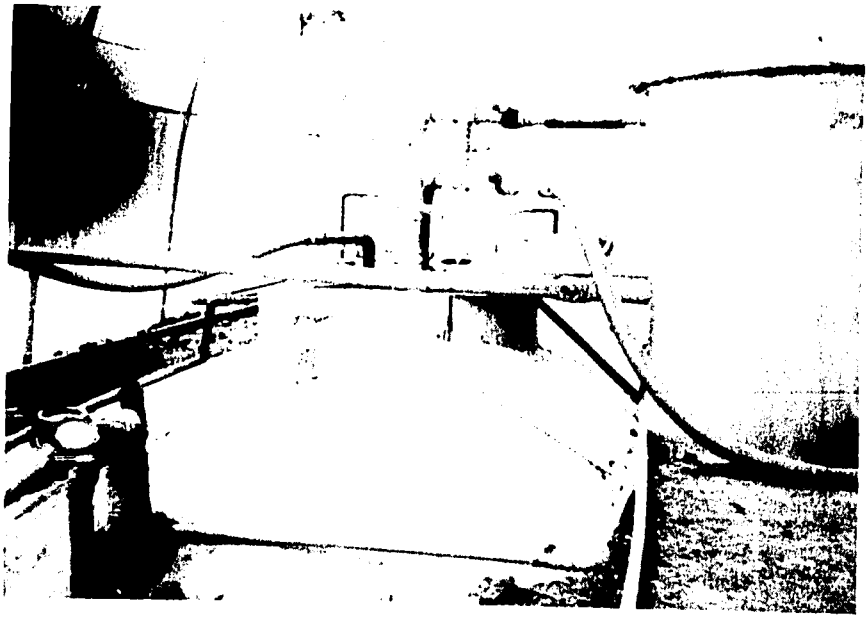


FIGURE 6 Biogas technology supplied energy to a poultry farm in Shubra Kass, Gharbia. Equipment in plastic tent (top) includes a column for freeing gas of H_2S. An electricity generator is powered by the biogas (bottom).

Phosphate Ore[24]

Egypt's supply of high-quality phosphate ores is being depleted. Large reserves of low-grade ores remain, but with types and forms of impurities that are not easily removed. The phosphate ore evaluation project was initiated in 1978 by the Ore Beneficiation and Chemical Processing Laboratory of the Central Metallurgical Research and Development Institute (CMRDI), in collaboration with the Egyptian phosphate industry. The goals were to evaluate the characteristics of the phosphate ore reserves; to study technical and economic problems in converting the ores to fertilizer end-products; and to develop the facilities and problem-solving capabilities of CMRDI and expand its services to the fertilizer industry.

The project covered pilot plant studies of ore beneficiation, and development of production flow sheets; laboratory and pilot studies of chemical conversion of ore to phosphoric acid and to phosphate fertilizer end products, and development of production flow sheets; technical/economic evaluation of these processes; and agronomic studies of the produced products.

Under the project, CMRDI assembled a team of chemists and chemical engineers with appropriate experience in the phosphate industry. Facilities were improved with the supply and operation of new laboratory and pilot plant equipment. The evaluation work centered on the Nile Valley (Al-Sabalya) and Western Desert (Abu Tartur).

Bentonite Clays

The project started in 1981 with CMRDI as the implementation agency. The goal was to evaluate local bentonite clays and to study the technical and economic factors involved in meeting local industrial needs and saving on foreign exchange.

Bentonite clays have the useful property of absorbing water to many times their own weight and becoming nearly impervious to further passage of liquids. This property is especially useful in soil conditioning for land reclamation, to maintain moisture in sandy soils destined for agriculture. Bentonites are also used in quantity to stabilize soils during construction, to serve as binders in metal casting, to decolorize vegetable and mineral oils, to permit deep drilling in oil exploration, and to serve as carriers for catalysts in chemical processing and in other industrial processes.

The use of bentonites as soil conditioners or stabilizers is a high-volume application. Clays can be used

with little or no treatment, though removal of waste materials and maintenance of quality standards are essential for consumer acceptance. Thus, it is important to develop the technical and analytical capabilities to monitor and assure quality control (see Figure 7).

The other uses of bentonites are low volume applications with high unit prices. Egypt imports these specialized bentonite products at an annual cost of $15-20 million.

Under the project, a mineralogical evaluation has been undertaken of the bentonite deposits of Qasr El-Sagha (El-Fayum) and the Cairo-Alexandria desert road. Beneficiation trials have been carried out, and flow sheets of an economically feasible process are being developed. Trials have also been made of acid activation of bentonites and testing as bleaching clays; and of alkali activation of beneficiated bentonites and testing for metal casting, as a foundry binder, and as a drilling stabilizer.

The economic feasibility of activating bentonite deposits has also been assessed. A team of Egyptian chemists and chemical engineers received training in the techniques being used.

Red Sea Fisheries

In spite of high potential fishery resources--the River Nile, Mediterranean, Red Sea, Northern Delta Lakes, and inland lakes--Egypt's per capita fish consumption is in the range of 4-5 kg/year, compared with the world average of 9.5 kg.

Furthermore, the catch from the Red Sea averages only 8 percent of Egypt's total fisheries production. Before the Red Sea fisheries could be considered for inclusion in Egypt's economic development plan, studies of the resource base and sustainability of catch were needed to determine the potential commercial value. To address this development issue, the Egyptian Institute of Oceanography and Fishes undertook a study to: assess the present fisheries potential, improve the understanding of the region's biological productivity, determine the inputs required to expand commercial fishing, and develop a plan for further studies of commercial exploitation. Collection of statistics on fish species focused on open-sea (pelagic) fish, reef fish, spiny lobsters, and deep-water shrimp.

The geographical area being considered for exploitation is the Foul Bay near the Egyptian-Sudanese border. A work plan was designed to include studies of the bay's physical and oceanographic features, a socioeconomic

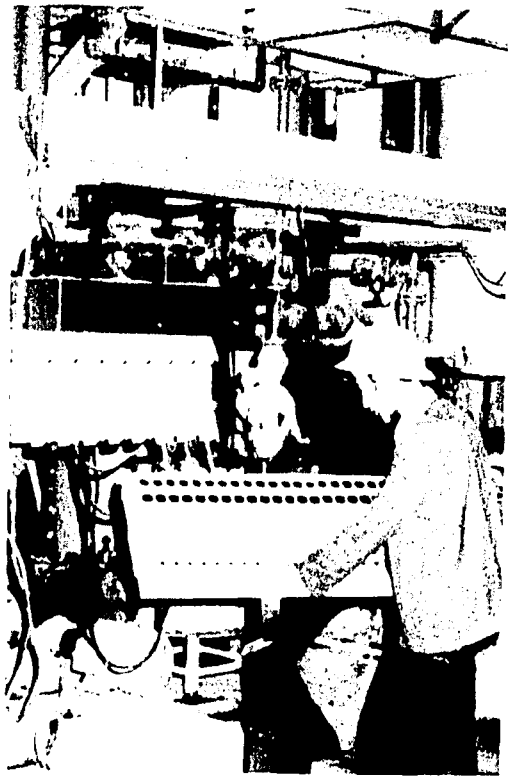


FIGURE 7 The increasing size of citrus trees (top) demonstrates the benefit of applying bentonite clay to sandy soils. A pilot processing unit was installed at El-Tebbin (bottom).

profile of the population, and the fishery resource, including infrastructure. Problems of creating a long-term sustainable fisheries program, including marketing, are being assessed.

Corrosion[25]

To illustrate corrosion's destructiveness, the U.S. National Bureau of Standards recently estimated that 40 percent of U.S. steel consumption goes directly for replacement of steel destroyed by corrosion. This represents about $70 billion annually, or 4 percent of the Gross National Product. In 1982, a CMRDI-MOI study estimated Egypt's annual loss from corrosion to be LE 500 million, also about 4 percent of GNP.

The corrosion R&D project was developed in the NRC/Cairo Laboratory of Electrochemistry and Corrosion with the basic goals of establishing a modern corrosion research laboratory, and evaluating corrosion problems in the Egyptian context. Highly sensitive and accurate equipment for measuring surface phenomena, to be used for fundamental research on corrosion, has been installed at the NRC laboratory. A team of specialists, capable of offering services to Egyptian industry on corrosion problems, has been trained under the project.

As a demonstration, the team is evaluating corrosion problems at the Suez Oil Refinery and recommending methods to help reduce their costs. Another study is being made in the Egyptian steel industry to improve corrosion control methods. Also, a series of corrosion inhibitors, made from locally produced materials, are being tested.

Wool Scouring and Wax Recovery[26]

The wool project involves the typical kind of research activity that is brought by industrial clients to an R&D laboratory. In this case, the client is the Misr Beida Dyers Company, Kafr Al-Dawar, which scours, cards, and strands imported raw wool into tops (thick, untwisted wool fibers used for spinning yarns) for sale to textile firms. The firm's value added is in the range of LE 5-7 million per year. It is the only Egyptian company engaged in this activity.

The company was experiencing a set of problems that it recognized as being amenable to solution via R&D. Misr Beida Dyers' technical and management leadership, together with qualified personnel from NRC/Cairo Textiles Research Laboratory, defined the R&D goals as improving

the economic efficiency of wool scouring by reducing the consumption of process heat, water, and chemicals; improving the quality of wool tops; recovering high-quality wool wax byproducts for local and export markets; and reducing process wastes by removing the pollutants before the wash water is discharged to the environment.

Started in April 1979, the project plan included three stages: (1) process system analysis in the factory, a literature search and technical reporting, and visits to international processors; (2) studies of operation variables and development of an operations flow sheet; and (3) establishing a wool scouring/wool wax recovery unit on site, with full scale testing and study of economic feasibility.

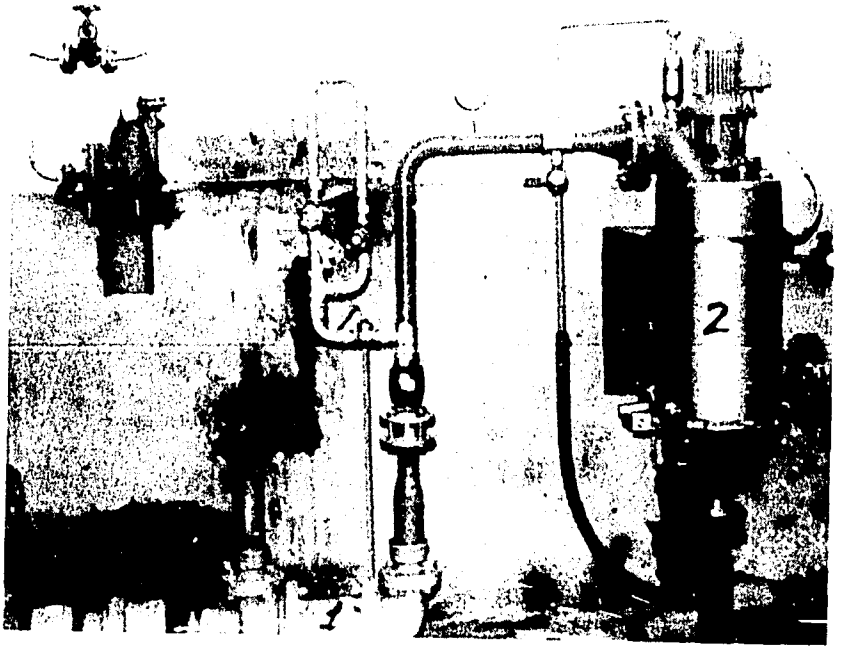
Pharmaceutical Chemicals

Pharmaceutical consumption in Egypt has been increasing at about 15 percent a year for 20 years, and is expected to continue increasing at a minimum of 10 percent per year through the year 2000. The Egyptian drug industry, numbering seven public and two private firms, primarily formulates and packages imported products. The value of pharmaceutical chemical inputs is expected to reach LE 400 million (in 1984 prices) by the end of the century. Since the Egyptian drug industry currently produces only LE 6.0 million worth of pharmaceuticals a year, local manufacture of even 50 percent of that potential, or LE 200 million worth, would represent an increase of great magnitude.

The basic goal of the pharmaceutical project was to select, adapt, and test processes up to the preproduction stage for a small number of pharmaceutical chemicals that are vital and economically feasible to manufacture in Egypt. A related goal was to demonstrate that a partnership between the NRC/Cairo and the Egyptian drug industry could move rapidly through the R&D stage to the production of pharmaceuticals that would meet with consumer acceptance.

The development process emphasized synthetic pharmaceuticals. This approach was of paramount importance because the expertise acquired can be utilized in a continuing program of adaptation for local chemical and pharmaceutical manufacturing. Moreover, success in the synthetics branch can lead to expansion in other branches of fine chemical and biological products.

A high-level advisory committee was established with representatives from the seven public sector companies, and team leaders from NRC. The committee selected 11



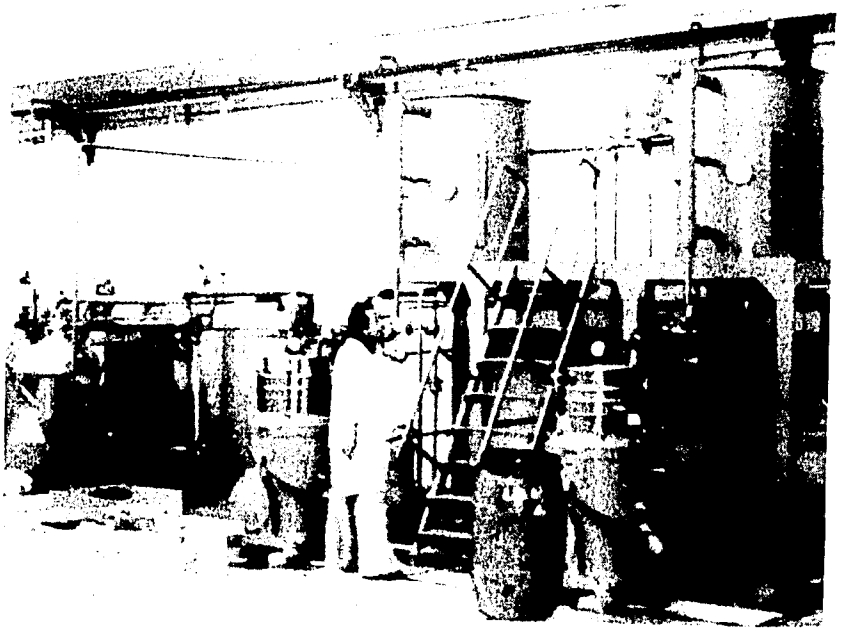


FIGURE 8 A processing line for wool scouring and wax recovery was developed and installed at Misr Beida Dyers, Kafr Al-Dawar. Detail (top) shows feed line (1) and strainer (2).

chemicals for laboratory investigations on the basis of demand, technology acquisition, material availability, and economic feasibility. Training and consultancy on pilot plant operations were undertaken with the collaboration of U.S. companies, such as Ciba Geigy, Upjohn, and Merck Sharp & Dohme. Pilot runs have been made at Al-Nasr Pharmaceutical Chemicals Company, Abu-Zabal.

FACILITIES DEVELOPMENT PROJECTS

Equipment Procurement, Repair, and Maintenance

In Egypt, as is common among developing countries, scientific instruments are procured from diverse sources of supply, creating problems of maintenance, standardization, and repair. These problems were investigated by two fact-finding teams from the United States: in September 1974, a team was sent to Cairo by the U.S. National Science Foundation, and, in June 1974, USAID sponsored an assessment that was carried out by the Research Triangle Institute. Both teams agreed that the minimum instrumentation capability essential to the conduct of scientific research did not exist in the universities, in the NRC, nor in the Scientific Instrumentation Centre (SIC). They concluded that modernization of facilities should be completed without delay.

The Applied S&T Program, based on recommendations of the two teams, included a project devoted to instrumentation technology. The three objectives were: to provide equipment and supplies needed to demonstrate the effective participation of R&D in problems of national development (scientific instrumentation, testing equipment, and pilot plant facilities); to improve scientific instrument maintenance and repair (M&R) capabilities at Egyptian institutions; and to institutionalize M&R training.

The solution agreed to was the selection of the SIC as a national organization to coordinate or carry out services related to the selection, procurement, and maintenance of equipment as well as conduct M&R training. A material testing laboratory was equipped to serve the textile, pharmaceutical, polymers, ceramics, pulp and paper, and leather industries. A network of maintenance and repair units was set up, with units at the universities of Cairo, Alexandria, Tanta, Zagazig, Menufia, Suez Canal, Assuit, Al-Menia, and in the NRC and SIC.

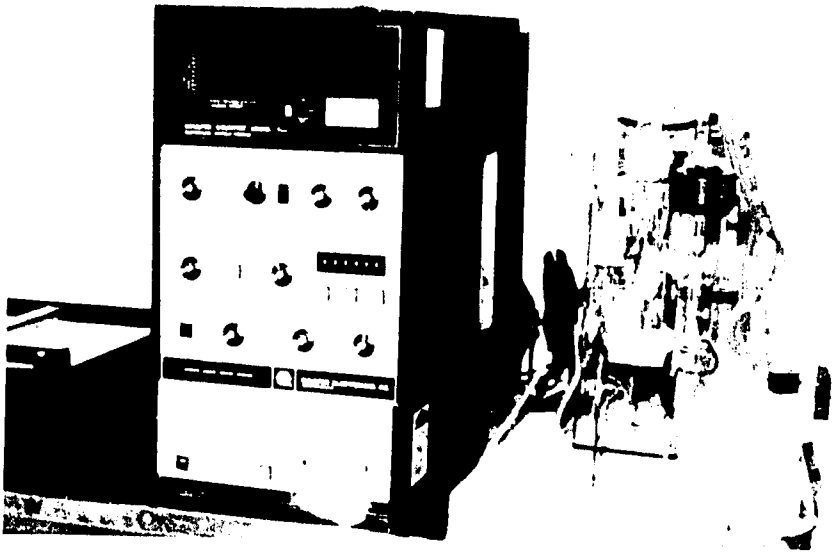


FIGURE 9 Materials testing equipment (top) was installed at a laboratory of the National Research Centre in Cairo. Maintenance and repair units (bottom), installed at a number of agencies, are necessary to keep instruments in good working order.

Information System Network[27-29]

Scientific and technical information--STI--has been "on the agenda" in Egypt for over a decade. In 1974, STI was identified as a priority concern under the U.S.-Egyptian Agreement on Cooperation in Technology, Research, and Development. A meeting of Egyptian officials and NSF representatives, in early 1975, followed by a symposium of U.S. and Egyptian specialists in the spring of 1976, led to the formation of a U.S.-Egyptian Program Committee on STI in November 1976.

The committee endorsed the undertaking of a national program of scientific and technical information, with the primary objective of supporting Egypt's socioeconomic development. In the Applied S&T Program, the establishment of an STI system network was considered a major element in the development of an infrastructure for support of science and technology.

Under the STI program, an assessment of information needs and available information resources was carried out. The preparatory phase included drafts of a national S&T information policy, a system analysis, a design study, and plans for a nationwide system of services and for the education of information specialists.

Experimental demonstrations and tests were followed by a final review of the design and plan. Equipped with hardware and software, a network of sectoral information service nodes was established. A management system, along with marketing services and organization charts, was also devised.

Standards, Measurements, and Quality Control

In Egypt, three organizations are involved in standards, measurements, and quality control activities. A project was designed to develop the facilities of these organizations and the coordinative links between them; develop their manpower through specialized training and specialized workshops and seminars; and supply them with instruments, standard reference materials, and support and maintenance services.

The National Institute for Standards (NIS), under the ASRT, is the national measurement reference laboratory of Egypt, fulfilling a function similar to the United States' National Bureau of Standards. NIS maintains the primary measurement standards for science, technology, and industry; it also has responsibility for setting standards for material testing and safety.

One of the essential activities under the project was the acquisition, repair and maintenance of NIS's electronic instruments and other equipment. The instruments supplied related to standards and measurements for force, time and frequency, electrical measurements, dimensional metrology, photometry, and legal metrology for assay and weights. The support services related to dosimetry, acoustics, production and construction safety, mass and flow measurements, and fire research.

The Egyptian Organization for Standardization and Quality Control (EOS), under the Ministry of Industry, is a standards-writing and quality-control institution. It maintains national secondary measurement standards for calibration of measuring instruments for manufacturing industries and processing plants. It awards quality marks to manufacturers and processors if their measuring and production capability is demonstrated to be within the required accuracy for ensuring high quality. Under the project, EOS was enabled to assay chemical composition by x-ray florescence, and to do hydraulic testing. It was provided with instrument repair, maintenance, and calibration services; and supported by a workshop.

The Assay and Weights Administration (AWA), under the Ministry of Commerce, assays and marks jewelry and other objects containing precious metals (gold, silver, platinum). It surveys and tests the accuracy of balances and flow meters, for example, for water and gasoline. Under the project, AWA was assisted with its legal metrology and alloy and gem assays.

V

PROGRAM ACHIEVEMENTS

Earlier chapters of this report have described the goals and principal activities of the Applied Science and Technology Program. This chapter provides an overview of the main achievements of these efforts.

R&D MANAGEMENT

The R&D Management Project particularly emphasized three objectives. The first was manpower development: changes in attitude among all participants (researchers as well as managers) were considered necessary to improve personnel performance. The second was institutional development: in particular, the strengthening of the structures and functions of S&T institutes collaborating in the program. The third was to achieve better links with end users: a management mechanism for the marketing of R&D services needed to be established. The project met these objectives.

R&D Management Training

Between 1979 and 1981, 58 senior administrators and senior research staff went to the United States for training in R&D management at the Denver Research Institute (DRI), the Battelle Memorial Institute, Georgetown University, and the Massachusetts Institute of Technology. Six of the training workshops, each of 3 weeks' duration, occurred at DRI where Egyptian managers were given a specially tailored experience in R&D project management, R&D institutional management, R&D marketing, technical and economic feasibility studies, and technology assessment. The results of this training were expected to be indirect, and long-term, and to be reflected in the general accomplishments of the Applied S&T Program.

The National Research Centre (NRC), in collaboration with the Academy of Scientific Research and Technology (ASRT), then had the primary responsibility for making R&D management training a routine activity. Through the NRC's initiative, an Egyptian Core Management Group (CMG) was established to plan, organize, and conduct training programs. In addition to teaching the principles of R&D management, the trainers concentrated on case studies of R&D projects, R&D control and performance measures, technical and economic appraisals, marketing, and the researcher-client relationship. The courses are now offered each year in Egypt to researchers and administrators. More than 700 persons have participated. Thus, the CMG has achieved "institutionalization" of R&D management training within the NRC and ASRT, thereby meeting an important objective of the Applied S&T Program.

The CMG also responds to requests for R&D management training from universities, ministries, and public sector enterprises. Recipients of the training include all ASRT-affiliated institutes, Cairo University, the Atomic Energy Institute, the General Administration for Organization and Management, and the Nutrition Institute. In this way, training in R&D management has spread throughout the S&T community.

Management Practices and Systems

The NRC has been a major beneficiary of the cooperative program. Seven of the 10 key positions in its new management system were filled by Egyptians who went to the United States for specialized training in R&D management, as described above. NRC's experience with the multidisciplinary and multi-institutional programs demonstrated the ability of its senior management to design, plan, and execute complex projects. A matrix showing NRC's assignment of manpower to the projects in the Applied S&T Program is shown below. Further, all of the NRC's offices--programming, marketing, and technical --are developing the capacity to address personnel performance as a management priority. Two important institutes, the Central Metallurgical Research and Development Institute and the Nutrition Institute, are directed by senior researchers who developed their management orientation and skills through active participation in the CMG.

As another accomplishment, the ASRT developed its Five-Year S&T Plan (1982 through 1987) in response to the needs of the national development plan. The ASRT also established a management system to monitor and evaluate development projects.

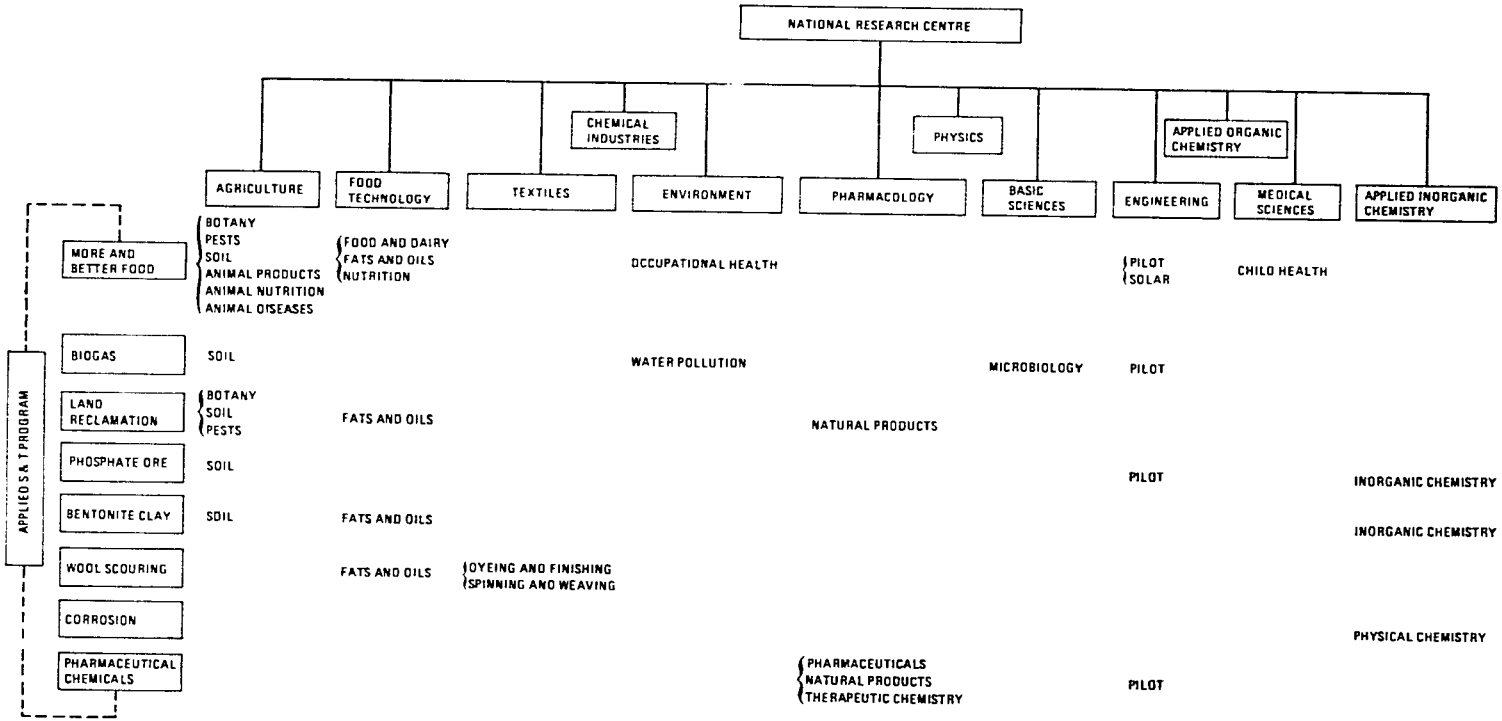


FIGURE 10 Chart showing assignment of laboratory personnel to projects.

Specialized consultancy services have been organized. The NRC and other ASRT-affiliated institutes are establishing units that will provide R&D services under contract to public and private entities. As set forth in their by-laws, the contract services offered by these units provide additional income to the institute and researchers involved. Also, the CMG group continues to provide consultancy services to other sectors.

The CMC has made contributions in addition to its training and consultancy activities, including: the preparation of the Egyptian National Paper on S&T for Development (which was submitted to the United Nations Conference on Science and Technology for Development in Vienna, in August 1979), and the formulation of the document "A National Technology Policy for Egypt." The team collaborated with a U.S. counterpart group, set up by USAID, to propose a new strategy for assistance to Egyptian S&T from 1986 until 1990. Also, the team had the sole responsibility for evaluating a nutrition education program (USAID-Catholic Relief Services-Nutrition Institute).

TECHNOLOGY POLICY

The Applied S&T Program offered a unique opportunity for the ASRT to work towards the development of a national technology policy. In the process of developing this policy, the ASRT mobilized a cross section of the nation's best talents. Table 5 gives affiliations and the number of experts involved. Three notable achievements of the Technology Policy Project are described below.

ASRT's Leadership

As the institutional focus for this national effort, ASRT successfully reached out to universities, ministries, and government and nongovernment agencies to mobilize the nation's specialists. The effort is a good example of ASRT's unique capability to provide leadership within the S&T community, and to influence and enhance transfer and diffusion of technology at the national level.

Development of Policy Statement

ASRT established 6 working groups, with 10-15 selected individuals in each group, to assess the range

TABLE 5 Experts Contributing to National S&T Policy and Their Affiliations

Affiliation	Number of Experts
ASRT & Affiliated Institutes	44
Ministry of Industry	23
Universities	18
Consultants	18
Other Ministries:	
Health	8
Foreign Affairs	8
Planning	7
Agriculture	6
Petroleum	6
Construction and Housing	4
Justice	3
Economy	2
Social Affairs	2
Defense	2
Transportation and Communications	2
Peoples Assembly and Shoura Council	4
National Specialized Council	4
Administrative Development	1
American University of Cairo	2
Total	164

of technology choices, the problems of technology transfer, the Egyptian organizations and mechanisms for technology development and international cooperation, and the instruments for implementing technology policy.

A technical secretariat was assigned the responsibility for preparing the National Technology Policy Statement.(19) A 24-page document was prepared, setting out the justification and feasibility of a national technology policy; the elements, goals and objectives of such a policy; planning, legislation, economics, and finance; research subjects and applications related to Egyptian development versus transfer from abroad; problems of production and quality control; the environment for technology development, including organization; and the nature of future technology. After review by all sectors concerned, the policy document was sent to the Ministerial Policy Committee.

Follow-Up of Policy Statement

The ASRT focused its follow-up on the economic sectors. Within each sector, its approach was to bring together researchers and producers of technology and the executives responsible for operations and policy. Three sectors--agriculture, irrigation, and industry--were selected for special examination. Working groups were organized. Then responsibilities for studies and data gathering were assigned, and technology needs and policy requirements were identified. Thus, sector-by-sector, policy statements are becoming operational realities.

DEMONSTRATION AND R&D PROJECTS

Two major objectives of the demonstration and R&D projects were: (1) to develop an effective mechanism for interaction of Egyptian scientists and all potential users of research; and (2) to strengthen the managerial capabilities of S&T institutes in dealing with multidisciplinary R&D programs. General information on the nine projects is given in Table 6; the project sites are also marked on a map of Egypt located before the Introduction.

Effective Working Relationships

More than 700 researchers, from 11 organizations, were involved in the projects. The More and Better Food Program (MBF) alone included more than 400 researchers and research assistants from 9 organizations and 11 specialties; food projects were carried out in 7 governorates, and involved more than 90,000 farmers. In a practical sense, successful implementation of the Applied S&T Program depended on effective working relationships. Effective relations between the R&D community and potential users was especially important because the projects dealt with priority concerns, such as food, agriculture, nutrition, health, industry, and energy.

Development of Institutional Capabilities

A significant achievement of the projects was that the NRC and ASRT acquired skills for managing and monitoring programs involving multiple disciplines and institutions. This experience also allowed the two institutions to develop their own capabilities. An illustration of the diversity of institutions involved

TABLE 6 Demonstration and R&D Project

Project	Implementation Sites	Key Statistics	Potential Users
1. More & Better Food	Village level Kafr Al-Khadra (Menufia) Omar Makram (Beheira) Al-Tahady (Beheira) Beni-Magdoul (Giza) Governorate level Giza, Beni-Suef, El Menia, Assuit, Sohag El-Fayum	Projects: 31 Area: 130,000 feddans Farmer participants: 90,000 Researchers: 400 Institutes: 9	Local farmers Ministry of Agriculture extension services Private sector Ministry of Industry, food technology NRC
2. Biogas Technology for Rural Development	Al-Manawat (Giza) Omar Makram (Beheira) Shuba Kass (Gharbia) Misr Aluminium Company	Digester types developed: 3 Researchers: 55 Institutes: 2 NRC divisions: 3	Local farmers Public/private sectors NRC
3. Land Reclamation	El-Salhia (El-Ismailia) El-Nubaria (Beheira) Inshass (Sharkia)	Researchers: 30 Institutes: 3	Ministry of Land Reclamation Ministry of Irrigation Public/private sectors
4. Phosphate Ore Beneficiation	Al-Sabaiya Abu Tartur	Researchers: 25 Institutes: 3	Egyptian Fertilizer Industry NRC
5. Utilization of Egyptian Bentonite Clays	Kasr El-Sagha (El-Fayum) Cairo-Alex Desert road Institutes: CMRDI Geological Survey	Researchers: 47 NRC, CMRDI	Public/private industries
6. Red Sea Fisheries	Ras Ben..as (Red Sea Governorate)	Researchers: 36 Institutes/Sectors: 2	Red Sea Governorate Fishermen
7. Corrosion Causes and Control	El-Suez Refinery (El-Suez)	Researchers: 15 Institutes/Sectors: 3	Petroleum Industry Construction Industries
8. Wool Scouring and Wool Wax Recovery	Misr Belga Dyers Company Kafr Al-Dawar (Beheira)	Researchers: 12 Institutes: 2	Textile Industry
9. Preparation of Selected Pharmaceutical Chemicals	Al-Nasr Pharmaceutical Company (Abu-Zabal)	Researchers: 36	Pharmaceutical Industry

in the demonstration and R&D projects and of the number of NRC laboratories and research divisions that participated in each is in Table 7.

The cooperative involvement of research institutes and potential users led to the expanded commercialization of technical services. For example, the MBF projects included several contracts with private farms to manage fruit and vegetable crops. The biogas project involved contractual funding from public and private sources as well as international organizations. The phosphate and bentonite projects, as the result of better researcher-industry relationships, led to six new contracts for R&D.

Institutionalization and Expansion of Activities

As a specific example of expanded activities, the MBF Project is being extended into a more comprehensive rural development program. Expanded coverage includes socio-economic aspects such as the women's role in development and small rural enterprises. More generally, the socio-economic aspects of development have been recognized as a major element in the planning of all R&D projects.

Engineering and pilot plant investigations have led to adoption of new technology by industry, and in turn to a more sophisticated capability to carry out such investigations. Likewise, field studies have fed back valuable baseline data to the R&D institutions, enabling them to better meet the real needs of Egyptian society.

Positive Returns from R&D Projects

Most MBF demonstrations showed a positive return from the adoption by farmers of new, appropriate, simple technologies.

The cottonseed oil refining and the cheese manufacture projects demonstrated increased productivity, and, in addition, solved priority problems for these food industries.

Phosphate ore beneficiation was shown to offer the technical feasibility of making better use of Egypt's large deposits of low-grade phosphate ore to compensate for the depletion of high-quality reserves. Actual commercial implementation depends upon economic factors affecting world phosphate market forces.

As a result of the bentonite project, deposits of high-quality clays were mapped and characterized along the Cairo-Alexandria road.

The wool scouring project increased the income of the Misr Beida Dyers Company by about $650,000 per year in

TABLE 7 Participating Institutions and NRC Units

Project	Institutions	NRC Div.	NRC Labs.	Researchers and Research Assistants	Specialties
More and Better Food	9	5	13	400	15
Biogas	2	4	4	55	4
Land reclamation	3	3	5	30	6
Phosphates	3	3	3	25	3
Bentonite ore	2	3	3	47	6
Wool scouring	2	2	3	12	3
Corrosion	3	1	1	15	3
Pharmaceuticals	2	2	4	36	4

addition to improving wool quality and alleviating the company's water pollution problem.

The pharmaceutical chemicals project opened the possibility for local industry to manufacture 11 important drugs that were previously imported.

The corrosion control project created a state-of-the-art facility in NRC for applied study of surface science phenomena. The group is now able to monitor corrosion mechanisms and test corrosion inhibitors under more controlled circumstances.

National Recognition of Achievements

The MBF Project primarily planned for village-level implementation, was extended first to cover one entire governorate--a jointly financed ASRT-Giza Governorate program on S&T in rural development. After a review of the larger effort in Giza, the Supreme National Committee for Policies and Economics, chaired by the prime minister, recommended expansion for maize, peanuts, and tomatoes to cover five governorates, Giza, El-Fayum, Beni-Suef, Menia, and Assuit. This resulted in increased annual income of LE 35 million from three crops. The total area affected was nearly 91,000 feddans and the monetary return represents more than 175 percent of the total budget for the Applied S&T Program.

The Ministry of Agriculture has recognized MBF achievements in several ways. As stated above,

FIGURE 11 New variety of maize in Kafr Al-Khadra (Menufia). Onion farm in Omar Makram (bottom).

FIGURE 12 Biogas unit "Chinese design" in Omar Makram. The unit is covered with a plastic tent. Gas range operating with biogas supplied by above unit (bottom).

FIGURE 13
Making better use of Egypt's phosphate ore deposits is the objective of a pilot unit for phosphoric acid production (top). Upgrade treatments include use of rotary calciner (bottom).

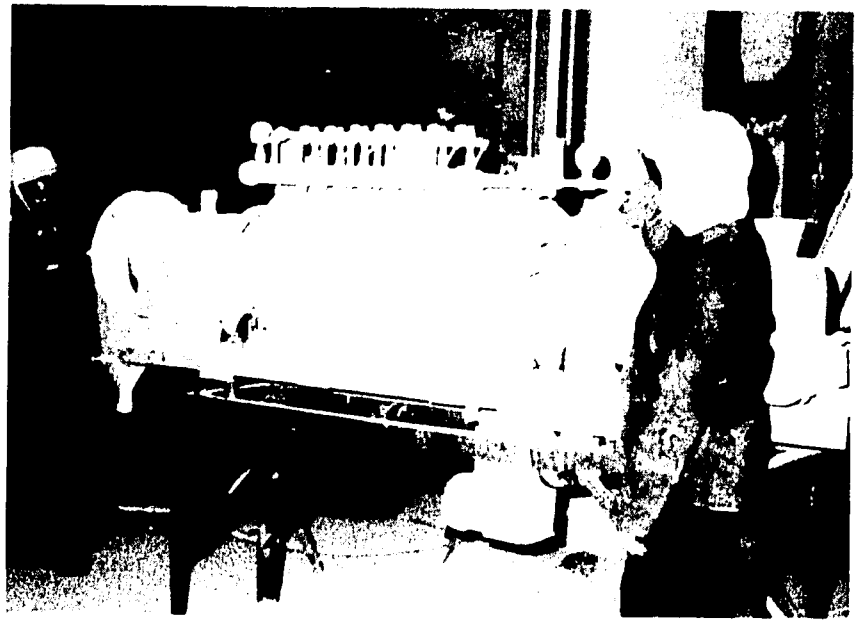
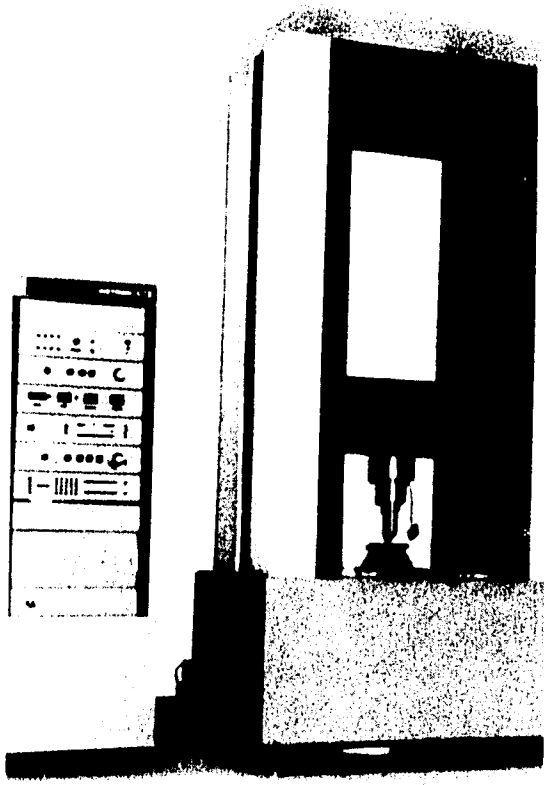


FIGURE 14 Materials testing (top); surface science testing (bottom); at NRC laboratories, Cairo.



demonstrations of maize, tomato, and peanut productivity were adopted for a national campaign. The ministry also recognized the food program achievements by inviting NRC staff to participate as members in its advisory committees. Also, the National School Lunch Program is based on the MBF team's accomplishments.

Members of the biogas project team were asked to serve as consultants to the national committees on energy. In November 1984, the project team held an international conference on State of the Art on Biogas Technology.

Under the bentonite project, a high-grade bentonite clay deposit, estimated at 1.5 million tons, was discovered along the Cairo-Alexandria road. The ore is suitable for use as an oil drilling clay, even without beneficiation, and will thus provide the opportunity to reduce dependence on imported clays.

The wool scouring project, in addition to providing an industrial process for the Misr Belda Dyers Company, is recognized by the Ministry of Industry as a prototype means of attacking the industrial water pollution problem.

The team leaders of the pharmaceutical chemicals project, together with the technical directors of the pharmaceutical companies, were asked to establish a national steering committee to act as the responsible body for synthesis of pharmaceutical chemicals in Egypt.

S&T FACILITIES DEVELOPMENT

The Applied S&T Program has featured an integrated approach to orienting Egypt's S&T community toward project work of priority importance to national development. In the program design, the two major elements were R&D management and demonstration and R&D projects. The third element, considered basic to effective implementation of research on a sustained basis, was support and development of S&T facilities. This element could be called "infrastructure" for the S&T system. These program expenditures provided for equipment and facilities (bench scale and pilot); for instrument repair and maintenance; for the establishment of an S&T information system network; and for the upgrading of the standards, measurements, and quality control services to industry.

Equipment Supplied through the Program

Of the overall Applied S&T Program budget of $24.1 million, the estimated cost of equipment,

materials, and supplies was about $14 million. Some 20 centers and institutes benefitted. Several were ASRT affiliates: NRC, Central Metallurgical Research and Development Institute (CMRDI), Institute of Oceanography and Fisheries (IOF), Scientific Instruments Centre (SIC), National Institute of Standards (NIS), and National Information and Documentation Centre (NIDOC). The Ministries assisted were Health, Industry, Electricity and Energy, Irrigation, and Agriculture. The universities assisted were Cairo, Ain Shams, Alexandria, Tanta, Zagazig, Menufia, Suez Canal, Assuit, and Menia.

Material testing laboratories were provided at NRC for six industrial applications: textiles, pharmaceuticals, polymers, ceramics, paper, and leather.

Hardware was provided for an information network with six nodes. This network connects the Ministries of Agriculture, Industry, Health, Energy, and ASRT's NIDOC.

Pilot plant facilities were provided for several R&D projects. Processes involved the beneficiation of phosphate ore and chemical conversion to fertilizer (CMRDI's laboratory at El-Tebbin, 30 km south of Cairo), the utilization of bentonite clay minerals in industry (CMRDI), and the industrial scouring of wool (Misr Beida Dyers, at Kafr Al-Dawar, Beheira). A food technology pilot plant, costing about $1.2 million, is being provided for the NRC. The government is funding a complex to house the pilot plant at an approximate cost of LE 1.0 million.

Bulk pharmaceutical chemicals were provided at a total cost of $300,000 (Al-Nasr Pharmaceutical, at Abu-Zabal, 20 km northeast of Cairo) for pilot plant testing on 11 products.

Special note should be taken of sophisticated, high-cost equipment for corrosion studies (550 ESCA/AES), at a cost of $400,000, and an x-ray fluorescent spectrometer, at $178,000 for the standards project. These are examples of equipment that otherwise probably would not have been at the disposal of Egyptian scientists.

Training in the Maintenance and Repair of Instruments

General courses on electronics and digital technology were given at the American University in Cairo, in collaboration with SIC, with participants coming from SIC, NRC, and other R&D institutes. Technical staff for maintenance and repair (M&R) centers were trained in the United States at the Instrumentation Systems Center of the University of Wisconsin-Madison, and the Biomedical Engineering and Instrumentation Branch of the National Institutes of Health, Bethesda, Maryland.

The U.S. training program covered the maintenance of electronic, mechanical, and electromechanical equipment; training for trainers; equipment procurement; and management of M&R centers. Twenty-six Egyptians were trained in the U.S. During Phase II of the project, a national instrumentation maintenance resource facility was established at SIC. The purpose of this unit, titled the Instrumentation Technical Unit, is to: (1) serve as a national equipment maintenance training facility, (2) provide repair services and technical assistance to other Egyptian organizations, and (3) support services such as replacement parts and technical literature to other organizations throughout Egypt.

The development of the technical training program was a joint effort between the NIH and SIC engineers and technicians to assure that it was tailored to meet the needs of Egypt. Over 220 M&R specialists were trained in Egypt under the leadership of the 26 originally trained in the United States as the core group.

In addition, 11 institutes now have maintenance and repair centers as a result of the program: NRC, SIC, and the universities of Cairo, Ain-Shams, Alexandria, Tanta, Zagazig, Menufia, Suez Canal, Assuit, and Menia.

Establishment of Information Service Network

Three U.S. institutions--the Georgia Institute of Technology at Atlanta; the Catholic University of America, Washington, D.C.; and the National Science Foundation--provided technical and managerial assistance that led to the establishment of the S&T information network linking the Ministries of Agriculture, Industry, Health, Electricity and Energy, and the S&T institutes (NIDOC unit).

The technical assistance covered strategic planning, service policies, system development, staff training, installation of hardware, management and operation of the network, and marketing of services.

Personnel training for this specialized kind of work, started in the U.S., is now totally carried out in Egypt. Compared to 12 personnel trained in the U.S., more than 1,200 have been trained in Egypt.

With assistance from Georgia Tech, the Egyptian National Scientific and Technical Information Network (ENSTINET) was established within the ASRT as the management unit for the overall S&T network. ENSTINET is responsible for management of the S&T network through agreements with the institutions served. A flow sheet for the network is shown below.

TABLE 8 Requests for Information Received by ENSTINET

Sector	Year 1981/82	1983	1984	1985 to Nov.	Total
Agriculture	--	47	737	373	1,157
Energy	--	2	32	42	76
Industry	--	--	73	74	147
Medicine	--	--	6	1,476	1,482
Science	788	647	866	865	3,166
Total	788	696	1,714	2,830	6,028

ENSTINET has initiated several major efforts, notably the introduction of on-line data base service in Egypt, the Arabization of software, and the development of a national bibliographic data base, including scientific journals, monographs, technical reports and theses. It assisted with the development of a management information system for the ASRT. And it is developing information marketing services for all user sectors. Table 8 shows the increase in requests for information that ENSTINET has received in recent years.

Standards, Measurements, and Quality Control

Facilities upgrading was essential for improving the national support services for setting basic standards, measurements, and quality control. Such functions cannot readily be carried out by individual institutes affiliated with different sectors. The project has involved the National Institute of Standards, affiliated with ASRT, the Egyptian Organization of Standards and Quality Control, the Ministry of Industry, and the Assay and Weights Organization, Ministry of Internal Trade. Technical and management assistance was provided by the U.S. National Bureau of Standards.

At a total cost of $975,000, the project provided special equipment for force measurement, dimensional metrology, time and frequency, electrical measurements, and photometry. Specialized technical training was offered on use of these devices, as well as in radiation protection, temperature metrology, fire research, and on the repair and maintenance of the instruments.

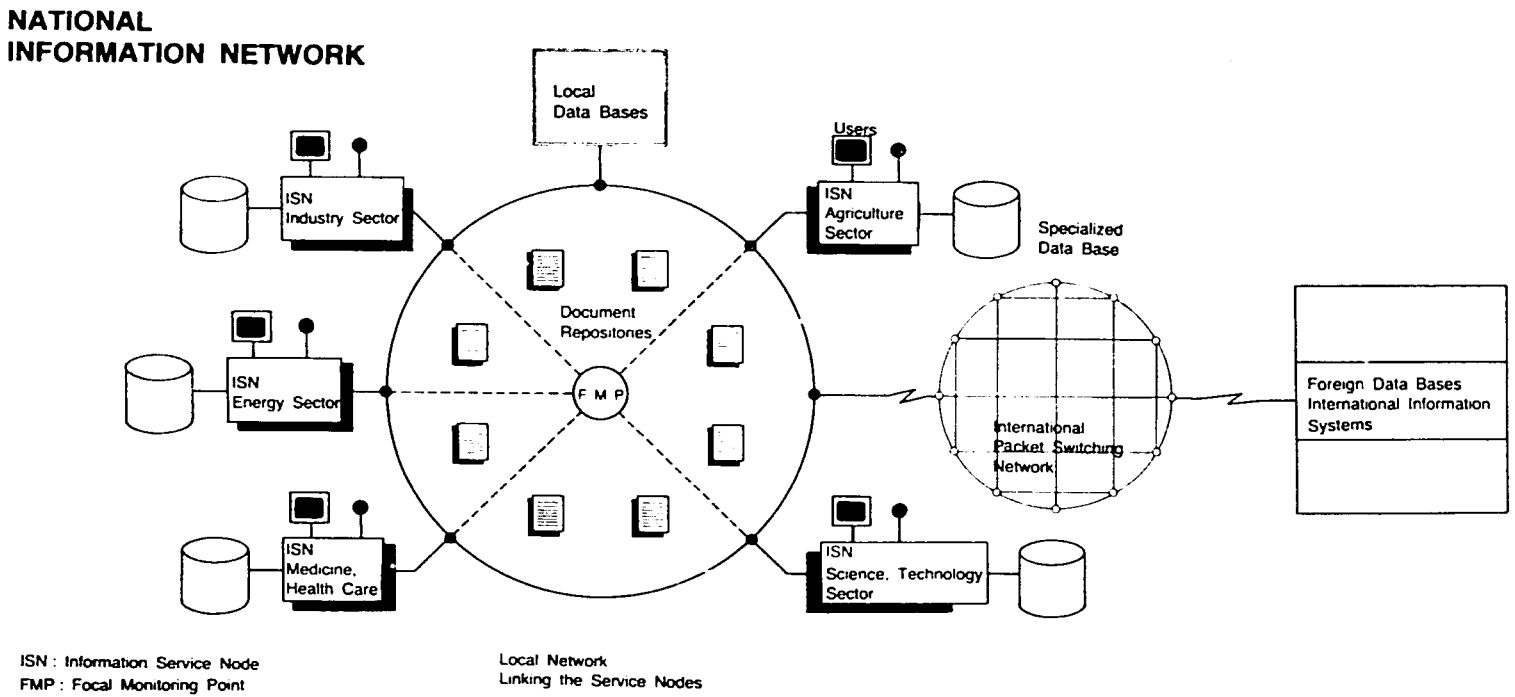


FIGURE 15 Flow sheet for the S&T information network.

The project also provided standard reference materials for 12 Egyptian sectors dealing with quality control.

The project has expanded quality control services to the industrial sector. In particular, iron and steel, cement, and electronics have become regular clients of these services.

VI

LESSONS

This chapter discusses lessons that can be distilled from the experience and achievements of the Applied Science and Technology Research Program. The lessons learned are stated in rather broad terms in the belief that they may illuminate S&T policy planning and program implementation for future Egyptian development activities. Although these lessons must be understood first in the context of Egyptian issues, it is hoped that they will have wider applicability for other developing country situations.

PROJECT-RELATED LESSONS

1. S&T resources for Egyptian national development can be effectively mobilized through the multidisciplinary team approach to problem solving.

Experience with the More and Better Food Project (MBF) illustrates this conclusion. The NRC mobilized more than 400 researchers and research assistants from 5 of its divisions and 13 laboratories in 15 specialties related to agriculture, food, nutrition, and health. Similarly, in the Biogas Technology Project (BTP), 4 divisions and 4 laboratories of NRC were involved, representing 55 researchers in 4 specialties (see Table 7).

2. The socioeconomic aspects of the design and implementation of S&T for development are vital.

The program has clearly demonstrated that technological changes are more successful when the economic implications and the social context in which they occur are considered; these are frequently as important as the technical aspects. A good illustration is the land

reclamation project: "Technical and Socioeconomic Evaluation of the Irrigation Systems in the New Lands and Their Impact on Crop Production, Soil Properties, and Water Requirements."[23]

Quantitative socioeconomic analyses are definitely more difficult to conduct than are technical analyses. In both MBF and BTP, special reports have been written to deal with the important issues.[30, 31, 32, 33]

3. Solutions to problems in the agricultural and industrial sectors are best achieved when the end users and R&D institutes form strong, active partnerships. Research institutes can cultivate these partnerships by organizing their consultancy, advisory, and research services with market-oriented management.

The NRC Pharmaceutical Industry Steering Committee is a splendid example of active participation of representatives of Egyptian firms from the public and private sectors.[34] A second illustration is the wool scouring/wool wax recovery project, where a full-scale facility was built, tested, and incorporated into the normal operations of the Misr Beida Dyers plant. The wool scouring project increased the firm's income by $650,000 per year and resulted in improved wool quality, as well as the alleviation of water pollution problems from wool scouring operations.

4. Technology assessment and adaptation are vital to the application of S&T for development in Egypt. The skills required go beyond research experience, and demand appraisal of the feasibility of technologies developed abroad as well as their engineering adaptation to Egypt's physical, economic, and social conditions.

Examples may be drawn from the demonstration and R&D projects:

o The projects involving phosphate ores and bentonite clays depended upon standard chemical engineering unit operations and processes in the transformation of Egyptian raw materials to useful end products. There were, however, constraints arising from Egyptian conditions such as scarcity of process water, nature of the raw materials, and scale of operations. These factors and others including transportation, power requirements, and environmental conditions determine the economic feasibility of a project to an even greater degree than the choice of technology itself.

o The BTP investigated both Chinese and Indian reactor designs; neither was precisely suitable for Egyptian rural conditions, so an adaptation was necessary. This example is typical of the approach that is often necessary in user-oriented S&T for development: it relied more heavily on engineering design than on research in the more traditional sense.

o The land reclamation project studied and adapted sprinkler and drip irrigation techniques as part of its exploration of possibilities for water savings. Appraisal of these technologies involved on-site reliability of electric power supply, availability of maintenance and repair (M&R) services, the landowner's experience in and willingness to use nontraditional irrigation systems, and realistic pricing of inputs (labor, water, electricity, M&R services, fertilizers, and pesticides).

5. There is a growing role for a modern, strong, and well-coordinated S&T information system in Egypt that is linked to worldwide networks.

Table 8 (page 59) shows the increasing use of the Egyptian National Scientific and Technical Information Network (ENSTINET) from 1981 through 1985. A cautionary note is in order, however: increasingly, "information" is a commodity that is sold and, because many sources of supply are likely to be networks or data banks outside Egypt, foreign exchange will be needed to buy it.

6. A comprehensive and versatile system for equipment maintenance and repair (M&R) is an essential underpinning for S&T.

Although the Applied S&T Program helped strengthen the M&R system in Egypt, the continued health of the various M&R centers requires good leadership, adequate staff incentives, a reliable supply of spare parts, ongoing and high-quality M&R training programs, and excellent links to the equipment manufacturers, most of whom are outside Egypt.

7. S&T capacity building and problem solving can be complementary objectives of a single program.

The Applied S&T Program had a specific, problem-oriented focus. At the same time, heavy

investments were also made in training staff and in procuring scientific equipment. Of the overall budget of $24.1 million, the estimated cost of equipment, materials, and supplies was about $14 million. Twenty Egyptian centers and institutes benefited by acquiring laboratory equipment and instrumentation, pilot plant facilities, microcomputer facilities, and testing equipment.

MANAGEMENT LESSONS

1. Attention to R&D management skills at all project and program levels in laboratoies and institutes pays big dividends. The incorporation of R&D management principles is essential for successful multidisciplinary and multi-institutional S&T endeavors.

The "steering committee" is one example of the use of a new management technique in Egypt for multidisciplinary and multi-institutional programs. Effective use of these committees was made in the MBF, bentonite clays, and pharmaceuticals projects. Biogas technology was more centrally managed within the Pilot Plant Laboratory of NRC, but was a clearly multidisciplinary effort and very successfully incorporated a three-person international advisory panel that served for more than five years.

2. At the level of the NRC, an R&D management core group has functioned successfully in institutionalizing R&D management training and promoting a strengthened management information system and marketing effort.

The NRC is a large and complex multidisciplinary R&D facility with a program that, until recently, was largely self-generated. It is now becoming more user-oriented and is adapting to contract research as a central principle of marketing. A core group of NRC senior researchers, constituted as an R&D management advisory committee, has been given responsibility for R&D management training. This core group planned and conducted 21 workshops attended by more than 700 persons from more than 40 public and private Egyptian organizations. This same R&D management core group is instituting a more comprehensive computer-based program and project information system for NRC and a strengthened R&D marketing effort.(17)

3. The ASRT has an important role in coordinating R&D policy planning to improve the utilization of scarce S&T resources for development.

The role of ASRT in calling attention to the need for better coordination of Egyptian S&T resources for national socioeconomic development is discussed earlier in this report (see pages 46-48). As one example, some 46 Egyptian institutes, belonging to 6 national ministries or agencies, are engaged in food, agriculture, and nutrition research, yet there is no coordinating mechanism.

4. At the level of international cooperation and program policy planning, the Joint Consultative Committee (JCC) for the Applied Science and Technology Research Program proved to be a successful mechanism.

A brief description of the JCC's role is found earlier (see page 22). Its advisory function to the ASRT president was important far beyond the areas of the projects. It served as the steering committee for the policy planning element of the overall program. Its regular (twice yearly) meetings catalyzed program management and scheduling. It helped achieve better access to the highest S&T decision-making levels in the two governments. Continuity of JCC membership over the eight-year program provided a long-range overview that was critical to the program's success.

5. Procurement is a specific management function that needs attention in future bilateral S&T programs.

On the U.S. side, government-mandated procurement regulations are complex. Many are required by law and thus will always result in long lead times for purchasing equipment. Examples are the U.S. regulations for sources, origins, and shipping. In-country procurement (in Egypt) also can be complex. Simplification and time savings should be possible, however, with a better understanding that procurement for S&T projects is basically different from procurement for construction or commodities.

On the Egyptian side, import restrictions and frequent changes in customs procedures, even for equipment destined for R&D purposes and provided at no cost to an Egyptian institution, proved to be time consuming.

Perhaps a better recognition by all parties of the complexity of procurement and customs regulations is required. A special approach from both the U.S. and the Egyptian authorities might include formation of a joint coordination mechanism with full-time staff to monitor and assist procurement work.

6. All projects cannot achieve instant success in any complex program. A mechanism to review achievements, issues, and continuing priorities needs to be incorporated into S&T program agreements so that specific projects may be modified or dropped and their resources reallocated with greater flexibility.

Both the ASRT and the JCC confronted this issue. Guidelines for early project termination were not included in the program, and it was difficult to address the issues as they arose. In the future, there should be an explicit understanding that changes may need to be made in the portfolio of the total program or in the direction of projects. It may be useful to include this understanding in the program's terms of reference.

7. The Applied Science and Technology Research Program demonstrated to Egyptian scientists, many of whom are somewhat isolated from the world scientific community, that they can contribute and compete successfully. At the same time, the program underscored the extent to which S&T increasingly relies on international cooperation and communication.

Three examples illustrate the effects of improved coordination and communication.

o In the pharmaceutical chemicals project, the Egyptian team profited from orientation and training visits to pilot plant and R&D facilities in the United States and India. These visits validated and extended the work that had been initiated in Egypt, and thereby provided an additional dimension of experience to that project.

o The United Nations Industrial Development Organization recognized the importance of the bentonite clay project by inviting Egyptian team members to Tunisia so they could assist in that country's efforts to develop clay minerals for land reclamation.

o Initially, the biogas technology project team made an extensive visit to India, China, Thailand, the Philippines, and elsewhere to learn from experience in those countries. After five years of developing the Egyptian program, the team was responsible for organizing and conducting the 1984 International Conference on the State of the Art on Biogas Technology, Transfer and Diffusion. More than 100 persons from 40 countries participated in the conference.

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GLOSSARY

ARC	Agricultural Research Centre
ASRT	Academy of Scientific Research and Technology
AWA	Assay and Weights Administration
BOSTID	Board on Science and Technology for International Development
CMRDI	Central Metallurgical Research and Development Institute
EOS	Egyptian Organization for Standardization and Quality Control
ENSTINET	Egyptian National Scientific and Technical Information Network
GOFI	General Organization for Industrialization
GNP	Gross National Product
JCC	Joint Consultative Committee of the Applied Science and Technology Research Program
MOA	Ministry of Agriculture
MOH	Ministry of Health
MOIFC	Ministry of Investment and Foreign Cooperation
MOIND	Ministry of Industry
MBF	More and Better Food Program
NRC	National Research Centre

NAS/NRC	U.S. National Academy of Sciences/National Research Council
NIDOC	National Informaion and Documentation Centre
NIS	National Institute for Standards
S&T	Science and Technology
SIC	Scientific Instrumentation Centre
STI	Science and Technology Information Network
R&D	Research and Development
USAID	U.S. Agency for International Development